The Ciao System

A New Generation, Multi-Paradigm Programming Language and Environment
(Including a State-of-the-Art ISO-Prolog)
REFERENCE MANUAL
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Summary

Ciao is a *public domain*, *next generation* multi-paradigm programming environment with a unique set of features:

- **Ciao** offers a complete Prolog system, supporting *ISO-Prolog*, but its novel modular design allows both *restricting* and *extending* the language. As a result, it allows working with *fully declarative subsets* of Prolog and also to *extend* these subsets (or ISO-Prolog) both syntactically and semantically. Most importantly, these restrictions and extensions can be activated separately on each program module so that several extensions can coexist in the same application for different modules.
- **Ciao** also supports (through such extensions) programming with functions, higher-order (with predicate abstractions), constraints, and objects, as well as feature terms (records), persistence, several control rules (breadth-first search, iterative deepening, ...), concurrency (threads/engines), a good base for distributed execution (agents), and parallel execution. Libraries also support WWW programming, sockets, external interfaces (C, Java, TclTk, relational databases, etc.), etc.
- **Ciao** offers support for *programming in the large* with a robust module/object system, module-based separate/incremental compilation (automatically –no need for makefiles), an assertion language for declaring (*optional*) program properties (including types and modes, but also determinacy, non-failure, cost, etc.), automatic static inference and static/dynamic checking of such assertions, etc.
- **Ciao** also offers support for *programming in the small* producing small executables (including only those libraries actually used by the program) and support for writing scripts.
- The **Ciao** programming environment includes a classical top-level and a rich emacs interface with an embeddable source-level debugger and a number of execution visualization tools.
- The **Ciao** compiler (which can be run outside the top level shell) generates several forms of architecture-independent and stand-alone executables, which run with speed, efficiency, and executable size which are very competitive with other commercial and academic languages (including other Prolog/CLP systems). Library modules can be compiled into compact bytecode or C source files, and linked statically, dynamically, or autoloaded.
- The novel modular design of **Ciao** enables, in addition to modular program development, effective global program analysis and static debugging and optimization via source to source program transformation. These tasks are performed by the **Ciao preprocessor** (`ciaopp`, distributed separately).
- The **Ciao** programming environment also includes `lpdoc`, an automatic documentation generator for LP/CLP programs. It processes source files adorned with (**Ciao**) assertions and machine-readable comments and generates manuals in many formats including `postscript`, `pdf`, `texinfo`, `info`, `HTML`, `man`, etc. , as well as on-line help, ascii `README` files, entries for indices of manuals (`info`, WWW, ...), and maintains WWW distribution sites.

Ciao is distributed under the GNU Library General Public License (LGPL).

This documentation corresponds to version 1.13#1 (2011/3/15, 20:8:35 CEST).

1 Introduction

1.1 About this manual

This is the *Reference Manual* for the Ciao development system. It contains basic information on how to install Ciao and how to write, debug, and run Ciao programs from the command line, from inside GNU `emacs`, or from a windowing desktop. It also documents all the libraries available in the standard distribution.

This manual has been generated using the *LPdoc* semi-automatic documentation generator for LP/CLP programs [HC97,Her00]. `lpdoc` processes Ciao files (and files in Prolog and other CLP languages) adorned with assertions and machine-readable comments, which should be written in the Ciao assertion language [PBH97,PBH00]. From these, it generates manuals in many formats including `postscript`, `pdf`, `texinfo`, `info`, `HTML`, `man`, etc., as well as on-line help, ascii `README` files, entries for indices of manuals (`info`, WWW, ...), and maintains WWW distribution sites.

The big advantage of this approach is that it is easier to keep the on-line and printed documentation in sync with the source code [Knu84]. As a result, *this manual changes continually as the source code is modified.* Because of this, the manual has a version number. You should make sure the manual you are reading, whether it be printed or on-line, coincides with the version of the software that you are using.

The approach also implies that there is often a variability in the degree to which different libraries or system components are documented. Many libraries offer abundant documentation, but a few will offer little. The latter is due to the fact that we tend to include libraries in the manual if the code is found to be useful, even if they may still contain sparse documentation. This is because including a library in the manual will at the bare minimum provide formal information (such as the names of exported predicates and their arity, which other modules it loads, etc.), create index entries, pointers for on-line help in the electronic versions of the manuals, and command-line completion capabilities inside `emacs`. Again, the manual is being updated continuously as the different libraries (and machine-readable documentation in them) are improved.

1.2 About the Ciao development system

The Ciao system is a full programming environment for developing programs in the Prolog language and in several other languages which are extensions and modifications of Prolog and (Constraint) Logic Programming in several interesting and useful directions. The programming environment offers a number of tools such as the Ciao standalone compiler (`ciaoc`), a traditional-style top-level interactive shell (`ciaosh` or `ciao`), an interpreter of scripts written in Ciao (`ciao-shell`), a Ciao (and Prolog) `emacs` mode (which greatly helps the task of developing programs with support for editing, debugging, version/change tracking, etc.), numerous libraries, a powerful program preprocessor (`ciaopp` [BGH99,BLGPH04,HBPLG99], which supports static debugging and optimization from program analysis via source to source program transformation), and an automatic documentation generator (`lpdoc`) [HC97,Her00]. A number of execution visualization tools [CGH93,CH00d,CH00c] are also available.

This manual documents the first four of the tools mentioned above [see PART I - The program development environment], and the Ciao language and libraries. The `ciaopp` and `lpdoc` tools are documented in separate manuals.

The Ciao language [see PART II - The Ciao basic language (engine)] has been designed from the ground up to be small, but to also allow extensions and restrictions in a modular way. The first objective allows producing small executables (including only those builtins used by the program), providing basic support for pure logic programming, and being able to write scripts

in Ciao. The second one allows supporting standard ISO-Prolog [see PART III - ISO-Prolog library (iso)], as well as powerful extensions such as constraint logic programming, functional logic programming, and object-oriented logic programming [see PART VII - Ciao extensions], and restrictions such as working with pure horn clauses.

The design of Ciao has also focused on allowing modular program development, as well as automatic program manipulation and optimization. Ciao includes a robust module system [CH00a], module-based automatic incremental compilation [CH99b], and modular global program analysis, debugging and optimization [PH99], based on a rich assertion language [see PART V - Assertions, Properties, Types, Modes, Comments (assertions)] for declaring (optional) program properties (including types and modes), which can be checked either statically or dynamically. The program analysis, static debugging and optimization tasks related to these assertions are performed by the `ciaopp` preprocessor, as mentioned above. These assertions (together with special comment-style declarations) are also the ones used by the `lpdoc` autodocumenter to generate documentation for programs (the comment-style declarations are documented in the `lpdoc` manual).

Ciao also includes several other features and utilities, such as support for several forms of executables, concurrency (threads), distributed and parallel execution, higher-order, WWW programming (PiLLoW [CHV96b]), interfaces to other languages like C and Java, database interfaces, graphical interfaces, etc., etc. [see PARTS VI to XI].

1.3 ISO-Prolog compliance versus extensibility

One of the innovative features of Ciao is that it has been designed to subsume *ISO-Prolog* (International Standard ISO/IEC 13211-1, PROLOG: Part 1–General Core [DEDC96]), while at the same time extending it in many important ways. The intention is to ensure that all ISO-compliant Prolog programs run correctly under Ciao. At the same time, the Ciao module system (see [PART II - The Ciao basic language (engine)] and [CH00a] for a discussion of the motivations behind the design) allows selectively avoiding the loading of most ISO-builtins (and changing some other ISO characteristics) when not needed, so that it is possible to work with purer subsets of Prolog and also to build small executables. Also, this module system makes it possible to develop extensions using these purer subsets (or even the full ISO-standard) as a starting point. Using these features, the Ciao distribution includes libraries which significantly extend the language both syntactically and semantically.

Compliance with ISO is still not complete: currently there are some minor deviations in, e.g., the treatment of characters, the syntax, some of the arithmetic functions, and part of the error system. On the other hand, Ciao has been reported by independent sources (members of the standarization body) to be one of the most conforming Prologs at the moment of this writing, and the first one to be able to compile all the standard-conforming test cases. Also, Ciao does not offer a strictly conforming mode which rejects uses of non-ISO features. However, in order to aid programmers who wish to write standard compliant programs, library predicates that correspond to those in the ISO-Prolog standard are marked specially in the manuals, and differences between the Ciao and the prescribed ISO-Prolog behaviours, if any, are commented appropriately.

The intention of the Ciao developers is to progressively complete the compliance of Ciao with the published parts of the ISO standard as well as with other reasonable extensions of the standard may be published in the future. However, since one of the design objectives of Ciao is to address some shortcomings of previous implementations of Prolog and logic programming in general, we also hope that some of the better ideas present in the system will make it eventually into other systems and the standards.

1.4 About the name of the System

Ciao is often referred to as "Ciao Prolog," a name which has an interesting (and not unintended) interpretation. Ciao is an interesting word which means both *hello* and *goodbye*. 'Ciao Prolog' intends to be a really good, all-round, freely available ISO-Prolog system which can be used as a classical Prolog, in both academic and industrial environments (and, in particular, to introduce users to Prolog and to constraint and logic programming –the *hello* part). An indeed many programmers use it just that way. But Ciao is also a new-generation, multiparadigm programming language and program development system which goes well beyond Prolog and other classical logic programming languages. And it has the advantage (when compared to other new-generation LP systems) that it does so while keeping full Prolog compatibility when needed.

1.5 Referring to Ciao

If you find Ciao or any of its components useful, we would appreciate very much if you added a reference to this manual (i.e., the Ciao reference manual [BCC97]) in your work. The following is an appropriate BiBTeX entry with the relevant data:

```
@techreport{ciao-reference-manual-tr,
  author =       {F. Bueno and D. Cabeza and M. Carro and M. Hermenegildo
                  and P. L\'{o}pez-Garc\'{\i}a and G. Puebla},
  title =        {The Ciao System. Reference Manual},
  institution =  {School of Computer Science, T. U. of Madrid (UPM)
                  and IMDEA Software Institute},
  year =         1997,
  month =        {August},
  number =       {{CLIP}3/1997.2011},
  note =         {Available from http://www.cliplab.org/}
}
```

1.6 Syntax terminology and notational conventions

This manual assumes some familiarity with logic programming and the Prolog language. The reader is referred to standard textbooks on logic programming and Prolog (such as, e.g., [SS86,CM81,Apt97,Hog84]) for background. However, we would like to refresh herein some concepts for the sake of establishing terminology. Also, we will briefly introduce a few of the extensions that Ciao brings to the Prolog language.

1.6.1 Predicates and their components

Procedures are called *predicates* and predicate calls *literals*. They all have the classical syntax of procedures (and of logic predications and of mathematical functions). Predicates are identified in this manual by a keyword 'PREDICATE' at the right margin of the place where they are documented.

Program instructions are expressions made up of control constructs (Chapter 13 [Control constructs/predicates], page 99) and literals, and are called *goals*. Literals are also (atomic) goals.

A predicate definition is a sequence of clauses. A clause has the form "`H :- B.`" (ending in '`.`'), where `H` is syntactically the same as a literal and is called the clause *head*, and `B` is a goal and is called the clause *body*. A clause with no body is written "`H.`" and is called a *fact*. Clauses with body are also called *rules*. A program is a sequence of predicate definitions.

1.6.2 Characters and character strings

We adopt the following convention for delineating character strings in the text of this manual: when a string is being used as an atom it is written thus: `user` or `'user'`; but in all other circumstances double quotes are used (as in `"hello"`).

When referring to keyboard characters, printing characters are written thus: ⟨a⟩, while control characters are written like this: ⟨^A⟩. Thus ⟨^C⟩ is the character you get by holding down the ⟨CTL⟩ key while you type ⟨c⟩. Finally, the special control characters carriage-return, line-feed and space are often abbreviated to ⟨RET⟩, ⟨LFD⟩ and ⟨SPC⟩ respectively.

1.6.3 Predicate specs

Predicates are distinguished by their name *and* their arity. We will call `name/arity` a *predicate spec*. The notation `name/arity` is therefore used when it is necessary to refer to a predicate unambiguously. For example, `concatenate/3` specifies the predicate which is named "concatenate" and which takes 3 arguments.

(Note that different predicates may have the same name and different arity. Conversely, of course, they may have the same arity and different name.)

1.6.4 Modes

When documenting a predicate, we will often describe its usage with a mode spec which has the form `name(Arg1, ..., ArgN)` where each `Arg` may be preceded by a *mode*. A mode is a functor which is wrapped around an argument (or prepended if defined as an operator). Such a mode allows documenting in a compact way the instantiation state on call and exit of the argument to which it is applied. The set of modes which can be used in Ciao is not fixed. Instead, arbitrary modes can be defined by in programs using the `modedef/1` declarations of the Ciao *assertion language* (Chapter 54 [The Ciao assertion package], page 339 for details). Modes are identified in this manual by a keyword 'MODE'.

Herein, we will use the set of modes defined in the Ciao `isomodes` library, which is essentially the same as those used in the ISO-Prolog standard (Chapter 58 [ISO-Prolog modes], page 371).

1.6.5 Properties and types

Although Ciao is *not* a typed language, it allows writing (and using) types, as well as (more general) properties. There may be properties of the states and of the computation. Properties of the states allow expressing characteristics of the program variables during computation, like in `sorted(X)` (`X` is a sorted list). Properties of the computation allow expressing characteristics of a whole computation, like in `is_det(p(X,Y))` (such calls yield only one solution). Properties are just a special form of predicates (Chapter 56 [Declaring regular types], page 355) and are identified in this manual by a keyword 'PROPERTY'.

Ciao types are *regular types* (Chapter 56 [Declaring regular types], page 355), which are a special form of properties themselves. They are identified in this manual by a keyword 'REG-TYPE'.

1.6.6 Declarations

A *declaration* provides information to one of the Ciao environment tools. Declarations are interspersed in the code of a program. Usually the target tool is either the compiler (telling it that a predicate is dynamic, or a meta-predicate, etc.), the preprocessor (which understands declarations of properties and types, assertions, etc.), or the autodocumenter (which understands the previous declarations and also certain "comment" declarations).

A declaration has the form `:- D.` where `D` is syntactically the same as a literal. Declarations are identified in this manual by a keyword 'DECLARATION'.

In Ciao users can define (and document) new declarations. New declarations are typically useful when defining extensions to the language (which in Ciao are called packages). Such extensions are often implemented as expansions (see Chapter 26 [Extending the syntax], page 193). There are many such extensions in Ciao. The `functions` library, which provides fuctional syntax, is an example. The fact that in Ciao expansions are local to modules (as operators, see below) makes it possible to use a certain language extension in one module without affecting other modules.

1.6.7 Operators

An *operator* is a functor (or predicate name) which has been declared as such, thus allowing its use in a prefix, infix, or suffix fashion, instead of the standard procedure-like fashion. E.g., declaring `+` as an infix operator allows writing `X+Y` instead of `'+'(X,Y)` (which may still, of course, be written).

Operators in Ciao are local to the module/file where they are declared. However, some operators are standard and allowed in every program (see Chapter 37 [Defining operators], page 255). This manual documents the operator declarations in each (library) module where they are included. As with expansions, the fact that in Ciao operators are local to modules makes it possible to use a certain language extension in one module without affecting other modules.

1.7 A tour of the manual

The rest of the introductory chapters after this one provide a first "getting started" introduction for newcomers to the Ciao system. The rest of the chapters in the manual are organized into a sequence of major parts as follows:

1.7.1 PART I - The program development environment

This part documents the components of the basic Ciao program development environment. They include:

ciaoc: the standalone compiler, which creates executables without having to enter the interactive top-level.

ciaosh: (also invoked simply as `ciao`) is an interactive top-level shell, similar to the one found on most Prolog systems (with some enhancements).

debugger.pl: a Byrd box-type debugger, similar to the one found on most Prolog systems (also with some enhancements, such as source-level debugging). This is not a standalone application, but is rather included in `ciaosh`, as is done in other systems supporting the Prolog language. However, it is also *embeddable*, in the sense that it can be included as a library in executables, and activated dynamically and conditionally while such executables are running.

ciao-shell: an interpreter/compiler for *Ciao scripts* (i.e., files containing Ciao code which run without needing explicit compilation).

ciao.el: a *complete program development enviroment*, based on GNU emacs, with syntax coloring, direct access to all the tools described above (as well as the preprocessor and the documenter), atomatic location of errors, source-level debugging, context-sensitive access to on-line help/manuals, etc. The use of this environment is *very highly recommended*!

The Ciao program development environment also includes `ciaopp`, the preprocessor, and `lpdoc`, the documentation generator, which are described in separate manuals.

1.7.2 PART II - The Ciao basic language (engine)

This part documents the *Ciao basic builtins*. These predefined predicates and declarations are available in every program, unless the `pure` package is used (by using a `:- module(_,_,[pure]).` declaration or `:- use_package(pure).`). These predicates are contained in the `engine` directory within the `lib` library. The rest of the library predicates, including the packages that provide most of the ISO-Prolog builtins, are documented in subsequent parts.

1.7.3 PART III - ISO-Prolog library (iso)

This part documents the *iso* package which provides to Ciao programs (most of) the ISO-Prolog functionality, including the *ISO-Prolog builtins* not covered by the basic library.

1.7.4 PART IV - Classic Prolog library (classic)

This part documents some Ciao libraries which provide additional predicates and functionalities that, despite not being in the ISO standard, are present in many popular Prolog systems. This includes definite clause grammars (DCGs), "Quintus-style" internal database, list processing predicates, DEC-10 Prolog-style input/output, formatted output, dynamic loading of modules, activation of operators at run-time, etc.

1.7.5 PART V - Assertions, Properties, Types, Modes, Comments (assertions)

Ciao allows *annotating* the program code with *assertions*. Such assertions include type and instantiation mode declarations, but also more general properties as well as comments in the style of the *literate programming*. These assertions document predicates (and modules and whole applications) and can be used by the Ciao preprocessor/compiler while debugging and optimizing the program or library, and by the Ciao documenter to build the program or library reference manual.

1.7.6 PART VI - Ciao library miscellanea

This part documents several Ciao libraries which provide different useful additional functionalities. Such functionalities include performing operating system calls, gathering statistics from the Ciao engine, file and file name manipulation, error and exception handling, fast reading and writing of terms (marshalling and unmarshalling), file locking, program reporting messages, pretty-printing programs and assertions, a browser of the system libraries, additional expansion utilities, concurrent aggregates, graph visualization, etc.

1.7.7 PART VII - Ciao extensions

The libraries documented in this part extend the Ciao language in several different ways. The extensions include:

- pure Prolog programming (well, this can be viewed more as a restriction than an extension);
- feature terms or *records* (i.e., structures with names for each field);
- parallel programming (e.g., &-Prolog style);
- functional syntax;
- higher-order library;
- global variables;
- `setarg` and `undo`;
- delaying predicate execution;

- active modules;
- breadth-first execution;
- iterative deepening-based execution;
- constraint logic programming;
- object oriented programming.

1.7.8 PART VIII - Interfaces to other languages and systems

The following interfaces to/from Ciao are documented in this part:

- External interface (e.g., to C).
- Socket interface.
- Tcl/tk interface.
- Web interface (http, html, xml, etc.);
- Persistent predicate databases (interface between the Ciao internal database and the external file system).
- SQL-like database interface (interface between the Ciao internal database and external SQL/ODBC systems).
- Java interface.
- Calling emacs from Ciao.

1.7.9 PART IX - Abstract data types

This part includes libraries which implement some generic data structures (abstract data types) that are used frequently in programs or in the Ciao system itself.

1.7.10 PART X - Miscellaneous standalone utilities

This is the documentation for a set of miscellaneous standalone utilities contained in the `etc` directory of the Ciao distribution.

1.7.11 PART XI - Contributed libraries

This part includes a number of libraries which have contributed by users of the Ciao system. Over time, some of these libraries are moved to the main library directories of the system.

1.7.12 PART XII - Appendices

These appendices describe the installation of the Ciao environment on different systems and some other issues such as reporting bugs, signing up on the Ciao user's mailing list, downloading new versions, limitations, etc.

1.8 Acknowledgments

The Ciao system is a joint effort on one side of some present (Francisco Bueno, Manuel Carro, Manuel Hermenegildo, *Pedro López*, and *Germán Puebla*) and past (Daniel Cabeza, *María José García de la Banda*) members of the *CLIP group* at the School of Computer Science, *Technical University of Madrid* and at the *IMDEA Software Institute*, and on the other side of several colleagues and students that have collaborated with us over the years of its development. The following is an (inevitably incomplete) list of those that have contributed most significantly to the development of Ciao:

- The *Ciao engine*, compiler, preprocessor, libraries, and documentation, although completely rewritten at this point, have their origins in the *&-Prolog parallel Prolog* engine and *parallelizing compiler*, developed by Manuel Hermenegildo, Kevin Greene, Kalyan Muthukumar, and Roger Nasr at *MCC* and later at *UPM*. The &-Prolog engine and low-level (*WAM*) compilers in turn were derived from early versions (0.5 to 0.7) of *SICStus Prolog* [Car88]. SICStus is an excellent, high performance Prolog system, developed by Mats Carlsson and colleagues at the *Swedish Institute of Computer Science* (*SICS*), that every user of Prolog should check out [Swe95,AAF91]. Very special thanks are due to Seif Haridi, Mats Carlsson, and colleagues at SICS for allowing the SICStus 0.5-0.7 components in *&-Prolog* and its successor, Ciao, to be distributed freely. Parts of the parallel abstract machine have been developed in collaboration with Gopal Gupta and Enrico Pontelli (*New Mexico State University*).
- Many aspects of the analyzers in the *Ciao preprocessor* (`ciaopp`) have been developed in collaboration with Peter Stuckey (*Melbourne U.*), Kim Marriott (*Monash U.*), Maurice Bruynooghe, Gerda Janssens, Anne Mulkers, and Veroniek Dumortier (*K.U. Leuven*), and Saumya Debray (*U. of Arizona*). The assertion system has been developed in collaboration with Jan Maluzynski and Wlodek Drabent (*Linkoping U.*) and Pierre Deransart (*INRIA*). The core of type inference system derives from the system developed by John Gallagher [GdW94] (*Bristol University*) and later adapted to CLP(FD) by Pawel Pietrzak (*Linkoping U.*).
- The constraint solvers for *R* and *Q* are derived from the code developed by Christian Holzbauer (*Austrian Research Institute for AI* in Vienna) [Hol94,Hol90,Hol92].
- The Ciao manuals include material from the *DECsystem-10 Prolog User's Manual* by D.L. Bowen (editor), L. Byrd, F.C.N. Pereira, L.M. Pereira, and D.H.D. Warren [BBP81]. They also contain material from the SICStus Prolog user manuals for SICStus versions 0.5-0.7 by Mats Carlsson and Johan Widen [Car88], as well as from the Prolog ISO standard documentation [DEDC96].
- Ciao is designed to be highly extendable in a modular way. Many of the libraries distributed with Ciao have been developed by other people all of which is impossible to mention here. Individual author names are included in the documentation of each library and appear in the indices.
- The development of the Ciao system has been supported in part by European research projects PEPMA, ACCLAIM, PARFORCE, DISCIPL, AMOS, ASAP, MOBIUS, and SCUBE; by MICYT projects IPL-D, ELLA, EDIPIA, CUBICO, MERIT, and DOVES; and by CM projects PROMESAS and PROMETIDOS.

If you feel you have contributed to the development of Ciao and we have forgotten to add your name to this list or to the acknowledgements given in the different chapters and indices, please let us know and we will be glad to give proper credits.

1.9 Version/Change Log

Version 1.12 (2005/7/3, 18:50:50 CEST)

Temporary version before transition to SVN log comments. (Jose Morales)

Version 1.10 (2004/7/29, 16:12:3 CEST)

- Classical prolog mode as default behavior.
- Emacs-based environment improved.
  - Improved emacs inferior (interaction) mode for Ciao and CiaoPP.
  - Xemacs compatibility improved (thanks to A. Rigo).
  - New icons and modifications in the environment for the preprocessor.
  - Icons now installed in a separate dir.

    - Compatibility with newer versions of `Cygwin`.
    - Changes to programming environment:
        - Double-click startup of programming environment.
        - Reorganized menus: help and customization grouped in separate menus.
        - Error location extended.
        - Automatic/Manual location of errors produced when running Ciao tools now customizable.
        - Presentation of CiaoPP preprocessor output improved.
    - Faces and coloring improved:
        - Faces for syntax-based highlighting more customizable.
        - Syntax-based coloring greatly improved. Literal-level assertions also correctly colored now.
        - Syntax-based coloring now also working on ASCII terminals (for newer versions of emacs).
        - Listing user-defined directives allowed to be colored in special face.
        - Syntax errors now colored also in inferior buffers.
        - Customizable faces now appear in the documentation.
        - Added new tool bar button (and binding) to refontify block/buffer.
        - Error marks now cleared automatically also when generating docs.
        - Added some fixes to hooks in lpdoc buffer.
- Bug fixes in compiler.
    - Replication of clauses in some cases (thanks to S. Craig).
- Improvements related to supported platforms
    - Compilation and installation in different palatforms have been improved.
    - New Mac OS X kernels supported.
- Improvement and bugs fixes in the engine:
    - Got rid of several segmentation violation problems.
    - Number of significant decimal digits to be printed now computed accurately.
    - Added support to test conversion of a Ciao integer into a machine int.
    - Unbound length atoms now always working.
    - C interface .h files reachable through a more standard location (thanks to R. Bagnara).
    - Compatibility with newer versions of gcc.
- New libraries and utilities added to the system:
    - Factsdb: facts defined in external files can now be automatically cached on-demand.
    - Symfnames: File aliasing to internal streams added.
- New libraries added (in beta state):
    - fd: clp(FD)
    - xml_path: XML querying and transformation to Prolog.
    - xdr_handle: XDR schema to HTML forms utility.
    - ddlist: Two-way traversal list library.
    - gnuplot: Interface to GnuPlot.

    - time_analyzer: Execution time profiling.
- Some libraries greatly improved:
    - Interface to Tcl/Tk very improved.
        - Corrected many bugs in both interaction Prolog to Tcl/Tk and viceversa.
        - Execution of Prolog goals from TclTk revamped.
        - Treatment of Tcl events corrected.
        - Predicate `tcl_eval/3` now allows the execution of Tcl procedures running multiple Prolog goals.
        - Documentation heavily reworked.
        - Fixed unification of prolog goals run from the Tcl side.
    - Pillow library improved in many senses.
        - HTTP media type parameter values returned are always strings now, not atoms.
        - Changed verbatim() pillow term so that newlines are translated to `<br>`.
        - Changed management of cookies so that special characters in values are correctly handled.
        - Added predicate `url_query_values/2`, reversible. Predicate `url_query/2` now obsolete.
        - Now attribute values in tags are escaped to handle values which have double quotes.
        - Improved `get_form_input/1` and `url_query/2` so that names of parameters having unusual characters are always correctly handled.
    - Fixed bug in tokenizer regarding non-terminated single or multiple-line comments. When the last line of a file has a single-line comment and does not end in a newline, it is accepted as correct. When an open-comment /* sequence is not terminated in a file, a syntax error exception is thrown.
- Other libraries improved:
    - Added native_props to assertions package and included `nonground/1`.
    - In atom2terms, changed interpretation of double quoted strings so that they are not parsed to terms.
    - Control on exceptions improved.
    - Added `native/1,2` to basic_props.
    - Davinci error processing improved.
    - Foreign predicates are now automatically declared as implementation-defined.
    - In lists, added `cross_product/2` to compute the cartesian product of a list of lists. Also added `delete_non_ground/3`, enabling deletion of nonground terms from a list.
    - In llists added `transpose/2` and changed `append/2` implementation with a much more efficient code.
    - The make library has been improved.
    - In persdb, added `pretractall_fact/1` and `retractall_fact/1` as persdb native capabilities.
    - Improved behavior with user environment from persdb.

- In persdb, added support for `persistent_dir/4`, which includes arguments to specify permission modes for persistent directory and files.
- Some minor updates in persdb_sql.
- Added treatment of operators and module:pred calls to pretty-printer.
- Updated report of read of syntax errors.
- File locking capabilities included in `open/3`.
- Several improvements in library system.
- New input/output facilities added to sockets.
- Added `most_specific_generalization/3` and `most_general_instance/3` to terms_check.
- Added `sort_dict/2` to library vndict.
- The xref library now treats also empty references.

- Miscellaneous updates:
  - Extended documentation in libraries actmods, arrays, foreign_interface, javall, persdb_mysql, prolog_sys, old_database, and terms_vars.

Version 1.9 (2002/5/16, 23:17:34 CEST)
New development version after stable 1.8p0 (MCL, DCG)

Version 1.8 (2002/5/16, 21:20:27 CEST)

- Improvements related to supported platforms:
  - Support for Mac OS X 10.1, based on the Darwin kernel.
  - Initial support for compilation on Linux for Power PC (contributed by Paulo Moura).
  - Workaround for incorrect C compilation while using newer (> 2.95) gcc compilers.
  - .bat files generated in Windows.
- Changes in compiler behavior and user interface:
  - Corrected a bug which caused wrong code generation in some cases.
  - Changed execution of initialization directives. Now the initialization of a module/file never runs before the initializations of the modules from which the module/file imports (excluding circular dependences).
  - The engine is more intelligent when looking for an engine to execute bytecode; this caters for a variety of situations when setting explicitly the CIAOLIB environment variable.
  - Fixed bugs in the toplevel: behaviour of `module:main` calls and initialization of a module (now happens after related modules are loaded).
  - Layout char not needed any more to end Prolog files.
  - Syntax errors now disable .itf creation, so that they show next time the code is used without change.
  - Redefinition warnings now issued only when an unqualified call is seen.
  - Context menu in Windows can now load a file into the toplevel.
  - Updated Windows installation in order to run CGI executables under Windows: a new information item is added to the registry.
  - Added new directories found in recent Linux distributions to INFOPATH.
  - Emacs-based environment and debugger improved:
    - Errors located immediataly after code loading.
    - Improved ciao-check-types-modes (preprocessor progress now visible).

    - Fixed loading regions repeatedly (no more predicate redefinition warnings).
    - Added entries in `ciaopp` menu to set verbosity of output.
    - Fixed some additional xemacs compatibility issues (related to searches).
    - Errors reported by inferior processes are now explored in forward order (i.e., the first error rewported is the first one highlighted). Improved tracking of errors.
    - Specific tool bar now available, with icons for main fuctions (works from emacs 21.1 on). Also, other minor adaptations for working with emacs 21.1 and later.
    - Debugger faces are now locally defined (and better customization). This also improves comtability with xemacs (which has different faces).
    - Direct access to a common use of the preprocessor (checking modes/types and locating errors) from toolbar.
    - Inferior modes for Ciao and CiaoPP improved: contextual help turned on by default.
    - Fixes to set-query. Also, previous query now appears in prompt.
    - Improved behaviour of stored query.
    - Improved behaviour of recentering, finding errors, etc.
    - Wait for prompt has better termination characteristics.
    - Added new interactive entry points (M-x): ciao, prolog, ciaopp.
    - Better tracking of last inferior buffer used.
    - Miscellanous bugs removed; some colors changed to adapt to different Emacs versions.
    - Fixed some remaining incompatibilities with xemacs.
    - `:- doc` now also supported and highlighted.
    - Eliminated need for calendar.el
    - Added some missing library directives to fontlock list, organized this better.
- New libraries added to the system:
    - hiord: new library which needs to be loaded in order to use higher-order call/N and P(X) syntax. Improved model for predicate abstractions.
    - fuzzy: allows representing fuzzy information in the form or Prolog rules.
    - use_url: allows loading a module remotely by using a WWW address of the module source code
    - andorra: alternative search method where goals which become deterministic at run time are executed before others.
    - iterative deepening (id): alternative search method which makes a depth-first search until a predetermined depth is reached. Complete but in general cheaper than breadth first.
    - det_hook: allows making actions when a deterministic situation is reached.
    - ProVRML: read VRML code and translate it into Prolog terms, and the other way around.
    - io_alias_redirection: change where stdin/stdout/stderr point to from within Ciao programs.
    - tcl_tk: an interface to Tcl/Tk programs.

    - tcl_tk_obj: object-based interface to Tcl/Tk graphical objects.
    - CiaoPP: options to interface with the CiaoPP Prolog preprocessor.
- Some libraries greatly improved:
    - WebDB: utilities to create WWW-based database interfaces.
    - Improved java interface implementation (this forced renaming some interface primitives).
    - User-transparent persistent predicate database revamped:
        - Implemented passerta_fact/1 (asserta_fact/1).
        - Now it is never necessary to explicitly call init_persdb, a call to initialize_db is only needed after dynamically defining facts of persistent_dir/2. Thus, pcurrent_fact/1 predicate eliminated.
        - Facts of persistent predicates included in the program code are now included in the persistent database when it is created. They are ignored in successive executions.
        - Files where persistent predicates reside are now created inside a directory named as the module where the persistent predicates are defined, and are named as F_A* for predicate F/A.
        - Now there are two packages: persdb and 'persdb/ll' (for low level). In the first, the standard builtins asserta_fact/1, assertz_fact/1, and retract_fact/1 are replaced by new versions which handle persistent data predicates, behaving as usual for normal data predicates. In the second package, predicates with names starting with 'p' are defined, so that there is not overhead in calling the standard builtins.
        - Needed declarations for persistent_dir/2 are now included in the packages.
    - SQL now works with mysql.
    - system: expanded to contain more predicates which act as interface to the underlying system / operating system.
- Other libraries improved:
    - xref: creates cross-references among Prolog files.
    - concurrency: new predicates to create new concurrent predicates on-the-fly.
    - sockets: bugs corrected.
    - objects: concurrent facts now properly recognized.
    - fast read/write: bugs corrected.
    - Added 'webbased' protocol for active modules: publication of active module address can now be made through WWW.
    - Predicates in library(dynmods) moved to library(compiler).
    - Expansion and meta predicates improved.
    - Pretty printing.
    - Assertion processing.
    - Module-qualified function calls expansion improved.
    - Module expansion calls goal expansion even at runtime.
- Updates to builtins (there are a few more; these are the most relevant):
    - Added a prolog_flag to retrieve the version and patch.
    - current_predicate/1 in library(dynamic) now enumerates non-engine modules, prolog_sys:current_predicate/2 no longer exists.
    - exec/* bug fixed.

    - srandom/1 bug fixed.
  - Updates for C interface:
    - Fixed bugs in already existing code.
    - Added support for creation and traversing of Prolog data structures from C predicates.
    - Added support for raising Prolog exceptions from C predicates.
    - Preliminary support for calling Prolog from C.
  - Miscellaneous updates:
    - Installation made more robust.
    - Some pending documentation added.
    - 'ciao' script now adds (locally) to path the place where it has been installed, so that other programs can be located without being explicitly in the $PATH.
    - Loading programs is somewhat faster now.
    - Some improvement in printing path names in Windows.

Version 1.7 (2000/7/12, 19:1:20 CEST)
Development version following even 1.6 distribution.

Version 1.6 (2000/7/12, 18:55:50 CEST)
- Source-level debugger in emacs, breakpts.
- Emacs environment improved, added menus for Ciaopp and LPDoc.
- Debugger embeddable in executables.
- Stand-alone executables available for UNIX-like operating systems.
- Many improvements to emacs interface.
- Menu-based interface to autodocumenter.
- Threads now available in Win32.
- Many improvements to threads.
- Modular clp(R) / clp(Q).
- Libraries implementing And-fair breadth-first and iterative deepening included.
- Improved syntax for predicate abstractions.
- Library of higher-order list predicates.
- Better code expansion facilities (macros).
- New delay predicates (when/2).
- Compressed object code/executables on demand.
- The size of atoms is now unbound.
- Fast creation of new unique atoms.
- Number of clauses/predicates essentially unbound.
- Delayed goals with freeze restored.
- Faster compilation and startup.
- Much faster fast write/read.
- Improved documentation.
- Other new libraries.
- Improved installation/deinstallation on all platforms.
- Many improvements to autodocumenter.
- Many bug fixes in libraries and engine.

Version 1.5 (1999/11/29, 16:16:23 MEST)
Development version following even 1.4 distribution.

Version 1.4 (1999/11/27, 19:0:0 MEST)
- Documentation greatly improved.
- Automatic (re)compilation of foreign files.
- Concurrency primitives revamped; restored &Prolog-like multiengine capability.
- Windows installation and overall operation greatly improved.
- New version of O'Ciao class/object library, with improved performance.
- Added support for "predicate abstractions" in call/N.
- Implemented reexportation through reexport declarations.
- Changed precedence of importations, last one is now higher.
- Modules can now implicitly export all predicates.
- Many minor bugs fixed.

Version 1.3 (1999/6/16, 17:5:58 MEST)
Development version following even 1.2 distribution.

Version 1.2 (1999/6/14, 16:54:55 MEST)
Temporary version distributed locally for extensive testing of reexportation and other 1.3 features.

Version 1.1 (1999/6/4, 13:30:37 MEST)
Development version following even 1.0 distribution.

Version 1.0 (1999/6/4, 13:27:42 MEST)
- Added Tcl/Tk interface library to distribution.
- Added push_prolog_flag/2 and pop_prolog_flag/1 declarations/builtins.
- Filename processing in Windows improved.
- Added redefining/1 declaration to avoid redefining warnings.
- Changed syntax/1 declaration to use_package/1.
- Added add_clause_trans/1 declaration.
- Changed format of .itf files such that a '+' stands for all the standard imports from engine, which are included in c_itf source internally (from engine(builtin_exports)). Further changes in itf data handling, so that once an .itf file is read in a session, the file is cached and next time it is needed no access to the file system is required.
- Many bugs fixed.

Version 0.9 (1999/3/10, 17:3:49 CET)
- Test version before 1.0 release. Many bugs fixed.

Version 0.8 (1998/10/27, 13:12:36 MET)
- Changed compiler so that only one pass is done, eliminated `.dep` files.
- New concurrency primitives.
- Changed assertion comment operator to #.
- Implemented higher-order with call/N.
- Integrated SQL-interface to external databases with persistent predicate concept.
- First implementation of object oriented programming package.
- Some bugs fixed.

Version 0.7 (1998/9/15, 12:12:33 MEST)

- Improved debugger capabilities and made easier to use.
- Simplified assertion format.
- New arithmetic functions added, which complete all ISO functions.
- Some bugs fixed.

Version 0.6 (1998/7/16, 21:12:7 MET DST)

- Defining other path aliases (in addition to 'library') which can be loaded dynamically in executables is now possible.
- Added the posibility to define multifile predicates in the shell.
- Added the posibility to define dynamic predicates dynamically.
- Added addmodule meta-argument type.
- Implemented persistent data predicates.
- New version of PiLLoW WWW library (XML, templates, etc.).
- Ported active modules from "distributed Ciao" (independent development version of Ciao).
- Implemented lazy loading in executables.
- Modularized engine(builtin).
- Some bugs fixed.

Version 0.5 (1998/3/23)

- First Windows version.
- Integrated debugger in toplevel.
- Implemented DCG's as (Ciao-style) expansions.
- Builtins renamed to match ISO-Prolog.
- Made ISO the default syntax/package.

Version 0.4 (1998/2/24)

- First version with the new Ciao emacs mode.
- Full integration of concurrent engine and compiler/library.
- Added new_declaration/1 directive.
- Added modular syntax enhancements.
- Shell script interpreter separated from toplevel shell.
- Added new compilation warnings.

Version 0.3 (1997/8/20)

- Ciao builtins modularized.
- New prolog flags can be defined by libraries.
- Standalone comand-line compiler available, with automatic "make".
- Added assertions and regular types.
- First version using the automatic documentation generator.

Version 0.2 (1997/4/16)

- First module system implemented.
- Implemented exceptions using catch/3 and throw/1.
- Added functional & record syntax.
- Added modular sentence, term, and goal translations.
- Implemented attributed variables.
- First CLPQ/CLPR implementation.
- Added the posibility of linking external .so files.

- Changes in syntax to allow `P(X)` and `"string"||L`.
- Changed to be closer to ISO-Prolog.
- Implemented Prolog shell scripts.
- Implemented data predicates.

Version 0.1 (1997/2/13)
First fully integrated, standalone Ciao distribution. Based on integrating into an evolution of the &-Prolog engine/libraries/preprocessor [Her86,HG91] many functionalities from several previous independent development versions of Ciao [HC93,HC94,HCC95,Bue95,CLI95,HBdlBP95,HBC96,CHV96b,HBC99].

2 Getting started on Un*x-like machines

Author(s): Manuel Hermenegildo.

This part guides you through some very basic first steps with Ciao on a Un*x-like system. It assumes that Ciao is already installed correctly on your Un*x system. If this is not the case, then follow the instructions in Chapter 229 [Installing Ciao from the source distribution], page 1099 first.

We start with by describing the basics of using Ciao from a normal command shell such as `sh/bash`, `csh/tcsh`, etc. We strongly recommend reading also Section 2.4 [An introduction to the Ciao emacs environment (Un*x)], page 24 for the basics on using Ciao under `emacs`, which is a much simpler and much more powerful way of developing Ciao programs, and has the advantage of offering an almost identical environment under Un*x and Windows.

2.1 Testing your Ciao Un*x installation

It is a good idea to start by performing some tests to check that Ciao is installed correctly on your system (these are the same tests that you are instructed to do during installation, so you can obviously skip them if you have done them already at that time). If any of these tests do not succeed either your environment variables are not set properly (see Section 2.2 [Un*x user setup], page 21 for how to fix this):

- Typing `ciao` (or `ciaosh`) should start the typical Prolog-style top-level shell.
- In the top-level shell, Ciao library modules should load correctly. Type for example `use_module(library(dec10_io))` –you should get back a prompt with no errors reported.
- To exit the top level shell, type `halt.` as usual, or ⟨^D⟩.
- Typing `ciaoc` should produce the help message from the Ciao standalone compiler.
- Typing `ciao-shell` should produce a message saying that no code was found. This is a Ciao application which can be used to write scripts written in Ciao, i.e., files which do not need any explicit compilation to be run.

Also, the following documentation-related actions should work:

- If the `info` program is installed, typing `info` should produce a list of manuals which *should include Ciao manual(s) in a separate area* (you may need to log out and back in so that your shell variables are reinitialized for this to work).
- Opening with a WWW browser (e.g., `netscape`) the directory or `URL` corresponding to the `DOCDIR` setting should show a series of Ciao-related manuals. Note that *style sheets* should be activated for correct formatting of the manual.
- Typing `man ciao` should produce a man page with some very basic general information on Ciao (and pointing to the on-line manuals).
- The `DOCDIR` directory should contain the manual also in the other formats such as `postscript` or `pdf` which specially useful for printing. See Section 2.3.7 [Printing manuals (Un*x)], page 24 for instructions.

2.2 Un*x user setup

If the tests above have succeeded, the system is probably installed correctly and your environment variables have been set already. In that case you can skip to the next section.

Otherwise, if you have not already done so, make the following modifications in your startup scripts, so that these files are used (`<LIBROOT>` must be replaced with the appropriate value, i.e., where the Ciao library is installed):

- For users a *csh-compatible shell* (`csh`, `tcsh`, ...), add to `~/.cshrc`:

```
if ( -e <v>libroot</v>/ciao/DOTcshrc ) then
   source <v>libroot</v>/ciao/DOTcshrc
endif
```

Note: while this is recognized by the terminal shell, and therefore by the text-mode Emacs which comes with Mac OS X, the Aqua native Emacs 21 does not recognize that initialization. It is thus necessary, at this moment, to set manually the Ciao shell (ciaosh) and Ciao library location by hand. This can be done from the Ciao menu within Emacs after a Ciao file has been loaded. We believe that the reason is that Mac OS X does not actually consult the per-user initialization files on startup. It should also be possible to put the right initializations in the .emacs file using the `setenv` function of Emacs-lisp, as in

```
(setenv "CIAOLIB" "<v>libroot</v>/ciao")
```

The same can be done for the rest of the variables initialized in `<v>libroot</v>/ciao/DOTcshrc`

- For users of an *sh-compatible shell* (`sh`, `bash`, ...), the installer will add to `~/.bashrc` the next lines:

```
if [ -f <v>libroot</v>/ciao/DOTprofile ]; then
   . <v>libroot</v>/ciao/DOTprofile
fi
```

  This will set up things so that the Ciao executables are found and you can access the Ciao system manuals using the `info` command. Note that, depending on your shell, *you may have to log out and back in* for the changes to take effect.

- Also, if you use `emacs` (highly recommended) the install will add the next line to your `~/.emacs` file:

```
(load-file "<v>libroot</v>/ciao/ciao-mode-init.el")
(if (file-exists-p "<v>libroot</v>/ciao/ciao-mode-init.el")
  (load-file "<v>libroot</v>/ciao/ciao-mode-init.el")
)
```

If after following these steps things do not work properly, then the installation was probably not completed properly and you may want to try reinstalling the system.

2.3 Using Ciao from a Un*x command shell

2.3.1 Starting/exiting the top-level shell (Un*x)

The basic methods for starting/exiting the top-level shell have been discussed above. If upon typing `ciao` you get a "command not found" error or you get a longer message from Ciao before starting, it means that either Ciao was not installed correctly or you environment variables are not set up properly. Follow the instructions on the message printed by Ciao or refer to the installation instructions regarding user-setup for details.

2.3.2 Getting help (Un*x)

The basic methods for accessing the manual on-line have also been discussed above. Use the table of contents and the indices of *predicates*, *libraries*, *concepts*, etc. to find what you are looking for. Context-sensitive help is available within the `emacs` environment (see below).

2.3.3 Compiling and running programs (Un*x)

Once the shell is started, you can compile and execute modules inside the interactive top-level shell in the standard way. E.g., type `use_module(`*file*`).`, `use_module(library(`*file*`)).` for

library modules, `ensure_loaded(`*file*`).` for files which are not modules, and `use_package(`*file*`).` for library packages (these are syntactic/semantic packages that extend the Ciao language in many different ways). Note that the use of `compile/1` and `consult/1` is discouraged in Ciao.

For example, you may want to type `use_package(iso)` to ensure Ciao has loaded all the ISO builtins (whether this is done by default or not depends on your `.ciaorc` file). Do not worry about any "module already in executable" messages –these are normal and simply mean that a certain module is already pre-loaded in the top-level shell. At this point, typing `write(hello).` should work.

Note that some predicates that may be built-ins in typical Prolog implementations are available through libraries in Ciao. This facilitates making small executables.

To change the working directory to, say, the `examples` directory in the Ciao root directory, first do:

```
?- use_module(library(system)).
```

(loading the `system` library makes a number of system-related predicates such as `cd/1` accessible) and then:

```
?- cd('$/examples').
```

(in Ciao the sequence `$/` *at the beginning of a path name* is replaced by the path of the Ciao root directory).

For more information see Chapter 5 [The interactive top-level shell], page 41.

2.3.4 Generating executables (Un*x)

Executables can be generated from the top-level shell (using `make_exec/2`) or using the standalone compiler (`ciaoc`). To be able to make an executable, the file should define the predicate `main/1` (or `main/0`), which will be called upon startup (see the corresponding manual section for details). In its simplest use, given a top-level *foo*`.pl` file for an application, the compilation process produces an executable `foo`, automatically detecting which other files used by `foo.pl` need recompilation.

For example, within the `examples` directory, you can type:

```
?- make_exec(hw,_).
```

which should produce an executable. Typing `hw` in a shell (or double-clicking on the icon from a graphical window) should execute it.

For more information see Chapter 5 [The interactive top-level shell], page 41 and Chapter 4 [The stand-alone command-line compiler], page 33.

2.3.5 Running Ciao scripts (Un*x)

Ciao allows writing scripts. These are files containing Ciao source but which get executed without having to explicitly compile them (in the same way as, e.g., `.bat` files or programs in scripting languages). As an example, you can run the file `hw` in the `examples` directory of the Ciao distribution and look at the source with an editor. You can try changing the `Hello world` message and running the program again (no need to recompile!).

As you can see, the file should define the predicate `main/1` (not `main/0`), which will be called upon startup. The two header lines are necessary in Un*x in. In Windows you can leave them in or you can take them out, but you need to rename the script to `hw.pls`. Leaving the lines in has the advantage that the script will also work in Un*x without any change.

For more information see Chapter 8 [The script interpreter], page 63.

2.3.6 The Ciao initialization file (Un*x)

The Ciao toplevel can be made to execute upon startup a number of commands (such as, e.g., loading certain files or setting certain Ciao flags) contained in an initialization file. This file should be called `.ciaorc` and placed in your *home* directory (e.g., `~`, the same in which the `.emacs` file is put). You may need to set the environment variable `HOME` to the path of this directory for the Ciao toplevel shell to be able to locate this file on startup.

2.3.7 Printing manuals (Un*x)

As mentioned before, the manual is available in several formats in the `reference` directory within the `doc` directory in the Ciao distribution, including `postscript` or `pdf`, which are specially useful for printing. These files are also available in the `DOCDIR` directory specified during installation. Printing can be done using an application such as `ghostview` (freely available from `http://www.cs.wisc.edu/~ghost/index.html`) or `acrobat reader` (`http://www.adobe.com`, only `pdf`).

2.4 An introduction to the Ciao emacs environment (Un*x)

While it is easy to use Ciao with any editor of your choice, using it within the `emacs` editor/program development system is highly recommended: Ciao includes an `emacs` *mode* which provides a very complete *application development environment* which greatly simplifies many program development tasks. See Chapter 10 [Using Ciao inside GNU emacs], page 67 for details on the capabilities of `ciao/ emacs` combination.

If the (freely available) `emacs` editor/environment is not installed in your system, we highly recommend that you also install it at this point (there are instructions for where to find `emacs` and how to install it in the Ciao installation instructions). After having done this you can try for example the following things:

- A few basic things:
  - Typing ⟨^H⟩ ⟨i⟩ (or in the menus `Help->Manuals->Browse Manuals with Info`) should open a list of manuals in info format in which the Ciao manual(s) should appear.
  - When opening a Ciao file, i.e., a file with `.pl` or `.pls` ending, using ⟨^X⟩⟨^F⟩`filename` (or using the menus) the code should appear highlighted according to syntax (e.g., comments in red), and `Ciao/Prolog` menus should appear in the menu bar on top of the `emacs` window.
  - Loading the file using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨l⟩) should start in another emacs buffer the Ciao toplevel shell and load the file. You should now be able to switch the the toplevel shell and make queries from within `emacs`.

  Note: when using `emacs` it is *very convenient* to swap the locations of the (normally not very useful) ⟨Caps Lock⟩ key and the (very useful in `emacs`) ⟨Ctrl⟩ key on the keyboard. How to do this is explained in the `emacs` frequently asked questions FAQs (see the `emacs` download instructions for their location).

  (if these things do not work the system or emacs may not be installed properly).
- You can go to the location of most of the errors that may be reported during compilation by typing ⟨^C⟩ ⟨`⟩.
- You can also, e.g., create executables from the `Ciao/Prolog` menu, as well as compile individual files, or generate active modules.
- Loading a file for source-level debugging using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨d⟩) and then issuing a query should start the source-level debugger and move a marker on the code in a window while execution is stepped through in the window running the Ciao top level.

- You can add the lines needed in Un*x for turning any file defining `main/1` into a script from the Ciao/Prolog menu or by typing ⟨^C⟩ ⟨I⟩ ⟨S⟩.
- You can also work with the preprocessor and auto-documenter directly from emacs: see their manuals or browse through the corresponding menus that appear when editing `.pl` files.

We encourage you once more to read Chapter 10 [Using Ciao inside GNU emacs], page 67 to discover the many other functionalities of this environment.

2.5 Keeping up to date (Un*x)

You may want to read Chapter 231 [Beyond installation], page 1113 for instructions on how to sign up on the Ciao user's mailing list, receive announcements regarding new versions, download new versions, report bugs, etc.

3 Getting started on Windows machines

Author(s): Manuel Hermenegildo.

This part guides you through some very basic first steps with Ciao on an MSWindows ("Win32") system. It assumes that Ciao is already installed correctly on your Windows system. If this is not the case, then follow the instructions in Chapter 230 [Installing Ciao from a Win32 binary distribution], page 1109 (or Chapter 229 [Installing Ciao from the source distribution], page 1099) first.

We start with by describing the basics of using Ciao from the Windows explorer and/or a DOS command shell. We strongly recommend reading also Section 3.3 [An introduction to the Ciao emacs environment (Win32)], page 29 for the basics on using Ciao under `emacs`, which is a much simpler and much more powerful way of developing Ciao programs, and has the advantage of offering an almost identical environment under Windows and Un*x.

3.1 Testing your Ciao Win32 installation

It is a good idea to start by performing some tests to check that Ciao is installed correctly on your system (these are the same tests that you are instructed to do during installation, so you can obviously skip them if you have done them already at that time):

- Ciao-related file types (`.pl` source files, `.cpx` executables, `.itf,.po,.asr` interface files, `.pls` scripts, etc.) should have specific icons associated with them (you can look at the files in the folders in the Ciao distribution to check).
- Double-clicking on the shortcut to `ciaosh(.cpx)` on the desktop should start the typical Prolog-style top-level shell in a window. If this shortcut has not been created on the desktop, then double-clicking on the `ciaosh(.cpx)` icon inside the `shell` folder within the Ciao source folder should have the same effect.
- In the top-level shell, Ciao library modules should load correctly. Type for example `use_module(library(dec10_io)).` at the Ciao top-level prompt –you should get back a prompt with no errors reported.
- To exit the top level shell, type `halt.` as usual, or ⟨^D⟩.

Also, the following documentation-related actions should work:

- Double-clicking on the shortcut to `ciao(.html)` which appears on the desktop should show the Ciao manual in your default WWW browser. If this shortcut has not been created you can double-click on the `ciao(.html)` file in the `doc\reference\ciao_html` folder inside the Ciao source folder. Make sure you configure your browser to use *style sheets* for correct formatting of the manual (note, however, that some older versions of Explorer did not support style sheets well and will give better results turning them off).
- The `doc\reference` folder contains the manual also in the other formats present in the distribution, such as `info` (very convenient for users of the `emacs` editor/program development system) and `postscript` or `pdf`, which are specially useful for printing. See Section 3.2.7 [Printing manuals (Win32)], page 29 for instructions.

3.2 Using Ciao from the Windows explorer and command shell

3.2.1 Starting/exiting the top-level shell (Win32)

The basic methods for starting/exiting the top-level shell have been discussed above. The installation script also leaves a `ciaosh(.bat)` file inside the `shell` folder of the Ciao distribution which can be used to start the top-level shell from the command line in Windows systems.

3.2.2 Getting help (Win32)

The basic methods for accessing the manual on-line have also been discussed above. Use the table of contents and the indices of *predicates*, *libraries*, *concepts*, etc. to find what you are looking for. Context-sensitive help is available within the `emacs` environment (see below).

3.2.3 Compiling and running programs (Win32)

Once the shell is started, you can compile and execute Ciao modules inside the interactive toplevel shell in the standard way. E.g., type `use_module(`*file*`).`, `use_module(library(`*file*`)).` for library modules, `ensure_loaded(`*file*`).` for files which are not modules, and `use_package(`*file*`).` for library packages (these are syntactic/semantic packages that extend the Ciao language in many different ways). Note that the use of `compile/1` and `consult/1` is discouraged in Ciao.

For example, you may want to type `use_package(iso)` to ensure Ciao has loaded all the ISO builtins (whether this is done by default or not depends on your `.ciaorc` file). Do not worry about any "module already in executable" messages –these are normal and simply mean that a certain module is already pre-loaded in the toplevel shell. At this point, typing `write(hello).` should work.

Note that some predicates that may be built-ins in typical Prolog implementations are available through libraries in Ciao. This facilitates making small executables.

To change the working directory to, say, the `examples` directory in the Ciao source directory, first do:

```
?- use_module(library(system)).
```

(loading the `system` library makes a number of system-related predicates such as `cd/1` accessible) and then:

```
?- cd('$/examples').
```

(in Ciao the sequence `$/` *at the beginning of a path name* is replaced by the path of the Ciao root directory).

For more information see Chapter 5 [The interactive top-level shell], page 41.

3.2.4 Generating executables (Win32)

Executables can be generated from the toplevel shell (using `make_exec/2`) or using the standalone compiler (`ciaoc(.cpx)`, located in the `ciaoc` folder). To be able to make an executable, the file should define the predicate `main/1` (or `main/0`), which will be called upon startup (see the corresponding manual section for details).

For example, within the `examples` directory, you can type:

```
?- make_exec(hw,_).
```

which should produce an executable. Double-clicking on this executable should execute it.

Another way of creating Ciao executables from source files is by right-clicking on `.pl` files and choosing "make executable". This uses the standalone compiler (this has the disadvantage, however, that it is sometimes difficult to see the error messages).

For more information see Chapter 5 [The interactive top-level shell], page 41 and Chapter 4 [The stand-alone command-line compiler], page 33.

3.2.5 Running Ciao scripts (Win32)

Double-clicking on files ending in `.pls`, *Ciao scripts*, will also execute them. These are files containing Ciao source but which get executed without having to explicitly compile them (in the same way as, e.g., `.bat` files or programs in scripting languages). As an example, you can double-click on the file `hw.pls` in the `examples` folder and look at the source with an editor. You can try changing the `Hello world` message and double-clicking again (no need to recompile!).

As you can see, the file should define the predicate `main/1` (not `main/0`), which will be called upon startup. The two header lines are only necessary in Un*x. In Windows you can leave them in or you can take them out, but leaving them in has the advantage that the script will also work in Un*x without any change.

For more information see Chapter 8 [The script interpreter], page 63.

3.2.6 The Ciao initialization file (Win32)

The Ciao toplevel can be made to execute upon startup a number of commands (such as, e.g., loading certain files or setting certain Ciao flags) contained in an initialization file. This file should be called `.ciaorc` and placed in your *home* folder (e.g., the same in which the `.emacs` file is put). You may need to set the environment variable `HOME` to the path of this folder for the Ciao toplevel shell to be able to locate this file on startup.

3.2.7 Printing manuals (Win32)

As mentioned before, the manual is available in several formats in the `reference` folder within Ciao's `doc` folder, including `postscript` or `pdf`, which are specially useful for printing. This can be done using an application such as `ghostview` (freely available from `http://www.cs.wisc.edu/~ghost/index.html`) or `acrobat reader` (`http://www.adobe.com`, only `pdf`).

3.3 An introduction to the Ciao emacs environment (Win32)

While it is easy to use Ciao with any editor of your choice, using it within the `emacs` editor/program development system is highly recommended: Ciao includes an `emacs` *mode* which provides a very complete *application development environment* which greatly simplifies many program development tasks. See Chapter 10 [Using Ciao inside GNU emacs], page 67 for details on the capabilities of `ciao/ emacs` combination.

If the (freely available) `emacs` editor/environment is not installed in your system, we highly recommend that you also install it at this point (there are instructions for where to find `emacs` and how to install it in the Ciao installation instructions). After having done this you can try for example the following things:

- A few basic things:
  - Typing ⟨^H⟩ ⟨i⟩ (or in the menus `Help->Manuals->Browse Manuals with Info`) should open a list of manuals in info format in which the Ciao manual(s) should appear.
  - When opening a Ciao file, i.e., a file with `.pl` or `.pls` ending, using ⟨^X⟩⟨^F⟩`filename` (or using the menus) the code should appear highlighted according to syntax (e.g., comments in red), and `Ciao/Prolog` menus should appear in the menu bar on top of the `emacs` window.
  - Loading the file using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨l⟩) should start in another emacs buffer the Ciao toplevel shell and load the file. You should now be able to switch the the toplevel shell and make queries from within `emacs`.

Note: when using `emacs` it is *very convenient* to swap the locations of the (normally not very useful) ⟨Caps Lock⟩ key and the (very useful in `emacs`) ⟨Ctrl⟩ key on the keyboard. How to do this is explained in the `emacs` frequently asked questions FAQs (see the `emacs` download instructions for their location).

(if these things do not work the system or emacs may not be installed properly).

- You can go to the location of most of the errors that may be reported during compilation by typing ⟨^C⟩ ⟨`⟩.
- You can also, e.g., create executables from the `Ciao/Prolog` menu, as well as compile individual files, or generate active modules.
- Loading a file for source-level debugging using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨d⟩) and then issuing a query should start the source-level debugger and move a marker on the code in a window while execution is stepped through in the window running the Ciao top level.
- You can add the lines needed in Un*x for turning any file defining `main/1` into a script from the Ciao/Prolog menu or by typing ⟨^C⟩ ⟨I⟩ ⟨S⟩.
- You can also work with the preprocessor and auto-documenter directly from emacs: see their manuals or browse through the corresponding menus that appear when editing `.pl` files.

We encourage you once more to read Chapter 10 [Using Ciao inside GNU emacs], page 67 to discover the many other functionalities of this environment.

3.4 Keeping up to date (Win32)

You may want to read Chapter 231 [Beyond installation], page 1113 for instructions on how to sign up on the Ciao user's mailing list, receive announcements regarding new versions, download new versions, report bugs, etc.

PART I - The program development environment

Author(s): The CLIP Group.

This part documents the components of the basic Ciao program development environment. They include:

ciaoc: the standalone compiler, which creates executables without having to enter the interactive top-level.

ciaosh: (also invoked simply as `ciao`) is an interactive top-level shell, similar to the one found on most Prolog systems (with some enhancements).

debugger.pl: a Byrd box-type debugger, similar to the one found on most Prolog systems (also with some enhancements, such as source-level debugging). This is not a standalone application, but is rather included in `ciaosh`, as is done in other systems supporting the Prolog language. However, it is also *embeddable*, in the sense that it can be included as a library in executables, and activated dynamically and conditionally while such executables are running.

ciao-shell: an interpreter/compiler for *Ciao scripts* (i.e., files containing Ciao code which run without needing explicit compilation).

ciao.el: a *complete program development enviroment*, based on GNU emacs, with syntax coloring, direct access to all the tools described above (as well as the preprocessor and the documenter), atomatic location of errors, source-level debugging, context-sensitive access to on-line help/manuals, etc. The use of this environment is *very highly recommended*!

The Ciao program development environment also includes `ciaopp`, the preprocessor, and `lpdoc`, the documentation generator, which are described in separate manuals.

4 The stand-alone command-line compiler

Author(s): Daniel Cabeza, Edison Mera, The CLIP Group.

`ciaoc` [CH00b] is the Ciao stand-alone command-line compiler. `ciaoc` can be used to create executables or to compile individual files to object code (to be later linked with other files). `ciaoc` is specially useful when working from the command line. Also, it can be called to compile Ciao programs from other tools such as, e.g., shell scripts, `Makefile`s, or project files. All the capabilities of `ciaoc` are also available from the interactive top-level shell, which uses the ciaoc modules as its components.

4.1 Introduction to building executables

An *executable* can be built from a single file or from a collection of inter-related files. In the case of only one file, this file must define the predicate `main/0` or `main/1`. This predicate is the one which will be called when the executable is started. As an example, consider the following file, called `hello.pl`:

```
main :-
     write('Hello world'),
     nl.
```

To compile it from the command line using the `ciaoc` standalone compiler it suffices to type "`ciaoc hello`" (in Win32 you may have to put the complete path to the `ciaoc` folder of the Ciao distribution, where the installation process leaves a `ciaoc.bat` file):

```
/herme@clip:/tmp
[60]> ciaoc hello

/herme@clip:/tmp
[61]>
```

This produces an executable called `hello` in Un*x-like systems and `hello.cpx` under Win32 systems. This executable can then be run in Win32 by double-clicking on it and on Un*x systems by simply typing its name (see for Section 4.3 [Running executables from the command line], page 34 for how to run executables from the command line in Win32):

```
/herme@clip:/tmp
[61]> hello
Hello world
```

If the application is composed of several files the process is identical. Assume `hello.pl` is now:

```
:- use_module(aux, [p/1]).

main :-
     p(X),
     write(X),
     nl.
```

where the file `aux.pl` contains:

```
:- module(aux,[p/1]).

p('Hello world').
```

This can again be compiled using the `ciaoc` standalone compiler as before:

```
/herme@clip:/tmp
[60]> ciaoc hello

/herme@clip:/tmp
[61]> hello
Hello world
```

The invocation of `ciaoc hello` compiles the file `hello.pl` and all connected files that may need recompilation – in this case the file `aux.pl`. Also, if any library files used had not been compiled previously they would be compiled at this point (See Section 4.6 [Intermediate files in the compilation process], page 37). Also, if, say, `hello.pl` is changed and recompiled, the object code resulting from the previous compilation of `aux.pl` will be reused. This is all done without any need for `Makefile`s, and considerably accelerates the development process for large applications. This process can be observed by selecting the `-v` option when invoking `ciaoc` (which is equivalent to setting the `verbose_compilation` Prolog flag to `on` in the top-level interpreter).

If `main/1` is defined instead of `main/0` then when the executable is started the argument of `main/1` will be instantiated to a list of atoms, each one of them corresponding to a command line option. Consider the file `say.pl`:

```
main(Argv) :-
     write_list(Argv), nl.

write_list([]).
write_list([Arg|Args]) :-
     write(Arg),
     write(' '),
     write_list(Args).
```

Compiling this program and running it results in the following output:

```
/herme@clip:/tmp
[91]> ciaoc say

/herme@clip:/tmp
[91]> say hello dolly
hello dolly
```

The name of the generated executable can be controlled with the `-o` option (See Section 4.7 [Usage (ciaoc)], page 38).

4.2 Paths used by the compiler during compilation

The compiler will look for files mentioned in commands such as `use_module/1` or `ensure_loaded/1` in the current directory. Other paths can be added by including them in a file whose name is given to `ciaoc` using the `-u` option. This file should contain facts of the predicates `file_search_path/2` and `library_directory/1` (see the documentation for these predicates and also Chapter 9 [Customizing library paths and path aliases], page 65 for details).

4.3 Running executables from the command line

As mentioned before, what the `ciaoc` compiler generates and how it is started varies somewhat from OS to OS. In general, the product of compiling an application with `ciaoc` is a file that contains the bytecode (the product of the compilation) and invokes the Ciao engine on it.

- Un Un*x this is a *script* (see the first lines of the file) which invokes the ciao engine on this file. To run the generated executable from a Un*x shell, or from the `bash` shell that comes with the Cygwin libraries (see Section 229.6 [Installation and compilation under Windows], page 1105) it suffices to type its name at the shell command line, as in the examples above.
- In a Win32 system, the compiler produces a similar file with a `.cpx` ending. The Ciao installation process typically makes sure that the Windows registry contains the right entries so that this executable will run upon double-cliking on it.

  In you want to run the executable from the command line an additional `.bat` file is typically needed. To help in doing this, the Win32 installation process creates a `.bat` skeleton file called `bat_skel` in the `Win32` folder of the distribution) which allows running Ciao executables from the command line. If you want to run a Ciao executable `file.cpx` from the command line, you normally copy the skeleton file to the folder were the executable is and rename it to `file.bat`, then change its contents as explained in a comment inside the file itself.

  Note that this `.bat` file is usually not necessary in NT, as its command shell understands file extension associations. I.e., in windows NT it is possible to run the `file.cpx` executable directly. Due to limitations of `.bat` files in Windows 95/98, in those OSs no more than 9 command line arguments can be passed to the executable (in NT there is no such restriction).

  Finally, in a system in which Cygnus Win32 is installed executables can also be used directly from the `bash` shell command line, without any associated `.bat` files, by simply typing their name at the `bash` shell command line, in the same way as in Un*x. This only requires that the `bash` shell which comes with Cygnus Win32 be installed and accessible: simply, make sure that `/bin/sh.exe` exists.

Except for a couple of header lines, the contents of executables are almost identical under different OSs (except for self-contained ones). The bytecode they contain is architecture-independent. In fact, it is possible to create an executable under Un*x and run it on Windows or viceversa, by making only minor modifications (e.g., creating the `.bat` file and/or setting environment variables or editing the start of the file to point to the correct engine location).

4.4 Types of executables generated

While the default options used by `ciaoc` are sufficient for normal use, by selecting other options `ciaoc` can generate several different types of executables, which offer interesting tradeoffs among size of the generated executable, portability, and startup time [CH00b]:

Dynamic executables:

`ciaoc` produces by default *dynamic* executables. In this case the executable produced is a platform-independent file which includes in compiled form all the user defined files. On the other hand, any system libraries used by the application are loaded dynamically at startup. More precisely, any files that appear as `library(...)` in `use_module/1` and `ensure_loaded/1` declarations will not be included explicitly in the executable and will instead be loaded dynamically. Is is also possible to mark other path aliases (see the documentation for `file_search_path/2`) for dynamic loading by using the `-d` option. Files accessed through such aliases will also be loaded dynamically.

Dynamic loading allows making smaller executables. Such executables may be used directly in the same machine in which they were compiled, since suitable paths to the location of the libraries will be included as default in the executable by `ciaoc` during compilation.

The executable can also be used in another machine, even if the architecture and OS are different. The requirement is that the Ciao libraries (which will also include the appropriate Ciao engine for that architecture and OS) be installed in the target

machine, and that the `CIAOLIB` and `CIAOENGINE` environment variables are set appropriately for the executable to be able to find them (see Section 4.5 [Environment variables used by Ciao executables], page 37). How to do this differs slightly from OS to OS.

Static executables:

Selecting the `-s` option `ciaoc` produces a *static* executable. In this case the executable produced (again a platform-independent file) will include in it all the auxiliary files and any system libraries needed by the application. Thus, such an executable is almost complete, needing in order to run only the Ciao engine, which is platform-specific.[1] Again, if the executable is run in the same machine in which it was compiled then the engine is found automatically. If the executable is moved to another machine, the executable only needs access to a suitable engine (which can be done by setting the `CIAOENGINE` environment variable to point to this engine).

This type of compilation produces larger executables, but has the advantage that these executables can be installed and run in a different machine, with different architecture and OS, even if Ciao is not installed on that machine. To install (or distribute) such an executable, one only needs to copy the executable file itself and the appropriate engine for the target platform (See Chapter 229 [Installing Ciao from the source distribution], page 1099 or Chapter 230 [Installing Ciao from a Win32 binary distribution], page 1109 and Section 229.5 [Multiarchitecture support], page 1104), and to set things so that the executable can find the engine.[2]

Dynamic executables, with lazy loading:

Selecting the `-l` option is very similar to the case of dynamic executables above, except that the code in the library modules is not loaded when the program is started but rather it is done during execution, the first time a predicate defined in that file is called. This is advantageous if a large application is composed of many parts but is such that typically only some of the parts are used in each invocation. The Ciao preprocessor, `ciaopp`, is a good example of this: it has many capabilitites but typically only some of them are used in a given session. An executable with lazy load has the advantage that it starts fast, loading a minimal functionality on startup, and then loads the different modules automatically as needed.

Self-contained executables:

Self-contained executables are static executables (i.e., this option also implies *static* compilation) which include a Ciao engine along with the bytecode, so they do not depend on an external one for their execution. This is useful to create executables which run even if the machine where the program is to be executed does not have a Ciao engine installed and/or libraries. The disadvantage is that such execuatbles are platform-dependent (as well as larger than those that simply use an external library). This type of compilation is selected with the `-S` option. Cross-compilation is also possible with the `-SS` option, so you can specify the target OS and architecture (e.g.

[1] Currently there is an exception to this related to libraries which are written in languages other than Prolog, as, e.g., C. C files are currently always compiled to dynamically loadable object files (`.so` files), and they thus need to be included manually in a distribution of an application. This will be automated in upcoming versions of the Ciao system.

[2] It is also possible to produce real standalone executables, i.e., executables that do not need to have an engine around. However, this is not automated yet, although it is planned for an upcoming version of the compiler. In particular, the compiler can generate a `.c` file for each `.pl` file. Then all the `.c` files can be compiled together into a real executable (the engine is added one more element during link time) producing a complete executable for a given architecture. The downside of course is that such an executable will not be portable to other architectures without recompilation.

LINUXi86). To be able to use the latter option, it is necessary to have installed a ciaoengine for the target machine in the Ciao library (this requires compiling the engine in that OS/architecture and installing it, so that it is available in the library).

Compressed executables:
: In *compressed* executables the bytecode is compressed. This allows producing smaller executables, at the cost of a slightly slower startup time. This is selected with the `-z` option. You can also produce compressed libraries if you use `-zl` along with the `-c` option. If you select `-zl` while generating an executable, any library which is compiled to accomplish this will be also compressed.

Active modules:
: The compiler can also compile (via the `-a` option) a given file into an *active module* (see Chapter 109 [Active modules (high-level distributed execution)], page 583 for a description of this).

4.5 Environment variables used by Ciao executables

The executables generated by the Ciao compiler (including the ciao development tools themselves) locate automatically where the Ciao engine and libraries have been installed, since those paths are stored as defaults in the engine and compiler at installation time. Thus, there is no need for setting any environment variables in order to *run* Ciao executables (on a single architecture – see Section 229.5 [Multiarchitecture support], page 1104 for running on multiple architectures).

However, the default paths can be overridden by using the environment variables `CIAOENGINE` and `CIAOLIB`. The first one will tell the Ciao executables where to look for an engine, and the second will tell them where to look for the libraries. Thus, it is possible to actually use the Ciao system without installing it by setting these variables to the following values:

- `CIAOENGINE: $(CIAOSRC)/build/bin/$(CIAOARCH)/ciaoengine`
- `CIAOLIB: $(CIAOSRC)`

where `$(CIAOARCH)` is the string echoed by the command `CIAOSRC/etc/ciao_get_arch` (or `BINROOT/ciao_get_arch`, after installation).

This allows using alternate engines or libraries, which can be very useful for system development and experimentation.

4.6 Intermediate files in the compilation process

Compiling an individual source (i.e., `.pl`) file produces a `.itf` file and a `.po` file. The `.itf` file contains information of the *modular interface* of the file, such as information on exported and imported predicates and on the other modules used by this module. This information is used to know if a given file should be recompiled at a given point in time and also to be able to detect more errors statically including undefined predicates, mismatches on predicate charaterictics across modules, etc. The `.po` file contains the platform-independent object code for a file, ready for linking (statically or dynamically).

It is also possible to use `ciaoc` to explicitly generate the `.po` file for one or more `.pl` files by using the `-c` option.

If you want to view the wam instructions of one or more `.pl` files you can use the `-w` option. That will generate a `.wam` file with such instructions in a pretty format per each `.pl` file.

4.7 Usage (ciaoc)

The following provides details on the different command line options available when invoking `ciaoc`:

```
ciaoc <MiscOpts> <ExecOpts> [-o <execname>] <file> ...

  Make an executable from the listed files.  If there is
  more than one file, they must be non-module, and the
  first one must include the main predicate.  The -o
  option allows generating an arbitrary executable name.

ciaoc <MiscOpts> <ExecOpts> -a <publishmod> <module>

  Make an active module executable from <module> with
  address publish module <publishmod>.

ciaoc <MiscOpts> -c  <file> ...

  Compile listed files (make .po objects).

ciaoc <MiscOpts> -w  <file> ...

  Generate WAM code of listed files (in .wam files).

<MiscOpts> can be: [-v] [-ri] [-u <file>]  [-rc] [-op <suffix>] [-L <LibDir>]

<ExecOpts> can be: [-s|-S|-SS <target>|-z|-zl|-e|-l|(-ll <module>)*]
                   (-d <alias>)* [-x]

default extension for files is '.pl'

-h, --help
Show this help.
-u use <file> for compilation, often used to include LibDir paths, etc.
-op use <suffix> as the suffix for optimized (or otherwise tuned) code
-L look for libraries also in the <LibDir> directory
-c Compile listed files (make .po objects)
-w Generate WAM code of listed files (in .wam files).
-S
make standalone executable for the current OS and architecture, implies -s
-SS make standalone executable for <target> OS and architecture
valid <target> values may be: LINUXi86, SolarisSparc..., implies -s
-ll force <module> to be loaded lazily,  implies -l
-ac All the modules will be compiled using <Packages>
-acm <Modules> will be compiled using <Packages>
-d files using this path alias are dynamic (default: library)
-o Make an executable from the listed files.
-a Make an active module
-v, --verbose-compilation
verbose mode
```

```
-ri, --itf-format-r
Generate human readable .itf files
-x, --check-libraries
extended recompilation: only useful for Ciao standard library developers
-s, --executables-static
make a static executable (otherwise dynamic files are not included)
-z, --compress-exec
Generate executables with compressed bytecode
-zl, --compress-lib
generate libraries with compressed bytecode - any library (re)compiled as
consequence of normal executable compilation will also be affected
-l, --executables-lazyload
Idem with lazy load of dynamic files (except insecure cases)
-np, --use-compile-packages-no
Do not use compile packages
-na, --read-assertions-no
Do not read the assertions in the code
-rc, --runtime-checks
Generate code with runtime checks, requires to read assertions
--rtchecks-trust-no
Disable rtchecks for trust assertions
--rtchecks-entry-no
Disable rtchecks for entry assertions
--rtchecks-exit-no
Disable rtchecks for exit assertions
--rtchecks-test
enable rtchecks for test assertions. Used for debugging
purposes, but is better to use the unittest library
--rtchecks-level-exports
Use rtchecks only for external calls of the exported predicates
--rtchecks-inline
Expand library predicates inline as far as possible
--rtchecks-asrloc-no
Do not use assertion locators in the error messages
--rtchecks-predloc-no
Do not use predicate locators in the error messages
--rtchecks-namefmt-short
Show the name of predicates and properties in a reduced format
--rtchecks-callloc-no
Do not show the stack of predicates that caused the failure
--rtchecks-callloc-literal
Show the stack of predicates that caused the failure. Instrument it
in the literal. This mode provides more information, because reports
also the literal in the body of the predicate
--unused-pred-warnings
Show warnings about unused predicates.  Note that a predicate is
being used if it is exported, it appears in clause body of a
predicate being used, in a multifile predicate, in a predicate
used in :- initialization(...) or :- on_abort(...)
declarations, or if it is the meta-argument of a metapredicate.
```

4.8 Known bugs and planned improvements (`ciaoc`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.
- Also if appears in the body of an assertion referred to a predicate being used, but that is not implemented, because the assertion reader is not included in the compiler yet – EMM.

5 The interactive top-level shell

Author(s): Daniel Cabeza, The CLIP Group.

`ciaosh` is the Ciao interactive top-level shell. It provides the user with an interactive programming environment with tools for incrementally building programs, debugging programs by following their executions, and modifying parts of programs without having to start again from scratch. If available, it is strongly recommended to use it with the emacs interface provided, as it greatly simplifies the operation. This chapter documents general operation in the shell itself.

5.1 Shell invocation and startup

When invoked, the shell responds with a message of identification and the prompt `?-` as soon as it is ready to accept input, thus:

```
Ciao-Prolog X.Y #PP: Thu Mar 25 17:20:55 MET 1999
?-
```

When the shell is initialized it looks for a file `.ciaorc` in the HOME directory and makes an `include` of it, if it exists. This file is useful for including `use_module/1` declarations for the modules one wants to be loaded by default, changing prolog flags, etc. (Note that the `.ciaorc` file can only contain directives, not actual code; to load some code at startup put it in a separate file and load it using e.g. a `use_module/1` declaration.) If the initialization file does not exist, the default package `default_for_ciaosh` is included, to provide more or less what other prologs define by default. Thus, if you want to have available all builtins you had before adding the initialization file, you have to include `:- use_package(default_for_ciaosh)` in it. Two command-line options control the loading of the initialization file:

`-f` Fast start, do not load any initialization file.

`-l File` Look for initialization file `File` instead of `~/.ciaorc`. If it does not exist, include the default package.

5.2 Shell interaction

After the shell outputs the prompt, it is expecting either an internal command (see the following sections) or a *query* (a goal or sequence of goals). When typing in the input, which must be a valid prolog term, if the term does not end in the first line, subsequent lines are indented. For example:

```
?- X =
   f(a,
   b).

X = f(a,b) ?

yes
?-
```

The queries are executed by the shell as if they appeared in the user module. Thus, in addition to builtin predicates, predicates available to be executed directly are all predicates defined by loaded user files (files with no module declaration), and imported predicates from modules by the use of `use_module`.

The possible answers of the shell, after executing an internal command or query, are:

- If the execution failed (or produced an error), the answer is `no`.

- If the execution was successful and bindings where made (or constraints where imposed) on answer variables, then the shell outputs the values of answer variables, as a sequence of bindings (or constraints), and then prints a `?` as a prompt. At this point it is expecting an input line from the user. By entering a carriage-return (⟨RET⟩) or any line starting with `y`, the query terminates and the shell answer `yes`. Entering a '`,`' the shell enters a recursive level (see below). Finally, any other answer forces the system to backtrack and look for the next solution (answering as with the first solution).
- If the execution was successful, but no answer variable was bound or constrained, the answer is simply `yes`. This behavior can be changed by setting the prolog flag `prompt_alternatives_no_bindings` to `on`, so that if there are more solutions the user will be consulted as explained in the previous point (useful if the solutions produce side effects).

To allow using connection variables in queries without having to report their results, variables whose name starts with `_` are not considered in answers, the rest being the *answer variables*. This example illustrates the previous points:

```
?- member(a, [b, c]).

no
?- member(a, [a, b]).

yes
?- member(X, [a|L]).

X = a ? ;

L = [X|_] ?

yes
?- atom_codes(ciao, _C), member(L, _C).

L = 99 ? ;

L = 105 ? ;

L = 97 ? ;

L = 111 ? ;

no
?-
```

5.3 Entering recursive (conjunctive) shell levels

As stated before, when the user answers with '`,`' after a solution is presented, the shell enters a *recursive level*, changing its prompt to N `?-` (where N is the recursion level) and keeping the bindings or constraints of the solution (this is inspired by the *LogIn* language developed by H. Ait-Kaci, P. Lincoln and Roger Nasr [AKNL86]). Thus, the following queries will be executed within that context, and all variables in the lower level solutions will be reported in subsequent solutions at this level. To exit a recursive level, input an ⟨EOF⟩ character or the command `up`. The last solution after entering the level is repeated, to allow asking for more solutions. Use command `top` to exit all recursive levels and return to the top level. Example interaction:

```
?- directory_files('.',_Fs), member(F,_Fs).
```

```
F = 'file_utils.po' ? ,

1 ?- file_property(F, mod_time(T)).

F = 'file_utils.po',
T = 923497679 ?

yes
1 ?- up.

F = 'file_utils.po' ? ;

F = 'file_utils.pl' ? ;

F = 'file_utils.itf' ? ,

1 ?- file_property(F, mod_time(T)).

F = 'file_utils.itf',
T = 923497679 ?

yes
1 ?- ^D
F = 'file_utils.itf' ?

yes
?-
```

5.4 Usage and interface (`toplevel_doc`)

- **Library usage:**
  The following predicates can be used at the top-level shell natively (but see also the commands available in Chapter 6 [The interactive debugger], page 49 which are also available within the top-level shell).
- **Exports:**
  - *Predicates:*
    `use_module/1`, `use_module/2`, `ensure_loaded/1`, `make_exec/2`, `include/1`, `use_package/1`, `consult/1`, `compile/1`, `./2`, `make_po/1`, `unload/1`, `set_debug_mode/1`, `set_nodebug_mode/1`, `make_actmod/2`, `force_lazy/1`, `undo_force_lazy/1`, `dynamic_search_path/1`, `multifile/1`.
- **Other modules used:**
  - *System library modules:*
    `toplevel/toplevel`, `libpaths`, `compiler/compiler`, `compiler/exemaker`, `compiler/c_itf`, `debugger/debugger`.

5.5 Documentation on exports (`toplevel_doc`)

use_module/1: PREDICATE

Usage: `use_module(Module)`

- *Description:* Load into the top-level the module defined in `Module`, importing all the predicates it exports.
- *The following properties should hold at call time:*

  `Module` is a source name. (streams_basic:sourcename/1)

use_module/2: PREDICATE

Usage: `use_module(Module,Imports)`

- *Description:* Load into the top-level the module defined in `Module`, importing the predicates in `Imports`.
- *The following properties should hold at call time:*

  `Module` is a source name. (streams_basic:sourcename/1)

  `Imports` is a list of `prednames`. (basic_props:list/2)

ensure_loaded/1: PREDICATE

Usage: `ensure_loaded(File)`

- *Description:* Load into the top-level the code residing in file (or files) `File`, which is user (i.e. non-module) code.
- *The following properties should hold at call time:*

  `File` is a source name or a list of source names. (toplevel_doc:sourcenames/1)

make_exec/2: PREDICATE

Usage: `make_exec(File,ExecName)`

- *Description:* Make a Ciao executable from file (or files) `File`, giving it name `ExecName`. If `ExecName` is a variable, the compiler will choose a default name for the executable and will bind the variable `ExecName` to that name. The name is chosen as follows: if the main prolog file has no `.pl` extension or we are in Windows, the executable will have extension `.cpx`; else the executable will be named as the main prolog file without extension.
- *The following properties should hold at call time:*

  `File` is a source name or a list of source names. (toplevel_doc:sourcenames/1)
- *The following properties hold upon exit:*

  `ExecName` is an atom. (basic_props:atm/1)

include/1: PREDICATE

Usage: `include(File)`

- *Description:* The contents of the file `File` are included in the top-level shell. For the moment, it only works with some directives, which are interpreted by the shell, or with normal clauses (which are asserted), if library(dynamic) is loaded beforehand.
- *The following properties should hold at call time:*

  `File` is a source name. (streams_basic:sourcename/1)

use_package/1: PREDICATE

Usage: `use_package(Package)`

- *Description:* Include the package or packages specified in `Package`. Most package contents can be handled in the top level, but there are currently still some limitations.
- *The following properties should hold at call time:*

  `Package` is a source name or a list of source names. (toplevel_doc:sourcenames/1)

consult/1: PREDICATE

Usage: `consult(File)`

- *Description:* Provided for backward compatibility. Similar to `ensure_loaded/1`, but ensuring each listed file is loaded in consult mode (see Chapter 6 [The interactive debugger], page 49).
- *The following properties should hold at call time:*

  `File` is a source name or a list of source names. (toplevel_doc:sourcenames/1)

compile/1: PREDICATE

Usage: `compile(File)`

- *Description:* Provided for backward compatibility. Similar to `ensure_loaded/1`, but ensuring each listed file is loaded in compile mode (see Chapter 6 [The interactive debugger], page 49).
- *The following properties should hold at call time:*

  `File` is a source name or a list of source names. (toplevel_doc:sourcenames/1)

./2: PREDICATE

Usage: `[File|Files]`

- *Description:* Provided for backward compatibility, obsoleted by `ensure_loaded/1`.
- *The following properties should hold at call time:*

  `File` is a source name. (streams_basic:sourcename/1)

  `Files` is a list of `sourcenames`. (basic_props:list/2)

make_po/1: PREDICATE

Usage: `make_po(Files)`

- *Description:* Make object (`.po`) files from `Files`. Equivalent to executing `"ciaoc -c"` on the files.
- *The following properties should hold at call time:*

  `Files` is a source name or a list of source names. (toplevel_doc:sourcenames/1)

unload/1: PREDICATE

Usage: `unload(File)`

- *Description:* Unloads dynamically loaded file `File`.
- *The following properties should hold at call time:*

  `File` is a source name. (streams_basic:sourcename/1)

set_debug_mode/1: PREDICATE

Usage: `set_debug_mode(File)`

- *Description:* Set the loading mode of `File` to *consult*. See Chapter 6 [The interactive debugger], page 49.
- *The following properties should hold at call time:*

  `File` is a source name. (streams_basic:sourcename/1)

set_nodebug_mode/1: PREDICATE

Usage: `set_nodebug_mode(File)`

- *Description:* Set the loading mode of `File` to *compile*. See Chapter 6 [The interactive debugger], page 49.
- *The following properties should hold at call time:*

  `File` is a source name. (streams_basic:sourcename/1)

make_actmod/2: PREDICATE

Usage: `make_actmod(ModuleFile,PublishMod)`

- *Description:* Make an active module executable from the module residing in `ModuleFile`, using address publish module of name `PublishMod` (which needs to be in the library paths).
- *The following properties should hold at call time:*

  `ModuleFile` is a source name. (streams_basic:sourcename/1)

  `PublishMod` is an atom. (basic_props:atm/1)

force_lazy/1: PREDICATE

Usage: `force_lazy(Module)`

- *Description:* Force module of name `Module` to be loaded lazily in the subsequent created executables.
- *The following properties should hold at call time:*

  `Module` is an atom. (basic_props:atm/1)

undo_force_lazy/1: PREDICATE

Usage: `undo_force_lazy(Module)`

- *Description:* Disable a previous `force_lazy/1` on module `Module` (or, if it is uninstantiated, all previous `force_lazy/1`).
- *Calls should, and exit will be compatible with:*

  `Module` is an atom. (basic_props:atm/1)

dynamic_search_path/1: PREDICATE

Usage: `dynamic_search_path(Name)`

- *Description:* Asserting a fact to this data predicate, files using path alias `Name` will be treated as dynamic in the subsequent created executables.
- *The following properties should hold at call time:*

  `Name` is an atom. (basic_props:atm/1)

multifile/1: PREDICATE

Usage: `multifile Pred`

- *Description:* Dynamically declare predicate `Pred` as multifile. This is useful at the top-level shell to be able to call multifile predicates of loaded files.
- *The following properties should hold at call time:*

  `Pred` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

5.6 Documentation on internals (`toplevel_doc`)

sourcenames/1: PROPERTY

Is defined as follows:

```
sourcenames(File) :-
        sourcename(File).
sourcenames(Files) :-
        list(Files,sourcename).
```

See `sourcename/1` in Chapter 21 [Basic file/stream handling], page 159

Usage: `sourcenames(Files)`

- *Description:* `Files` is a source name or a list of source names.

6 The interactive debugger

Author(s): Daniel Cabeza, Manuel C. Rodriguez, Edison Mera, A. Ciepielewski (first version), Mats Carlsson (first version), T. Chikayama (first version), K. Shen (first version).

The Ciao program development environment includes a number of advanced debugging tools, such as a source-level debugger, the `ciaopp` preprocessor, and some execution visualizers. Herein we discuss the interactive debugger available in the standard top-level, which allows tracing the control flow of programs, in a similar way to other popular Prolog systems. This is a classical Byrd *box-type debugger* [Byr80,BBP81], with some enhancements, most notably being able to track the execution on the source program.

We also discuss the embedded debugger, which is a version of the debugger which can be embedded into executables. It allows triggering an interactive debugging session at any time while running an executable, without any need for the top-level shell.

Byrd's Procedure Box model of debugging execution provides a simple way of visualising control flow, including backtracking. Control flow is in principle viewed at the predicate level, rather than at the level of individual clauses. The Ciao debugger has the ability to mark selected modules and/or files for debugging (traditional and source debugging), rather than having to exhaustively trace the program. It also allows to selectively set spy-points and breakpoints. Spy-points allow the programmer to nominate interesting predicates at which program execution is to pause so that the programmer can interact with the debugger. Breakpoints are similar to spy-points, but allow pausing at a specific line in the code, corresponding to a particular literal. There is a wide choice of control and information options available during debugging interaction.

Note: While the debugger described herein can be used in a standalone way (i.e., from an operating system shell or terminal window) in the same way as other Prolog debuggers, the most convenient way of debugging Ciao programs is by using the programming environment (see Chapter 10 [Using Ciao inside GNU emacs], page 67). This environment has many debugging-related facilities, including displaying the source code for the module(s) corresponding to the procedure being executed, and higlighting dynamically the code segments corresponding to the different execution steps.

6.1 Marking modules and files for debugging in the top-level debugger

The Ciao debugger is module-based. This allows skipping during the debugging process all files (including system library files) except those in which a bug is suspected. This saves having to explictily and repetitively skip predicates in unrelated files during the debugging process. Also, there is an efficieny advantage: in order to be able to run the debugger on a module, it must be loaded in *debug (interpreted) mode*, which will execute slower than normal (compiled) modules. Thus, it is interesting to compile in debug mode only those modules that need to be traced. Instead of doing this (loading of modules in one mode or another) by hand each time, in Ciao (re)loading of modules in the appropriate mode is handled automatically by the Ciao compiler. However, this requires the user to *mark explicitly* the modules in which debugging is to be performed. The simplest way of achieving this is by executing in the Ciao shell prompt, for each suspicious module `Module` in the program, the command:

```
?- debug_module(Module).
```

or, alternatively:

```
?- debug_module_source(Module).
```

which in addition instructs the debugger to keep track of the line numbers in the source file and to report them during debugging. This is most useful when running the top-level inside the `emacs` editor since in that case the Ciao emacs mode allows performing full source-level debugging in each module marked as above, i.e., the source lines being executed will be highlighted dynamically during debugging in a window showing the source code of the module.

Note that, since all files with no module declaration belong to the pseudo-module `user`, the command to be issued for debugging a user file, say `foo.pl`, is `debug_module(user)` or `debug_module_source(user)`, and not `debug_module(foo)`.

The two ways of performing source-level debugging are fully compatible between them, i.e., Ciao allows having some modules loaded with `debug_module/1` and others with `debug_module_source/1`. To change from one interpreted mode to the other mode it suffices to select the module with the new interpreted mode (debugger mode), using the appropiate command, and reload the module.

The commands above perform in fact two related actions: first, they let the compiler know that if a file containing a module with this name is loaded, it should be loaded in interpreted mode (source or traditional). In addition, they instruct the debugger to actually prepare for debugging the code belonging to that module. After that, the modules which are to be debugged have to be (re)loaded so that they are compiled or loaded for interpretation in the appropriate way. The nice thing is that, due to the modular behaviour of the compiler/top-level, if the modules are part of a bigger application, it suffices to load the main module of the application, since this will automatically force the dependent modules which have changed to be loaded in the appropriate way, including those whose *loading mode* has changed (i.e., changing the loading mode has the effect of forcing the required re-loading of the module at the appropriate time).

Later in the debugging process, as the bug location is isolated, typically one will want to restrict more and more the modules where debugging takes place. To this end, and without the need for reloading, one can tell the debugger to not consider a module for debugging issuing a `nodebug_module/1` command, which counteracts a `debug_module/1` or `debug_module_source/1` command with the same module name, and reloading it (or the main file).

There are also two top-level commands `set_debug_mode/1` and `set_nodebug_mode/1`, which accept as argument a file spec (i.e., `library(foo)` or `foo`, even if it is a user file) to be able to load a file in interpreted mode without changing the set of modules that the debugger will try to spy.

6.2 The debugging process

Once modules or user files are marked for debugging and reloaded, the traditional debugging shell commands can be used (the documentation of the `debugger` library following this chapter contains all the commands and their description), with the same meaning as in other classical Prolog systems. The differences in their behavior are:

- Debugging takes place only in the modules in which it was activated,
- `nospy/1` and `spy/1` accept sequences of predicate specs, and they will search for those predicates only in the modules marked for debugging (traditional or source-level debugging).
- `breakpt/6` and `nobreakpt/6` allow setting breakpoints at selected clause literals and will search for those literals only in the modules marked for source-level debugging (modules marked with `debug_module_source/1`).

In particular, the system is initially in nodebug mode, in which no tracing is performed. The system can be put in debug mode by a call to `debug/0` in which execution of queries will proceed until the first *spy-point* or *breakpoint*. Alternatively, the system can be put in trace mode by a call to `trace/0` in which all predicates will be trace.

6.3 Marking modules and files for debugging with the embedded debugger

The embedded debugger, as the interpreted debugger, has three different modes of operation: debug, trace or nodebug. These debugger modes can be set by adding *one* of the following package declarations to the module:

```
:- use_package(debug).
:- use_package(trace).
:- use_package(nodebug).
```

and recompiling the application. These declarations *must* appear the last ones of all `use_package` declarations used. Also it is possible, as usual, to add the debugging package(s) in the module declaration using the third argument of the `module/3` declaration (and they should also be the last ones in the list), i.e., using one of:

```
:- module(..., ..., [..., debug]).
:- module(..., ..., [..., trace]).
:- module(..., ..., [..., nodebug]).
```

The nodebug mode allows turning off any debugging (and also the corresponding overhead) but keeping the spy-points and breakpoints in the code. The trace mode will start the debugger for any predicate in the file.

The embedded debugger has limitations over the interpreted debugger. The most important is that the "retry" option is not available. But it is possible to add, and remove, spy-points and breakpoins using the predicates `spy/1`, `nospy/1`, `breakpt/6` and `nobreakpt/6`, etc. These can be used in a clause declaration or as declarations. Also it is possible to add in the code predicates for issuing the debugger (i.e., use debug mode, and in a clause add the predicate `trace/0`). Finally, if a spy declaration is placed on the entry point of an executable (`:- spy(main/1)`) the debugger will not start the first time `main/1` predicate is called, i.e., at the beginning of program execution (however, it will if there are any subsequent calls to `main/1`). Starting the embedded debugger at the beginning of the execution of a program can be done easily however by simply adding the in trace mode.

Note that there is a particularly interesting way of using the embedded debugger: if an *application* is run in a shell buffer which has been set with Ciao inferior mode (⟨M-x⟩ `ciao-inferior-mode`) and this application starts emitting output from the embedded debugger (i.e., which contains the embedded debugger and is debugging its code) then the Ciao emacs mode will be able to follow these messages, for example tracking execution in the source level code. This also works if the application is written in a combination of languages, provided the parts written in Ciao are compiled with the embedded debugger package and is thus a covenient way of debugging multi-language applications. The only thing needed is to make sure that the output messages appear in a shell buffer that is in Ciao inferior mode.

See the following as a general example of use of the embedded debugger:

```
:- module( foo,[main/1],[assertions, debug]).

:- entry main/1.

main(X) :-
         display(X),
         spy(foo),
         foo(X),
         notrace,
         nl.

foo([]).
foo([X|T]) :-
        trace,
        bar(X),
        foo(T).

bar(X) :-
```

```
display(X).
```

6.4 The procedure box control flow model

During debugging the interpreter prints out a sequence of goals in various states of instantiation in order to show the state that the program has reached in its execution. However, in order to understand what is occurring it is necessary to understand when and why the interpreter prints out goals. As in other programming languages, key points of interest are procedure entry and return, but in Prolog there is the additional complexity of backtracking. One of the major confusions that novice Prolog programmers have to face is the question of what actually happens when a goal fails and the system suddenly starts backtracking. The Procedure Box model of Prolog execution views program control flow in terms of movement about the program text. This model provides a basis for the debugging mechanism in the interpreter, and enables the user to view the behaviour of the program in a consistent way. It also provides the basis for the visualization performed on the source level program when source level program when source-level debugging is activated within `emacs`.

Let us look at an example Prolog procedure:

The first clause states that `Y` is a descendant of `X` if `Y` is an offspring of `X`, and the second clause states that `Y` is a descendant of `X` if `Z` is an offspring of `X` and `Y` is a descendant of `Z`. In the diagram a box has been drawn around the whole procedure and labelled arrows indicate the control flow in and out of this box. There are four such arrows which we shall look at in turn.

- **Call**

  This arrow represents initial invocation of the procedure. When a goal of the form `descendant(X,Y)` is required to be satisfied, control passes through the Call port of the descendant box with the intention of matching a component clause and then satisfying any subgoals in the body of that clause. Note that this is independent of whether such a match is possible; i.e. first the box is called, and then the attempt to match takes place. Textually we can imagine moving to the code for descendant when meeting a call to descendant in some other part of the code.

- **Exit**

  This arrow represents a successful return from the procedure. This occurs when the initial goal has been unified with one of the component clauses and any subgoals have been satisfied. Control now passes out of the Exit port of the descendant box. Textually we stop following the code for descendant and go back to the place we came from.

- **Redo**

  This arrow indicates that a subsequent goal has failed and that the system is backtracking in an attempt to find alternatives to previous solutions. Control passes through the Redo port of the descendant box. An attempt will now be made to resatisfy one of the component subgoals in the body of the clause that last succeeded; or, if that fails, to completely rematch the original goal with an alternative clause and then try to satisfy any subgoals in the body of this new clause. Textually we follow the code backwards up the way we came looking for new ways of succeeding, possibly dropping down on to another clause and following that if necessary.

- **Fail**

  This arrow represents a failure of the initial goal, which might occur if no clause is matched, or if subgoals are never satisfied, or if any solution produced is always rejected by later processing. Control now passes out of the Fail port of the descendant box and the system continues to backtrack. Textually we move back to the code which called this procedure and keep moving backwards up the code looking for choice points.

In terms of this model, the information we get about the procedure box is only the control flow through these four ports. This means that at this level we are not concerned with which clause matches, and how any subgoals are satisfied, but rather we only wish to know the initial goal and the final outcome. However, it can be seen that whenever we are trying to satisfy subgoals, what we are actually doing is passing through the ports of *their* respective boxes. If we were following this (e.g., activating source-level debugging), then we would have complete information about the control flow inside the procedure box.

Note that the box we have drawn around the procedure should really be seen as an invocation box. That is, there will be a different box for each different invocation of the procedure. Obviously, with something like a recursive procedure, there will be many different Calls and Exits in the control flow, but these will be for different invocations. Since this might get confusing each invocation box is given a unique integer identifier in the messages, as described below.

Note that not all procedure calls are traced; there are a few basic predicates which have been made invisible since it is more convenient not to trace them. These include debugging directives, basic control structures, and some builtins. This means that messages will never be printed for these predicates during debugging.

6.5 Format of debugging messages

This section explains the two formats of the message output by the debugger at a port. All trace messages are output to the terminal regardless of where the current output stream is directed (which allows tracing programs while they are performing file I/O). The basic format, which will be shown in traditional debug and in source-level debugging within Ciao `emacs` mode, is as follows:

```
S  13  7  Call: T user:descendant(dani,_123) ?
```

`S` is a spy-point or breakpoint indicator. It is printed as '`+`', indicating that there is a spy-point on `descendant/2` in module `user`, as `'B'` denoting a breakpoint, or as ' ', denoting no spy-point or breakpoint. If there is a spy-point and a breakpoint in the same predicate the spy-point indicator takes preference over breakpoint indicator.

`T` is a subterm trace. This is used in conjunction with the `^` command (set subterm), described below. If a subterm has been selected, `T` is printed as the sequence of commands used to select the subterm. Normally, however, `T` is printed as ' ', indicating that no subterm has been selected.

The first number is the unique invocation identifier. It is always nondecreasing (provided that the debugger is switched on) regardless of whether or not the invocations are being actually seen. This number can be used to cross correlate the trace messages for the various ports, since it is unique for every invocation. It will also give an indication of the number of procedure calls made since the start of the execution. The invocation counter starts again for every fresh execution of a command, and it is also reset when retries (see later) are performed.

The number following this is the *current depth*; i.e., the number of direct *ancestors* this goal has. The next word specifies the particular port (`Call`, `Exit`, `Redo` or `Fail`). The goal is then printed so that its current instantiation state can be inspected. The final `?` is the prompt indicating that the debugger is waiting for user interaction. One of the option codes allowed (see below) can be input at this point.

The second format, quite similar to the format explained above, is shown when using source-level debugging outside the Ciao `emacs` mode, and it is as follows:

```
   In /home/mcarlos/ciao/foo.pl (5-9) descendant-1
S  13  7  Call: T user:descendant(dani,_123) ?
```

This format is identical to the format above except for the first line, which contains the information for location of the point in the source program text where execution is currently at. The first line contains the name of the source file, the start and end lines where the literal can be found, the substring to search for between those lines and the number of substrings to locate. This information for locating the point on the source file is not shown when executing the source-level debugger from the Ciao `emacs` mode.

Ports can be "unleashed" by calling the `leash/1` predicate omiting that port in the argument. This means that the debugger will stop but user interaction is not possible for an unleashed port. Obviously, the `?` prompt will not be shown in such messages, since the user has specified that no interaction is desired at this point.

6.6 Options available during debugging

This section describes the particular options that are available when the debugger prompts after printing out a debugging message. All the options are one letter mnemonics, some of which can be optionally followed by a decimal integer. They are read from the terminal with any blanks being completely ignored up to the next terminator (carriage-return, line-feed, or escape). Some options only actually require the terminator; e.g., the creep option, only requires ⟨RET⟩.

The only option which really needs to be remembered is '`h`' (followed by ⟨RET⟩). This provides help in the form of the following list of available options.

```
<cr>   creep            c      creep
 l     leap             s      skip
 r     retry            r <i>  retry i
 f     fail             f <i>  fail i
 d     display          p      print
 w     write            v <I>  variable(s)
 g     ancestors        g <n>  ancestors n
 n     nodebug          =      debugging
 +     spy this         -      nospy this
 a     abort
 @     command          u      unify
 <     reset printdepth < <n>  set printdepth
 ^     reset subterm    ^ <n>  set subterm
 ?     help             h      help
```

- `c` (*creep*)

  causes the debugger to single-step to the very next port and print a message. Then if the port is leashed the user is prompted for further interaction. Otherwise it continues creeping. If leashing is off, creep is the same as leap (see below) except that a complete trace is printed on the terminal.

- `l` (*leap*)

  causes the interpreter to resume running the program, only stopping when a spy-point or breakpoint is reached (or when the program terminates). Leaping can thus be used to follow the execution at a higher level than exhaustive tracing. All that is needed to do is to set spy-points and breakpoints on an evenly spread set of pertinent predicates or lines, and then follow the control flow through these by leaping from one to the other.

- `s` (*skip*)

  is only valid for Call and Redo ports, if it is issued in Exit or Fail ports it is equivalent to creep. It skips over the entire execution of the predicate. That is, no message will be seen until control comes back to this predicate (at either the Exit port or the Fail port). Skip is particularly useful while creeping since it guarantees that control will be returned after the (possibly complex) execution within the box. With skip then no message at all will appear until control returns to the Exit port or Fail port corresponding to this Call port or Redo port. This includes calls to predicates with spy-points and breakpoints set: they will be masked out during the skip. There is a way of overriding this: the `t` option after a ⟨^C⟩ interrupt will disable the masking. Normally, however, this masking is just what is required!

- `r` (*retry*)

  can be used at any of the four ports (although at the Call port it has no effect). It transfers control back to the Call port of the box. This allows restarting an invocation when, for example, it has left the programmer with some weird result. The state of execution is exactly the same as in the original call (unless the invocation has performed side effects, which will not be undone). When a retry is performed the invocation counter is reset so that counting will continue from the current invocation number regardless of what happened before the retry. This is in accord with the fact that execution has, in operational terms, returned to the state before anything else was called.

  If an integer is supplied after the retry command, then this is taken as specifying an invocation number and the system tries to get to the Call port, not of the current box, but of the invocation box specified. It does this by continuously failing until it reaches the right place. Unfortunately this process cannot be guaranteed: it may be the case that the invocation the programmer is looking for has been cut out of the search space by cuts in the program. In this case the system fails to the latest surviving Call port before the correct one.

- `f` (*fail*)
  can be used at any of the four ports (although at the Fail port it has no effect). It transfers control to the Fail port of the box, forcing the invocation to fail prematurely. If an integer is supplied after the command, then this is taken as specifying an invocation number and the system tries to get to the Fail port of the invocation box specified. It does this by continuously failing until it reaches the right place. Unfortunately, as before, this process cannot be guaranteed.
- `d` (*display*)
  displays the current goal using `display/1`. See `w` below.
- `p` (*print*)
  re-prints the current goal using `print/1`. Nested structures will be printed to the specified *printdepth* (see below).
- `w` (*write*)
  writes the current goal on the terminal using `write/1`.
- `v` (*variables*)
  writes the list of the modified variables and their values. If a variable name (identifier) `N` is supplied, then the value of variable `N` is shown.
- `g` (*ancestors*)
  provides a list of ancestors to the current goal, i.e., all goals that are hierarchically above the current goal in the calling sequence. It is always possible to jump to any goal in the ancestor list (by using retry, etc.). If an integer `n` is supplied, then only `n` ancestors will be printed. That is to say, the last `n` ancestors will be printed counting back from the current goal. Each entry in the list is preceded by the invocation number followed by the depth number (as would be given in a trace message).
- `n` (*nodebug*)
  switches the debugger off. Note that this is the correct way to switch debugging off at a trace point. The `@` option cannot be used because it always returns to the debugger.
- `=` (*debugging*)
  outputs information concerning the status of the current debugging session.
- `+` *spy*
  sets a spy-point on the current goal.
- `-` (*nospy*)
  removes the spy-point from the current goal.
- `a` (*abort*)
  causes an abort of the current execution. All the execution states built so far are destroyed and the system is put right back at the top-level of the interpreter. (This is the same as the built-in predicate `abort/0`.)
- `@` (*command*)
  allows calling arbitrary goals. The initial message `| ?-` will be output on the terminal, and a command is then read from the terminal and executed as if it was at top-level.
- `u` (*unify*)
  is available at the Call port and gives the option of providing a solution to the goal from the terminal rather than executing the goal. This is convenient, e.g., for providing a "stub" for a predicate that has not yet been written. A prompt `|:` will be output on the terminal, and the solution is then read from the terminal and unified with the goal.
- `<` (*printdepth*)
  sets a limit for the subterm nesting level that is printed in messages. While in the debugger, a printdepth is in effect for limiting the subterm nesting level when printing the current

goal. When displaying or writing the current goal, all nesting levels are shown. The limit is initially 10. This command, without arguments, resets the limit to 10. With an argument of `n` the limit is set to `n`.

- `^` (*subterm*)

  sets the subterm to be printed in messages. While at a particular port, a current subterm of the current goal is maintained. It is the current subterm which is displayed, printed, or written when prompting for a debugger command. Used in combination with the printdepth, this provides a means for navigating in the current goal for focusing on the part which is of interest. The current subterm is set to the current goal when arriving at a new port. This command, without arguments, resets the current subterm to the current goal. With an argument of `n` (greater than 0 and less or equal to the number of subterms of the current subterm), the current subterm is replaced by its `n`'th subterm. With an argument of `0`, the current subterm is replaced by its parent term.

- `?` or `h` (*help*)

  displays the table of options given above.

6.7 Calling predicates that are not exported by a module

The Ciao module system does not allow calling predicates which are not exported during debugging. However, as an aid during debugging, this is allowed (only from the top-level and for modules which are in debug mode or source-level debug mode) using the `call_in_module/2` predicate.

Note that this does not affect analysis or optimization issues, since it only works on modules which are loaded in debug mode or source-level debug mode, i.e. unoptimized.

6.8 Acknowledgements (debugger)

Originally written by Andrzej Ciepielewski. Minor modifications by Mats Carlsson. Later modifications (17 Dec 87) by Takashi Chikayama (making tracer to use `print/1` rather than `write/1`, temporarily switching debugging flag off while writing trace message and within "break" level). Additional modifications by Kish Shen (May 88): subterm navigation, handle unbound args in `spy/1` and `nospy/1`, trapping arithmetics errors in debug mode. Adapted then to &-Prolog and Ciao by Daniel Cabeza and included in the Ciao version control system. Extended for source-level debugging by Manuel C. Rodríguez. Option that shows variable names and values (`v <N>`) implemented by Edison Mera (2009). (See changelog if included in the document or in the version maintenance system for more detailed documentation on changes.)

7 Predicates controlling the interactive debugger

Author(s): A. Ciepielewski, Mats Carlsson, T. Chikayama, K. Shen, Daniel Cabeza, Manuel C. Rodriguez, Edison Mera.

This library implements predicates which are normally used in the interactive top-level shell to debug programs. A subset of them are available in the embeddable debugger.

7.1 Usage and interface (debugger)

- **Library usage:**
  `:- use_module(library(debugger)).`
- **Exports:**
  - *Predicates:*
    `call_in_module/2`, `debugging/0`, `leash/1`, `maxdepth/1`, `debug_module/1`, `debug_module_source/1`, `nodebug_module/1`, `nospy/1`, `spy/1`.
  - *Multifiles:*
    `define_flag/3`.
- **Other modules used:**
  - *System library modules:*
    `debugger/debugger_lib`, `format`, `ttyout`, `read`, `aggregates`, `varnames/apply_dict`, `lists`, `varnames/complete_dict`.

7.2 Documentation on exports (debugger)

call_in_module/2: PREDICATE

Usage: `call_in_module(Module,Predicate)`

- *Description:* Calls predicate `Predicate` belonging to module `Module`, even if that module does not export the predicate. This only works for modules which are in debug (interpreted) mode (i.e., they are not optimized).
- *The following properties should hold at call time:*
  `Module` is an atom. (basic_props:atm/1)
  `Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

debugging/0: PREDICATE

Usage:

- *Description:* Display debugger state.

leash/1: PREDICATE

Usage: `leash(Ports)`

- *Description:* Leash on ports `Ports`, some of `call`, `exit`, `redo`, `fail`. By default, all ports are on leash.

– *The following properties should hold at call time:*
`Ports` is a list of `ports`. (basic_props:list/2)

maxdepth/1: PREDICATE

Usage: `maxdepth(MaxDepth)`

– *Description:* Set maximum invocation depth in debugging to `MaxDepth`. Calls to compiled predicates are not included in the computation of the depth.

– *The following properties should hold at call time:*
`MaxDepth` is an integer. (basic_props:int/1)

debug_module/1: PREDICATE

Usage: `debug_module(Module)`

– *Description:* The debugger will take into acount module `Module` (assuming it is loaded in interpreted mode). When issuing this command at the toplevel shell, the compiler is instructed also to set to *interpret* the loading mode of files defining that module and also to mark it as 'modified' so that (re)loading this file or a main file that uses this module will force it to be reloaded for source-level debugging.

– *The following properties should hold at call time:*
`Module` is an atom. (basic_props:atm/1)

debug_module_source/1: PREDICATE

Usage: `debug_module_source(Module)`

– *Description:* The debugger will take into acount module `Module` (assuming it is is loaded in source-level debug mode). When issuing this command at the toplevel shell, the compiler is instructed also to set to *interpret* the loading mode of files defining that module and also to mark it as 'modified' so that (re)loading this file or a main file that uses this module will force it to be reloaded for source-level debugging.

– *The following properties should hold at call time:*
`Module` is an atom. (basic_props:atm/1)

nodebug_module/1: PREDICATE

Usage: `nodebug_module(Module)`

– *Description:* The debugger will not take into acount module `Module`. When issuing this command at the toplevel shell, the compiler is instructed also to set to *compile* the loading mode of files defining that module.

– *The following properties should hold at call time:*
`Module` is an atom. (basic_props:atm/1)

nospy/1: PREDICATE

Usage: `nospy(PredSpec)`

– *Description:* Remove spy-points on predicates belonging to debugged modules which match `PredSpec`. This predicate is defined as a prefix operator by the toplevel.

– *The following properties should hold at call time:*
`PredSpec` is a sequence of `multpredspec`s. (basic_props:sequence/2)

spy/1: PREDICATE

Usage: `spy(PredSpec)`

- *Description:* Set spy-points on predicates belonging to debugged modules and which match `PredSpec`, switching the debugger on if needed. This predicate is defined as a prefix operator by the toplevel.
- *The following properties should hold at call time:*

  `PredSpec` is a sequence of `multpredspec`s. (basic_props:sequence/2)

debug/0: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

nodebug/0: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

trace/0: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

notrace/0: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

get_debugger_state/1: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

get_debugger_state/1: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

nospyall/0: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

breakpt/6: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

nobreakpt/6: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

nobreakall/0: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

list_breakpt/0: (UNDOC_REEXPORT)

Imported from `debugger_lib` (see the corresponding documentation for details).

7.3 Documentation on multifiles (`debugger`)

define_flag/3: PREDICATE

The predicate is *multifile*.

Usage: `define_flag(Flag,FlagValues,Default)`

– *The following properties hold upon exit:*

`Flag` is an atom. (basic_props:atm/1)

Define the valid flag values (basic_props:flag_values/1)

7.4 Known bugs and planned improvements (`debugger`)

- Add an option to the emacs menu to automatically select all modules in a project.
- Consider the possibility to show debugging messages directly in the source code emacs buffer.

8 The script interpreter

Author(s): Daniel Cabeza, Manuel Hermenegildo.

`ciao-shell` is the Ciao script interpreter. It can be used to write *Prolog shell scripts* (see [Her96,CHV96b]), that is, executable files containing source code, which are compiled on demand.

Writing Prolog scripts can sometimes be advantageous with respect to creating binary executables for small- to medium-sized programs that are modified often and perform relatively simple tasks. The advantage is that no explicit compilation is necessary, and thus changes and updates to the program imply only editing the source file. The disadvantage is that startup of the script (the first time after it is modified) is slower than for an application that has been compiled previously.

An area of application is, for example, writing *CGI executables*: the slow speed of the network connection in comparison with that of executing a program makes program execution speed less important and has made scripting languages very popular for writing these applications. Logic languages are, a priori, excellent candidates to be used as scripting languages. For example, the built-in grammars and databases can sometimes greatly simplify many typical script-based applications.

8.1 How it works

Essentially, `ciao-shell` is a smaller version of the Ciao top-level, which starts by loading the file given to it as the first argument and then starts execution at `main/1` (the argument is instantiated to a list containing the command line options, in the usual way). Note that the Prolog script cannot have a `module` declaration for this to work. While loading the file, `ciao-shell` changes the prolog flag `quiet` so that no informational or warning messages are printed (error messages will be reported to `user_error`, however). The operation of `ciao-shell` in Unix-like systems is based in a special compiler feature: when the first character of a file is '`#`', the compiler skips the first lines until an empty line is found. In Windows, its use is as easy as naming the file with a `.pls` extension, which will launch `ciao-shell` appropriately.

For example, in a Linux/Unix system, assume a file called `hello` contains the following program:

```
#!/bin/sh
exec ciao-shell $0 "$@" # -*- mode: ciao; -*-

main(_) :-
     write('Hello world'), nl.
```

Then, the file `hello` can be *run* by simply making it executable and invoking it from the command line:

```
/herme@clip:/tmp
[86]> chmod +x hello

/herme@clip:/tmp
[87]> hello
Hello world
```

The line:

```
#!/bin/sh
```

invokes the `/bin/sh` shell which will interpret the following line:

```
exec ciao-shell $0 "$@" # -*- mode: ciao; -*-
```

and invoke `ciao-shell`, instructing it to read this same file (`$0`), passing it the rest of the arguments to `hello` as arguments to the prolog program. The second part of the line `# -*- mode: ciao; -*-` is simply a comment which is seen by `emacs` and instructs it to edit this file in Ciao mode (this is needed because these script files typically do not have a `.pl` ending). When `ciao-shell` starts, if it is the first time, it compiles the program (skipping the first lines, as explained above), or else at successive runs loads the `.po` object file, and then calls `main/1`.

Note that the process of creating Prolog scripts is made very simple by the Ciao emacs mode, which automatically inserts the header and makes the file executable (See Chapter 10 [Using Ciao inside GNU emacs], page 67).

8.2 Command line arguments in scripts

The following example illustrates the use of command-line arguments in scripts. Assume that a file called `say` contains the following lines:

```
#!/bin/sh
exec ciao-shell $0 "$@" # -*- mode: ciao; -*-

main(Argv) :-
     write_list(Argv), nl.

write_list([]).
write_list([Arg|Args]) :-
     write(Arg),
     write(' '),
     write_list(Args).
```

An example of use is:

```
/herme@clip:/tmp
[91]> say hello dolly
hello dolly
```

9 Customizing library paths and path aliases

Author(s): Daniel Cabeza.

This library provides means for customizing, from environment variables, the libraries and path aliases known by an executable. Many applications of Ciao, including `ciaoc`, `ciaosh`, and `ciao-shell` make use of this library. Note that if an executable is created dynamic, it will try to load its components at startup, before the procedures of this module can be invoked, so in this case all the components should be in standard locations.

9.1 Usage and interface (`libpaths`)

- **Library usage:**
  `:- use_module(library(libpaths)).`
- **Exports:**
  - *Predicates:*
    `get_alias_path/0`.
  - *Multifiles:*
    `file_search_path/2`, `library_directory/1`.
- **Other modules used:**
  - *System library modules:*
    `system`, `lists`.

9.2 Documentation on exports (`libpaths`)

get_alias_path/0: PREDICATE

`get_alias_path`

Consult the environment variable 'CIAOALIASPATH' and add facts to predicates `library_directory/1` and `file_search_path/2` to define new library paths and path aliases. The format of 'CIAOALIASPATH' is a sequence of paths or alias assignments separated by colons, an alias assignment is the name of the alias, an '=' and the path represented by that alias (no blanks allowed). For example, given

```
CIAOALIASPATH=/home/bardo/ciao:contrib=/usr/local/lib/ciao
```

the predicate will define /home/bardo/ciao as a library path and /usr/local/lib/ciao as the path represented by 'contrib'.

9.3 Documentation on multifiles (`libpaths`)

file_search_path/2: PREDICATE

See Chapter 21 [Basic file/stream handling], page 159.

The predicate is *multifile*.

The predicate is of type *dynamic*.

`file_search_path(X,Y)`

– *The following properties hold upon exit:*
`X` is ground. (basic_props:gnd/1)
`Y` is ground. (basic_props:gnd/1)

library_directory/1: PREDICATE

See Chapter 21 [Basic file/stream handling], page 159.

The predicate is *multifile*.

The predicate is of type *dynamic*.

`library_directory(X)`

– *The following properties hold upon exit:*
`X` is ground. (basic_props:gnd/1)

10 Using Ciao inside GNU emacs

Author(s): Manuel Hermenegildo, Manuel C. Rodriguez, Daniel Cabeza, , The Computational logic, Languages, , Implementation, and Parallelism (CLIP) Lab, `http://www.cliplab.org/`, `webmaster@clip.dia.fi.upm.es`, School of CS, T. U. of Madrid (UPM), IMDEA Software Institute.

The Ciao emacs interface (or *mode* in `emacs` terms) provides a rich, integrated user interface to the Ciao *program development environment* components, including the `ciaosh` interactive top level and the `ciaopp` preprocessor. While most features of the Ciao development environment are available from the command line of the preprocessor and the top-level shell, using Ciao inside `emacs` is highly recommended. The facilities that this mode provides include:

- *Syntax-based highlighting* (coloring), *auto-indentation*, *auto-fill*, etc. of code. This includes the assertions used by the preprocessor and the documentation strings used by the Ciao auto-documenter, `lpdoc`.
- Providing automatic access to on-line help for all predicates by accessing the Ciao system manuals in `info` format.
- Starting and communicating with `ciaopp`, the *Ciao preprocessor*, running in its own sub-shell. This allows easily performing certain kinds of *static checks* (useful for finding errors in programs before running them), program analysis tasks, and *program transformations* on source programs.
- Starting and communicating with the *Ciao top-level*, running in its own sub-shell. This facilitates loading programs, checking the *syntax* of programs (and of *assertions* within programs), marking and unmarking modules for interactive debugging, *tracing the source code* during debugging, making stand-alone executables, compiling modules to dynamically linkable Ciao objects, compiling modules to active objects, etc.
- Syntax highlighting and coloring of the error and warning messages produced by the top level, preprocessor, or any other tool using the same message format (such as the `lpdoc` auto-documenter), and *locating automatically the points in the source files where such errors occur*.
- Performing automatic *version control* and keeping a *changelog* of individual files or whole applications. This is done by automatically including changelog entries in source files, which can then be processed by the `lpdoc` auto-documenter.

This chapter explains how to use the Ciao `emacs` interface and how to set up your `emacs` environment for correct operation. The Ciao `emacs` interface can also be used to work with traditional Prolog or CLP systems.

10.1 Conventions for writing Ciao programs under Emacs

This is particularly important for the source-level debugger and the syntax-based coloring capabilities. This is due to the fact that it would be unrealistic to write a complete Ciao parser in Emacs lisp. These conventions are the following, in order of importance:

- Clauses should begin on the first column (this is used to recognize the beginning of a clause).
- C style comments should not be used in a clause, but can be used outside any clause.

The following suggestion is not strictly necessary but can improve operation:

- Body literals should be indented. There should be not more than one literal per line. This allows more precision in the location of program points during source-level debugging, i.e., when marking breakpoints and during line tracing.

Comments which start with `%`s are indented to the right if indentation is asked for.

For syntax-based highlighting to be performed font-lock must be available and not disabled (the Ciao mode enables it but it may be disabled elsewhere in, e.g., the `.emacs` file).

10.2 Checking the installation

Typically, a complete pre-installation of the Ciao `emacs` interface is completed during Ciao installation. To check that installation was done and sucessful, open a file with a `.pl` ending. You should see that `emacs` enters Ciao mode: the mode is identified in the status bar below the buffer and, if the emacs menu bar is enabled, you should see the Ciao menus. You should be able from the menu-bar, for example, to go to the Ciao manuals in the info or load the `.pl` file that you just opened into a Ciao top level.

If things don't work properly, see the section Section 10.21 [Installation of the Ciao emacs interface], page 85 later in this chapter.

10.3 Functionality and associated key sequences (bindings)

The following sections summarize the capabilities of the Ciao emacs interface and the (default) *key sequences* used to access those capabilities. Most of these functions are accessible also from the menu bar.

10.4 Syntax coloring and syntax-based editing

Syntax-based highlighting (coloring) of code is provided automatically when opening Ciao files. This includes also the assertions used by the preprocessor and the documentation strings used by the Ciao auto-documenter, `lpdoc`. The mode should be set to Ciao and the Ciao mode menus should appear on the menu bar. The colors and fonts used can be changed through the *customize* options in the help menu (see Section 10.20 [Customization], page 80).

During editing this coloring may be refreshed by calling the appropriate function (see below).

Limited syntax-based auto-indentation and auto-fill of code and comments is also provided. Syntax highlighting and coloring is also available for the error and warning messages produced by the top level, preprocessor, and auto-documenter, and, in general, for the output produced by these tools.

Commands:

⟨C-c⟩ ⟨h⟩ Undate (recompute) syntax-based highlighting (coloring).

⟨TAB⟩ Indent current line as Ciao code. With argument, indent any additional lines of the same clause rigidly along with this one.

10.5 Getting on-line help

The following commands are useful for getting on-line help. This is done by accessing the `info` version of the Ciao manuals or the `emacs` built-in help strings. Note also that the `info` standard `search` command (generally bound to ⟨s⟩) can be used inside `info` buffers to search for a given string.

⟨C-c⟩ ⟨TAB⟩ Find help for the symbol (e.g., predicate, directive, declaration, type, etc.) that is currently under the cursor. Opens a (hopefully) relevant part of the Ciao manuals in `info` mode. Requires that the Ciao manuals in `info` format be installed and accessible to `emacs` (i.e., they should appear somewhere in the info directory when typing `M-x info`). It also requires `word-help.el`, which is provided with Ciao. Refer to the installation instructions if this is not the case.

⟨C-c⟩ ⟨/⟩ Find a completion for the symbol (e.g., predicate, directive, declaration, type, etc.) that is currently under the cursor. Uses for completion the contents of the indices of the Ciao manuals. Same requirements as for finding help for the symbol.

⟨C-c⟩ ⟨RET⟩ Go to the part of the info directory containing the Ciao manuals.

⟨C-h⟩ ⟨m⟩ Show a short description of the Ciao emacs mode, including all key bindings.

10.6 Loading and compiling programs

These commands allow *loading programs*, *creating executables*, etc. by issuing the appropriate commands to a Ciao top level shell, running in its own buffer as a subprocess. See Chapter 5 [The interactive top-level shell], page 41 for details. The following commands implement the communication with the Ciao top level:

⟨C-c⟩ ⟨t⟩ Ensure that an inferior Ciao top-level process is running.

This opens a top-level window (if one did not exist already) where queries can be input directly. Programs can be loaded into this top level by typing the corresponding commands in this window (such as use_module, etc.), or, more typically, by opening the file to be loaded in an emacs window (where it can be edited) and issuing a load command (such as C-c l or C-c L) directly from there (see the loading commands of this mode and their bindings).

Note that many useful commands (e.g., to repeat and edit previous commands, interrupt jobs, locate errors, automatic completions, etc.) are available in this top-level window (see Section 10.7 [Commands available in toplevel and preprocessor buffers], page 70).

Often, it is not necessary to use this function since execution of any of the other functions related to the top level (e.g., loading buffers into the top level) ensures that a top level is started (starting one if required).

⟨C-c⟩ ⟨l⟩ Load the current buffer (and any auxiliary files it may use) into the top level.

The type of compilation performed (*compiling* or *interpreting*) is selected automatically depending on whether the buffer has been marked for debugging or not – see below. In case you try to load a file while in the middle of the debugging process the debugger is first aborted and then the buffer is loaded. Also, if there is a defined query, the user is asked whether it should be called.

⟨C-c⟩ ⟨f⟩ Load CiaoPP and then the current buffer (and any auxiliary files it may use) into the top level. Use CiaoPP auto_check_assrt predicate to check current buffer assertions and then load the buffer if there was no error.

⟨C-c⟩ ⟨x⟩ Make an executable from the code in the current buffer. The buffer must contain a `main/0` or `main/1` predicate. Note that compiler options can be set to determine whether the libraries and auxiliary files used by the executable will be statically linked, dynamically linked, auto-loaded, etc.

⟨C-c⟩ ⟨o⟩ Make a Ciao object (.po) file from the code in the current buffer. This is useful for example while debugging during development of a very large application which is compiled into an excutable, and only one or a few files are modified. If the application executable is dynamically linked, i.e., the component .po files are loaded dynamically during startup of the application, then this command can be used to recompile only the file or files which have changed, and the correct version will be loaded dynamically the next time the application is started. However, note that this must be done with care since it only works if the inter-module interfaces have not changed. The recommended, much safer way is to generate the executable again, letting the Ciao compiler, which is inherently incremental, determine what needs to be recompiled.

⟨C-c⟩ ⟨a⟩ Make an active module executable from the code in the current buffer. An active module is a remote procedure call server (see the `activemod` library documentation for details).

⟨C-c⟩ ⟨s⟩ Set the current buffer as the principal file in a multiple module programming environment.

⟨C-c⟩ ⟨L⟩ Load the module designated as *main module* (and all related files that it uses) into the top level. If no main module is defined it will load the current buffer.

The type of compilation performed (*compiling* or *interpreting*) is selected automatically depending on whether the buffer has been marked for debugging or not – see below. In case you try to load a file while in the middle of the debugging process the debugger is first aborted and then the buffer is loaded. Also, if there is a defined query, the user is asked whether is should be called.

⟨C-c⟩ ⟨q⟩ Set a default query. This may be useful specially during debugging sessions. However, as mentioned elsewhere, note that commands that repeat previous queries are also available.

This query can be recalled at any time using C-c Q. It is also possible to set things up so that this query will be issued automatically any time a program is (re)loaded. The functionality is available in the major mode (i.e., from a buffer containing a source file) and in the inferior mode (i.e., from the buffer running the top-level shell). When called from the major mode (i.e., from window containing a source file) then the user is prompted in the minibuffer for the query. When called from the inferior mode (i.e., from a top-level window) then the query on the current line, following the Ciao prompt, is taken as the default query.

To clear the default query use M-x ciao-clear-query or simply set it to an empty query: i.e., in a source buffer select C-c q and enter an empty query. In an inferior mode simply select C-c q on a line that contains only the system prompt.

⟨C-c⟩ ⟨Q⟩ Issue predefined query.

10.7 Commands available in toplevel and preprocessor buffers

The interactive top level and the preprocessor both are typically run in an iteractive buffer, in which it is possible to communicate with them in the same way as if they had been started from a standard shell. These interactive buffers run in the so-called *Ciao inferior mode*. This is a particular version of the standard emacs shell package (comint) and thus all the commands typically available when running shells inside emacs also work in these buffers. In addition, many of the commands and key bindings available in buffers containing Ciao source code are also available in these interactive buffers, when applicable. The Ciao-specific commands available include:

⟨C-c⟩ ⟨TAB⟩ Find help for the symbol (e.g., predicate, directive, declaration, type, etc.) that is currently under the cursor. Opens a (hopefully) relevant part of the Ciao manuals in `info` mode. Requires that the Ciao manuals in `info` format be installed and accessible to `emacs` (i.e., they should appear somewhere in the info directory when typing `M-x info`). It also requires `word-help.el`, which is provided with Ciao. Refer to the installation instructions if this is not the case.

⟨C-c⟩ ⟨/⟩ Find a completion for the symbol (e.g., predicate, directive, declaration, type, etc.) that is currently under the cursor. Uses for completion the contents of the indices of the Ciao manuals. Same requirements as for finding help for the symbol.

⟨C-c⟩ ⟨`⟩ Go to the location in the source file containing the next error reported by the last Ciao subprocess (preprocessor or toplevel) which was run.

⟨C-c⟩ ⟨e⟩ Remove error marks from last run (and also debugging marks if present).

⟨C-c⟩ ⟨q⟩ Set a default query. This may be useful specially during debugging sessions. However, as mentioned elsewhere, note that commands that repeat previous queries are also available.

This query can be recalled at any time using C-c Q. It is also possible to set things up so that this query will be issued automatically any time a program is (re)loaded.

The functionality is available in the major mode (i.e., from a buffer containing a source file) and in the inferior mode (i.e., from the buffer running the top-level shell). When called from the major mode (i.e., from window containing a source file) then the user is prompted in the minibuffer for the query. When called from the inferior mode (i.e., from a top-level window) then the query on the current line, following the Ciao prompt, is taken as the default query.

To clear the default query use M-x ciao-clear-query or simply set it to an empty query: i.e., in a source buffer select C-c q and enter an empty query. In an inferior mode simply select C-c q on a line that contains only the system prompt.

⟨C-c⟩ ⟨Q⟩ Issue predefined query.

⟨C-c⟩ ⟨C-v⟩ Show last output file produced by Ciao preprocessor. The preprocessor works by producing a file which is a transformed and/or adorned (with assertions) version of the input file. This command is often used after running the preprocessor in order to visit the output file and see the results from running the preprocessor.

⟨C-c⟩ ⟨v⟩ Report the version of the emacs Ciao mode.

The following are some of the commands from the comint shell package which may be specially useful (type `<f1> m` while in a Ciao interactive buffer for a complete list of commands):

⟨M-p⟩ Cycle backwards through input history, saving input.

⟨M-n⟩ Cycle forwards through input history.

⟨M-r⟩ Search backwards through input history for match for REGEXP. (Previous history elements are earlier commands.) With prefix argument N, search for Nth previous match. If N is negative, find the next or Nth next match.

⟨TAB⟩ Dynamically find completion of the item at point. Note that this completion command refers generally to filenames (rather than, e.g., predicate names, as in the previous functions).

⟨M-?⟩ List all (filename) completions of the item at point.

⟨RET⟩ Return at any point of the a line at the end of a buffer sends that line as input. Return not at end copies the rest of the current line to the end of the buffer and sends it as input.

⟨^D⟩ Delete ARG characters forward or send an EOF to subprocess. Sends an EOF only if point is at the end of the buffer and there is no input.

⟨^C⟩ ⟨^U⟩ Kill all text from last stuff output by interpreter to point.

⟨^C⟩ ⟨^W⟩ Kill characters backward until encountering the beginning of a word. With argument ARG, do this that many times.

⟨^C⟩ ⟨^C⟩ Interrupt the current subjob. This command also kills the pending input between the process mark and point.

⟨^C⟩ ⟨^Z⟩ Stop the current subjob. This command also kills the pending input between the process mark and point.

WARNING: if there is no current subjob, you can end up suspending the top-level process running in the buffer. If you accidentally do this, use M-x comint-continue-subjob to resume the process. (This is not a problem with most shells, since they ignore this signal.)

⟨^C⟩ ⟨^\⟩ Send quit signal to the current subjob. This command also kills the pending input between the process mark and point.

10.8 Locating errors and checking the syntax of assertions

These commands allow locating quickly the point in the source code corresponding to errors flagged by the compiler or preprocessor as well as performing several syntactic checks of assertions:

⟨C-c⟩ ⟨`⟩ Go to the location in the source file containing the next error reported by the last Ciao subprocess (preprocessor or toplevel) which was run.

⟨C-c⟩ ⟨e⟩ Remove error marks from last run (and also debugging marks if present).

⟨C-c⟩ ⟨E⟩ Check the *syntax* of the code and assertions in the current buffer, as well as imports and exports. This uses the standard top level (i.e., does not call the preprocessor and thus does not require the preprocessor to be installed). Note that full (semantic) assertion checking must be done with the preprocessor.

10.9 Commands which help typing in programs

The following commands are intended to help in the process of writing programs:

⟨C-c⟩ ⟨I⟩ ⟨S⟩ Insert a (Unix) header at the top of the current buffer so that the Ciao script interpreter will be called on this file if *run* from the command line. It also makes the file "executable" (e.g., '`chmod +x <file>`' in Unix). See Chapter 8 [The script interpreter], page 63 for details.

⟨C-c⟩ ⟨i⟩ Indent a Ciao or Prolog file.

10.10 Debugging programs

These commands allow marking modules for *debugging* by issuing the appropiate commands to a Ciao top level shell, running in its own buffer as a subprocess. There are two differents types of debugging: traditional debugging (using the byrd-box model and spy-points) and *source-level debugging* (same as traditional debugging plus source tracing and breakpoints). In order to use *breakpoints*, source debugging must be on. The following commands implement comunication with the Ciao top level:

⟨C-c⟩ ⟨d⟩ Debug (or stop debugging) buffer source. This is a shortcut which is particularly useful when using the source debugger on a single module. It corresponds to several lower-level actions. Those lower-level actions depend on how the module was selected for debugging. In case the module was not marked for source-level debugging, it marks the module corresponding to the current buffer for source-level debugging, reloads it to make sure that it is loaded in the correct way for debugging (same as C-c l), and sets the debugger in trace mode (i.e., issues the `trace.` command to the top-level shell). Conversely, if the module was already marked for source-level debugging then it will take the opposite actions, i.e., it unmarks the module for source-level debugging, reloads it, and sets the debugger to non-debug mode.

⟨C-c⟩ ⟨m⟩ Mark, or unmark, the current buffer for debugging (traditional debugging or source debugging). Note that if the buffer has already been loaded while it was unmarked for debugging (and has therefore been loaded in "compile" mode) it has to be loaded again. The minibuffer shows how the module is loaded now and allows selecting another mode for it. There are three posibilities: N for no debug, S for source debug and D for traditional debug.

⟨C-c⟩ ⟨M-m⟩ Visits all Ciao files which are currently open in a buffer allowing selecting for each of them whether to debug them or not and the type of debugging performed. When working on a multiple module program, it is possible to have many modules open

at a time. In this case, you will navigate through all open Ciao files and select the debug mode for each of them (same as doing C-c m for each).

⟨C-c⟩ ⟨S⟩ ⟨b⟩ Set a breakpoint on the current literal (goal). This can be done at any time (while debugging or not). The cursor must be *on the predicate symbol of the literal*. Breakpoints are only useful when using source-level debugging.

⟨C-c⟩ ⟨S⟩ ⟨v⟩ Remove a breakpoint from the current literal (goal). This can be done at any time (while debugging or not). The cursor must be *on the predicate symbol of the literal*.

⟨C-c⟩ ⟨S⟩ ⟨n⟩ Remove all breakpoints. This can be done at any time (while debugging or not).

⟨C-c⟩ ⟨S⟩ ⟨l⟩ Redisplay breakpoints in all Ciao buffers. This ensures that the marks in the source files and the Ciao toplevel are synchronized.

⟨C-c⟩ ⟨S⟩ ⟨r⟩ Remove breakpoint coloring in all Ciao files.

⟨C-c⟩ ⟨S⟩ ⟨t⟩ Set the debugger to the trace state. In this state, the program is executed step by step.

⟨C-c⟩ ⟨S⟩ ⟨d⟩ Set the debugger to the debug state. In this state, the program will only stop in breakpoints and spypoints. Breakpoints are specially supported in `emacs` and using source debug.

⟨C-c⟩ ⟨r⟩ Load the current region (between the cursor and a previous mark) into the top level. Since loading a region of a file is typically done for debugging and/or testing purposes, this command always loads the region in debugging mode (interpreted).

⟨C-c⟩ ⟨p⟩ Load the predicate around the cursor into the top level. Since loading a single predicate is typically done for debugging and/or testing purposes, this command always loads the predicate in debugging mode (interpreted).

⟨C-c⟩ ⟨u⟩ Run the test over the current buffer.

The test should be specified using a test assertion in the module.

10.11 Preprocessing programs

These commands allow *preprocessing programs* with `ciaopp`, the *Ciao preprocessor*.

CiaoPP is the abstract interpretation-based preprocessor of the Ciao multi-paradigm program development environment. CiaoPP can perform a number of program debugging, analysis, and source-to-source transformation tasks on (Ciao) Prolog programs. These tasks include:

- Inference of properties of the predicates and literals of the program, including types, modes and other variable instantiation properties, non-failure, determinacy, bounds on computational cost, bounds on sizes of terms in the program, etc.
- Certain kinds of static debugging and verification, finding errors before running the program. This includes checking how programs call system library predicates and also checking the assertions present in the program or in other modules used by the program. Such assertions represent essentially partial specifications of the program.
- Several kinds of source to source program transformations such as program specialization, slicing, partial evaluation of a program, program parallelization (taking granularity control into account), inclusion of run-time tests for assertions which cannot be checked completely at compile-time, etc.
- The abstract model of the program inferred by the analyzers is used in the system to certify that an untrusted mobile code is safe w.r.t. the given policy (i.e., an abstraction-carrying code approach to mobile code safety).

The information generated by analysis, the assertions in the system specifications are all written in the same assertion language, which is in turn also used by the Ciao system documentation generator, `lpdoc`.

CiaoPP is distributed under the GNU general public license.

See the preprocessor manual for details. The following commands implement the communication with the Ciao preprocessor:

⟨C-c⟩ ⟨A⟩ Call the preprocessor to perform a number of pre-selected analyses on the current buffer (and related modules).

⟨C-c⟩ ⟨T⟩ Call the preprocessor to perform compile-time checking of the assertions (types, modes, determinacy, nonfailure, cost, ...) in the current buffer (and against those in related modules).

⟨C-c⟩ ⟨O⟩ Uses the preprocessor to perform optimizations (partial evaluation, abstract specialization, parallelization, ...) on the current buffer (and related modules).

⟨C-c⟩ ⟨M⟩ Browse and select (using the preprocessor menus) the actions to be performed by the preprocessor when performing analisys used by M-x ciao- C-c A, C-c T, C-c O, and the corresponding toolbar buttons.

⟨C-c⟩ ⟨C-v⟩ Show last output file produced by Ciao preprocessor. The preprocessor works by producing a file which is a transformed and/or adorned (with assertions) version of the input file. This command is often used after running the preprocessor in order to visit the output file and see the results from running the preprocessor.

⟨C-c⟩ ⟨C-r⟩ Ensure that an inferior Ciao preprocessor process is running.

This opens a preprocessor top-level window (if one did not exist already) where preprocessing commands and preprocessing menu options can be input directly. Programs can be preprocessed by typing commands in this window, or, more typically, by opening the file to be preprocessed in an emacs window (where it can be edited) and issuing a command (such as C-c A, C-c T, C-c O, or C-c M) directly from there (see the preprocessing commands of this mode and their bindings).

Note that many useful commands (e.g., to repeat and edit previous commands, interrupt jobs, locate errors, automatic completions, etc.) are available in this top-level window (see Section 10.7 [Commands available in toplevel and preprocessor buffers], page 70).

Often, it is not necessary to use this function since execution of any of the other functions related to the top level (e.g., loading buffers into the top level) ensures that a top level is started (starting one if required).

10.12 Version control

The following commands can be used to carry out a simple but effective form of version control by keeping a log of changes on a file or a group of related files. Interestingly, this log is kept in a format that is understood by `lpdoc`, the Ciao documenter [Her99]. As a result, if these version comments are present, then `lpdoc` will be able to automatically assign up to date version numbers to the manuals that it generates. This way it is always possible to identify to which version of the software a manual corresponds. Also, `lpdoc` can create automatically sections describing the changes made since previous versions, which are extracted from the comments in the changelog entries.

The main effect of these commands is to automatically associate the following information to a set of changes performed in the file and/or in a set of related files:

- a *version number* (such as, e.g., `1.2`, where `1` is the major version number and `2` is the minor version number),

- a patch number (such as, e.g., the `4` in `1.2#4`),
- a time stamp (such as, e.g., `1998/12/14,17:20*28+MET`),
- the author of the change, and
- a comment explaining the change.

The version numbering used can be local to a single file or common to a number of related files. A simple version numbering policy is implemented: when a relevant change is made, the user typically inserts a changelog entry for it, using the appropriate command (or selecting the corresponding option when prompted while saving a file). This will cause the *patch number* for the file (or for the whole system that the file is part of) to be incremented automatically and the corresponding machine-readable comment to be inserted in the file. Major and minor version numbers can also be changed, but this is always invoked by hand (see below).

The changelog entry is written in the form of a `comment/2` declaration. As mentioned before, the advantage of using this kind of changelog entries is that these declarations can be processed by the `lpdoc` automatic documenter (see the `lpdoc` reference manual [Her99] or the `assertions` library documentation for more details on these declarations).

Whether the user is asked or not to introduce such changelog entries, and how the patch and version numbers should be increased is controlled by the presence in the file of a `comment/2` declaration of the type:

```
:- comment(version_maintenance,<type>).
```

(note that this requires including the `assertions` library in the source file). These declarations themselves are also typically introduced automatically when using this mode (see below).

The version maintenance mode can also be set alternatively by inserting a comment such as:

```
%% Local Variables:
%% mode: ciao
%% update-version-comments: "off"
%% End:
```

The lines above instruct emacs to put the buffer visiting the file in emacs Ciao mode and to turn version maintenance off. Setting the version maintenance mode in this way has the disadvantage that `lpdoc`, the auto-documenter, and other related tools will not be aware of the type of version maintenance being performed (the lines above are comments for Ciao). However, this can be useful in fact for setting the *version maintenance mode for packages* and other files meant for inclusion in other files, since that way the settings will not affect the file in which the package is included.

The following commands implement the version control support:

⟨C-c⟩ ⟨C-a⟩ Used to turn on or off version control for the file being visited in the current buffer. The user will be prompted to choose among the following options:

⟨y⟩ Turn version control on for this file.

⟨n⟩ Turn version control off for this file. A version control comment such as:

```
:- comment(version_maintenance,off).
```

will be added to the buffer and the file saved. No version control will be performed on this file until the line above is removed or modified (i.e., from now on C-x C-s simply saves the buffer).

⟨q⟩ Turn off prompting for the introduction of changelog entries for now. `emacs` will not ask again while the buffer is loaded, but it may ask again when saving after the next time you load the buffer (if `ciao-ask-for-version-maintenance-type` is set to `yes`).

If ⟨y⟩ is selected, then the system prompts again regarding how and where the version and patch number information is to be maintained. The following options are available:

`on` All version control information will be contained within this file. When saving a buffer (C-x C-s) emacs will ask if a changelog entry should be added to the file before saving. If a comment is entered by the user, a new patch number is assigned to it and the comment is added to the file. This patch number will be the one that follows the most recent changelog entry already in the file. This is obviously useful when maintaining version numbers individually for each file.

`<directory_name>`
Global version control will be performed coherently on several files. When saving a buffer (C-x C-s) emacs will ask if a changelog entry should be added to the file before saving. If a comment is given, the global patch number (which will be kept in the file: `<directory_name>/GlobalPatch`) is atomically incremented and the changelog entry is added to the current file, associated to that patch number. Also, a small entry is added to a file `<directory_name>/GlobalChangeLog` which points to the current file. This allows inspecting all changes sequentially by visiting all the files where the changes were made (see C-c C-n). This is obviously useful when maintaining a single thread of version and patch numbers for a set of files.

`off` Turns off version control: C-x C-s then simply saves the file as usual.

Some useful tips:

- If a changelog entry is in fact introduced, the cursor is left at the point in the file where the comment was inserted and the mark is left at the original file point. This allows inspecting (and possibly modifying) the changelog entry, and then returning to the original point in the file by simply typing C-x C-x.
- The first changelog entry is entered by default at the end of the buffer. Later, the changelog entries can be moved anywhere else in the file. New changelog entries are always inserted just above the first changelog entry which appears in the file.
- The comments in changelog entries can be edited at any time.
- If a changelog entry is moved to another file, and version numbers are shared by several files through a directory, the corresponding file pointer in the `<directory_name>/GlobalChangeLog` file needs to be changed also, for the entry to be locatable later using C-c C-n.

⟨C-x⟩ ⟨C-s⟩ This is the standard `emacs` command that saves a buffer by writing the contents into the associated `.pl` file. However, in the Ciao mode, if version control is set to on for ths file, then this command will ask the user before saving whether to introduce a changelog entry documenting the changes performed.

In addition, if:

- the buffer does not already contain a comment specifying the type of version control to be performed,
- and the customizable variable `ciao-ask-for-version-maintenance-type` is set to `yes` (go to the Ciao options menu, LPdoc area to change this, which is by default set to `no`),

then, before saving a buffer, the user will be also automatically asked to choose which kind of version control is desired for the file, as in C-c C-a.

⟨C-c⟩ ⟨C-s⟩ Same as C-x C-s except that it forces prompting for inclusion of a changelog entry even if the buffer is unmodified.

⟨C-c⟩ ⟨n⟩ Force a move to a new major/minor version number (the user will be prompted for the new numbers). Only applicable if using directory-based version maintenance. Note that otherwise it suffices with introducing a changelog entry in the file and changing its version number by hand.

⟨C-c⟩ ⟨C-n⟩ When a unique version numbering is being maintained across several files, this command allows inspecting all changes sequentially by visiting all the files in which the changes were made:

- If in a source file, find the next changelog entry in the source file, open in another window the corresponding `GlobalChangeLog` file, and position the cursor at the corresponding entry. This allows browsing the previous and following changes made, which may perhaps reside in other files in the system.
- If in a `GlobalChangeLog` file, look for the next entry in the file, and open in another window the source file in which the corresponding comment resides, positioning the corresponding comment at the top of the screen. This allows going through a section of the `GlobalChangeLog` file checking all the corresponding comments in the different files in which they occur.

10.13 Generating program documentation

These commands provide some bindings and facilities for generating and viewing the documentation corresponding to the current buffer. The documentation is generated in a temporary directory, which is created automatically. This is quite useful while modifying the documentation for a file, in order to check the output that will be produced, whithout having to set up a documentation directory by hand or to regenerate a large manual of which the file may be a part.

⟨C-c⟩ ⟨D⟩ ⟨B⟩ Generate the documentation for the current buffer in the default format. This allows generating a simple document for the current buffer. Basically, it creates a simple, default `SETTINGS.pl` file, sets `mainfile` in `SETTINGS.pl` to the current buffer and then generates the documentation in a temporary directory. This is useful for seeing how the documentation of a file will format. Note that for generating manuals the best approach is to set up a permanent documentation directory with the appropriate `SETTINGS.pl` file (see the LPdoc manual).

⟨C-c⟩ ⟨D⟩ ⟨F⟩ Change the default output format used by the LPdoc auto-documenter. It is set by default to `html` or to the environment variable `LPDOCFORMAT` if it is defined.

⟨C-c⟩ ⟨D⟩ ⟨S⟩ Visit, or create, the default `SETTINGS.pl` file (which controls all auto-documenter options).

⟨C-c⟩ ⟨D⟩ ⟨G⟩

Generate the documentation according to `SETTINGS.pl` in the default format. This allows generating complex documents but it assumes that `SETTINGS.pl` exists and that the options that it contains (main file, component files, paths, etc.) have been set properly. Documentation is generated in a temporary directory. Note however that for generating complex manuals the best approach is to set up a permanent documentation directory with the appropriate `SETTINGS.pl` and `Makefile` files (see the LPdoc manual).

⟨C-c⟩ ⟨D⟩ ⟨V⟩

Start a viewer on the documentation for the current buffer in the default format.

⟨C-c⟩ ⟨D⟩ ⟨W⟩
Change the root working dir used by the LPdoc auto-documenter. It is set by default to a new dir under `/tmp` or to the environment variable `LPDOCWDIR` if it is defined.

10.14 Setting top level preprocessor and documenter executables

These commands allow *changing the executables used* when starting the top-level, the preprocessor, or the auto-documenter. They also allow changing the arguments that these executables take, and changing the path where the libraries reside. In the case of the top-level and preprocessor, this should be done only by users which understand the implications, but it is very useful if several versions of Ciao or the preprocessor are available in the system. All these settings can be changed through the *customize* options in the help menu (see Section 10.20 [Customization], page 80).

⟨C-c⟩ ⟨S⟩ ⟨A⟩

⟨C-c⟩ ⟨S⟩ ⟨C⟩ Change the Ciao executable used to run the top level. It is set by default to `ciao` or, to the environment variable `CIAO` if it is defined.

⟨C-c⟩ ⟨S⟩ ⟨C-c⟩
Change the arguments passed to the Ciao executable. They are set by default to none or, to the environment variable `CIAOARGS` if it is defined.

⟨C-c⟩ ⟨S⟩ ⟨P⟩ Change the executable used to run the Ciao Preprocessor toplevel. It is set by default to `ciaopp` or, to the environment variable `CIAOPP` if it is defined.

⟨C-c⟩ ⟨S⟩ ⟨C-p⟩
Change the arguments passed to the Ciao preprocessor executable. They are set by default to none or to the environment variable `CIAOPPARGS` if it is defined.

⟨C-c⟩ ⟨S⟩ ⟨L⟩ Change the location of the Ciao library paths (changes the environment variable `CIAOLIB`).

⟨C-c⟩ ⟨S⟩ ⟨D⟩ Change the executable used to run the LPdoc auto-documenter. It is set by default to `lpdoc` or to the environment variable `LPDOC` if it is defined.

⟨C-c⟩ ⟨S⟩ ⟨C-d⟩
Change the arguments passed to the LPdoc auto-documenter. They are set by default to none or to the environment variable `LPDOCARGS` if it is defined.

⟨C-c⟩ ⟨S⟩ ⟨C-l⟩
Change the path in which the LPdoc library is installed. It is set by default to `/home/clip/lib` or to the environment variable `LPDOCLIB` if it is defined.

10.15 Other commands

Some other commands which are active in the Ciao mode:

⟨C-c⟩ ⟨C-l⟩ Recenter the most recently used Ciao inferior process buffer (top level or preprocessor).

10.16 Traditional Prolog Mode Commands

These commands provide some bindings and facilities for loading programs, which are present in emacs Prolog modes of traditional Prolog systems (e.g., SICStus). This is useful mainly if the Ciao emacs mode is used with such Prolog systems. Note that these commands (`compile/1` and `consult/1`) are deprecated in Ciao (due to the more advanced, separate compilation model in Ciao) and their use in the Ciao top-level is not recommended.

⟨C-c⟩ ⟨K⟩ Compile the entire buffer.

⟨C-c⟩ ⟨k⟩ Compile a given region.

⟨C-c⟩ ⟨C-k⟩ Compile the predicate around point.

⟨C-c⟩ ⟨C⟩ Consult the entire buffer.

⟨C-c⟩ ⟨c⟩ Consult a given region.

⟨C-c⟩ ⟨C-c⟩ Consult the predicate around point.

10.17 Coexistence with other Prolog-like interfaces

As mentioned previously, the Ciao `emacs` interface can also be used to work with traditional Prolog or CLP systems. Also, the Ciao `emacs` interface (*mode*) can coexist with other Prolog-related `emacs` interfaces (*modes*) (such as, e.g., the `SICStus` Prolog interface). Only one of the interfaces can be active at a time for a given buffer (i.e., for each given file opened inside `emacs`). In order the change a buffer to a given interface, move the cursor to that buffer and type `M-x ...-mode` (e.g., for the Ciao mode, `M-x ciao-mode`).

If several Prolog-related `emacs` interfaces are loaded, then typically the *last* one to be loaded takes precedence, in the sense that this will be the interface in which `emacs` will be set when opening files which have a `.pl` ending (this depends a bit on how things are set up in your `.emacs` file).

10.18 Getting the Ciao mode version

⟨C-c⟩ ⟨v⟩ Report the version of the emacs Ciao mode.

10.19 Using Ciao mode capabilities in standard shells

The capabilities (commands, coloring, error location, ...) which are active in the Ciao *inferior* mode can also be made available in any standard command line shell which is being run within emacs. This can be enabled by going to the buffer in which the shell is running and typing "⟨M-x⟩ `ciao-inferior-mode`". This is very useful for example when running the stand-alone compiler, the `lpdoc` auto-documenter, or even certain user applications (those that use the standard error message library) in an emacs sub-shell. Turning the Ciao inferior mode on on that sub-shell will highlight and color the error messages, and automatically find and visit the locations in the files in which the errors are reported.

Finally, one the most useful applications of this is when using the embedded debugger (a version of the debugger which can be embedded into executables so that an interactive debugging session can be triggered at any time while running that executable without needing the top-level shell). If an application is run in a shell buffer which has been set with Ciao inferior mode (⟨M-x⟩ `ciao-inferior-mode`) and this application starts emitting output from the embedded debugger (i.e., which contains the embedded debugger and is debugging its code) then the Ciao emacs mode will be able to follow these messages, for example tracking execution in the source level code. This also works if the application is written in a combination of languages, provided the

parts written in Ciao are compiled with the embedded debugger package and is thus a covenient way of debugging multi-language applications. The only thing needed is to make sure that the output messages appear in a shell buffer that is in Ciao inferior mode.

10.20 Customization

This section explains all variables used in the Ciao emacs mode which can be customized by users. Such customization can be performed (in later versions of `emacs`) from the `emacs` menus (`Help -> Customize -> Top-level Customization Group`), or also by adding a `setq` expression in the `.emacs` file. Such `setq` expression should be similar to:

```
(setq <variable> <new_value>)
```

The following sections list the different variables which can be customized for `ciao`, `ciaopp` and `lpdoc`.

10.20.1 Ciao general variables

`ciao-ask-for-version-maintenance-type` (*string*)
: If turned to yes the system asks prompts to set version control when saving files that do not set a version control system explicitly within the file.

`ciao-clip-logo` (*file*)
: CLIP logo image.

`ciao-create-sample-file-on-startup` (*boolean*)
: When starting the Ciao environment using ciao-startup two buffers are opened: one with a toplevel and another with a sample file. This toggle controls whether the sample file, meant for novice users, is created or not. Set by default, non-novice users will probably want to turn it off.

`ciao-indent-width` (*integer*)
: Indentation for a new goal.

`ciao-inhibit-toolbar` (*boolean*)
: *Non-nil means don't use the specialized Ciao toolbar.

`ciao-library-path` (*string*)
: Path to the Ciao System libraries (reads/sets the CIAOLIB environment variable). Typically left empty, since ciao executables know which library to use.

`ciao-locate-also-note-messages` (*boolean*)
: If set, also when errors of type NOTE are detected the corresponding file is visited and the location marked. It is set to nil by default because sometimes the user prefers not to take any action with respect to these messages (for example, many come from the documenter, indicating that adding certain declarations the documentation would be improved).

`ciao-locate-errors-after-run` (*boolean*)
: If set, location of any errors produced when running Ciao tools (loading or preprocessing code, running the documenter, etc.) will be initiated automatically. I.e., after running a command, the system will automatically highlight any error messages and the corresponding areas in source files if possible. If set to nil this location will only happen after typing C-c ‘ or accessing the corresponding menu or tool bar button.

`ciao-logo` (*file*)
: Ciao logo image.

`ciao-main-filename` (*string*)
Name of main file in a multiple module program. Setting thsi is very useful when working on a multi-module program because it allows issuing a load command after working on an inferior module which will reload from the main module, thus also reloading automatically all dependent modules.

`ciao-os-shell-prompt-pattern` (*string*)
Regular expression used to describe the shell prompt pattern, so that error location works in inferior shells. This is useful for example so that errors are located when generating documentation, and also when using the embedded debugger or any other application in a shell. It is best to be as precise as possible when defining this so that the standard Ciao error location does not get confused.

`ciao-query` (*string*)
Query to use in Ciao. Setting this is useful when using a long or complicated query because it saves from having to type it over and over again. It is possible to set that this query will be issued any time a program is (re)loaded.

`ciao-system` (*string*)
Name of Ciao executable which runs the classical top level.

`ciao-system-args` (*string*)
Arguments passed to Ciao toplevel executable.

`ciao-toplevel-buffer-name` (*string*)
Basic name of the buffer running the Ciao toplevel inferior process.

`ciao-user-directives` (*list*)
List of identifiers of any directives defined by users which you would like highlighted (colored). Be careful, since wrong entries may affect other syntax highlighting.

10.20.2 CiaoPP variables

`ciao-ciaopp-buffer-name` (*string*)
Basic name of the buffer running the Ciao preprocessor inferior process.

`ciao-ciaopp-gmenu-buffer-name` (*string*)
Basic name of the buffer running the Ciao preprocessor graphical menu interface.

`ciao-ciaopp-system` (*string*)
Name of Ciao preprocessor executable.

`ciao-ciaopp-system-args` (*string*)
Arguments passed to Ciao preprocessor executable.

`ciao-ciaopp-use-graphical-menu` (*boolean*)
If set, an interactive graphical menu is used for controlling CiaoPP, instead of asking ascii questions in the CiaoPP buffer.

10.20.3 LPdoc variables

`ciao-lpdoc-buffer-name` (*string*)
Basic name of the buffer running the auto-documenter inferior process.

`ciao-lpdoc-docformat` (*symbol*)
Name of default output format used by LPdoc.

`ciao-lpdoc-libpath` (*directory*)
Path in which the LPdoc library is installed.

`ciao-lpdoc-system` (*string*)
Name of LPdoc auto-documenter executable.

`ciao-lpdoc-system-args` (*string*)
Arguments passed to LPdoc executable.

`ciao-lpdoc-wdir-root` (*directory*)
Name of root working dir used by LPdoc.

10.20.4 Faces used in syntax-based highlighting (coloring)

`ciao-button-pressed-widget-face` (*face*)
Face used for documentation text.

`ciao-button-widget-face` (*face*)
Face used for documentation text.

`ciao-edit-widget-face` (*face*)
Face used for documentation text.

`ciao-face-answer-val` (*face*)
Face to use for answer values in top level.

`ciao-face-answer-var` (*face*)
Face to use for answer variables in top level.

`ciao-face-builtin-directive` (*face*)
Face to use for the standard directives.

`ciao-face-check-assrt` (*face*)
Face to use for check assertions.

`ciao-face-checked-assrt` (*face*)
Face to use for checked assertions.

`ciao-face-ciaopp-option` (*face*)
Face to use for CiaoPP option menus.

`ciao-face-clauseheadname` (*face*)
Face to use for clause head functors.

`ciao-face-comment` (*face*)
Face to use for code comments using fixed pitch (double %).

`ciao-face-comment-variable-pitch` (*face*)
Face to use for code comments using variable pitch (single %).

`ciao-face-concurrency-op` (*face*)
Face to use for concurrency operators.

`ciao-face-condcode-directive` (*face*)
Face to use for the conditional code directives.

`ciao-face-cut` (*face*)
Face to use for cuts.

`ciao-face-debug-breakpoint` (*face*)
Face to use with breakpoints in source debugger.

`ciao-face-debug-call` (*face*)
Face to use when at call port in source debugger.

`ciao-face-debug-exit` (*face*)
Face to use when at exit port in source debugger.

`ciao-face-debug-expansion` (*face*)
Face to use in source debugger when source literal not located.

`ciao-face-debug-fail` (*face*)
Face to use when at fail port in source debugger.

`ciao-face-debug-mess` (*face*)
Face to use for debug messages.

`ciao-face-debug-redo` (*face*)
Face to use when at redo port in source debugger.

`ciao-face-entry-assrt` (*face*)
Face to use for entry assertions.

`ciao-face-error-mess` (*face*)
Face to use for error messages.

`ciao-face-false-assrt` (*face*)
Face to use for false assertions.

`ciao-face-fontify-sectioning` (*symbol*)
Whether to fontify sectioning macros with varying height or a color face.

If it is a number, use varying height faces. The number is used for scaling starting from 'ciao-face-sectioning-5-face'. Typically values from 1.05 to 1.3 give best results, depending on your font setup. If it is the symbol 'color', use 'font-lock-type-face'.

Caveats: Customizing the scaling factor applies to all sectioning faces unless those face have been saved by customize. Setting this variable directly does not take effect unless you call 'ciao-face-update-sectioning-faces' or restart Emacs.

Switching from 'color' to a number or vice versa does not take effect unless you call M-x font-lock-fontify-buffer or restart Emacs.

`ciao-face-funexp-atom` (*face*)
Face to use for atoms in functional notation.

`ciao-face-highlight-code` (*face*)
Face to use for highlighting code areas (e.g., when locating the code area that an error message refers to).

`ciao-face-library-directive` (*face*)
Face to use for directives defined in the library.

`ciao-face-lpdoc-bug-comment` (*face*)
Face to use for LPdoc bug comments.

`ciao-face-lpdoc-command` (*face*)
Face to use LPdoc commands inserted in documentation text.

`ciao-face-lpdoc-comment` (*face*)
Face to use for LPdoc textual comments.

`ciao-face-lpdoc-comment-variable-pitch` (*face*)
Face to use for LPdoc textual comments in variable pitch.

`ciao-face-lpdoc-crossref` (*face*)
Face to use for LPdoc cross-references.

`ciao-face-lpdoc-include` (*face*)
Face to use for LPdoc include commands.

`ciao-face-lpdoc-verbatim` (*face*)
Face to use for LPdoc verbatim text.

`ciao-face-lpdoc-version-comment` (*face*)
Face to use for LPdoc version comments.

`ciao-face-modedef-assrt` (*face*)
Face to use for modedef definitions.

`ciao-face-module-directive` (*face*)
Face to use for the module-related directives.

`ciao-face-no-answer` (*face*)
Face to use for no answer in top level.

`ciao-face-note-mess` (*face*)
Face to use for note messages.

`ciao-face-other-mess` (*face*)
Face to use for other messages.

`ciao-face-predicate-directive` (*face*)
Face to use for the predicate-related directives.

`ciao-face-prompt` (*face*)
Face to use for prompts in top-level and shells.

`ciao-face-prop-assrt` (*face*)
Face to use for property definitions.

`ciao-face-quoted-atom` (*face*)
Face to use for quoted atoms.

`ciao-face-script-header` (*face*)
Face to use for script headers.

`ciao-face-sectioning-0-face` (*face*)
Face for sectioning commands at level 0.

Probably you don't want to customize this face directly. Better change the base face 'ciao-face-sectioning-5-face' or customize the variable 'ciao-face-fontify-sectioning'.

`ciao-face-sectioning-1-face` (*face*)
Face for sectioning commands at level 1.

Probably you don't want to customize this face directly. Better change the base face 'ciao-face-sectioning-5-face' or customize the variable 'ciao-face-fontify-sectioning'.

`ciao-face-sectioning-2-face` (*face*)
Face for sectioning commands at level 2.

Probably you don't want to customize this face directly. Better change the base face 'ciao-face-sectioning-5-face' or customize the variable 'ciao-face-fontify-sectioning'.

`ciao-face-sectioning-3-face` (*face*)
Face for sectioning commands at level 3.

Probably you don't want to customize this face directly. Better change the base face 'ciao-face-sectioning-5-face' or customize the variable 'ciao-face-fontify-sectioning'.

`ciao-face-sectioning-4-face` (*face*)
Face for sectioning commands at level 4.

Probably you don't want to customize this face directly. Better change the base face 'ciao-face-sectioning-5-face' or customize the variable 'ciao-face-fontify-sectioning'.

`ciao-face-sectioning-5-face` (*face*)
Face for sectioning commands at level 5.

`ciao-face-startup-mess` (*face*)
Face to use for system splash message.

`ciao-face-string` (*face*)
Face to use for strings.

`ciao-face-test-assrt` (*face*)
Face to use for test assertions.

`ciao-face-texec-assrt` (*face*)
Face to use for texec assertions.

`ciao-face-true-assrt` (*face*)
Face to use for true assertions.

`ciao-face-trust-assrt` (*face*)
Face to use for trust assertions.

`ciao-face-type-assrt` (*face*)
Face to use for type definitions.

`ciao-face-user-directive` (*face*)
Face to use for directives defined by the user (see ciao-user-directives custom variable to add new ones).

`ciao-face-variable` (*face*)
Face to use for variables.

`ciao-face-warning-mess` (*face*)
Face to use for warning messages.

`ciao-face-yes-answer` (*face*)
Face to use for yes answer in top level.

`ciao-faces-use-variable-pitch-in-comments` (*boolean*)
Controls whether variable pitch fonts are used when highlighting comments. Unset by default. After changing this you must exit and reinitialize for the change to take effect.

`ciao-menu-error-widget-face` (*face*)
Face used for menu error representation in graphical interface.

`ciao-menu-note-widget-face` (*face*)
Face used for menu note representation in graphical interface.

`ciao-text-widget-face` (*face*)
Face used for documentation text.

10.21 Installation of the Ciao emacs interface

If opening a file ending with `.pl` puts emacs in another mode (such as `perl` mode, which is the –arguably incorrect– default setting in some `emacs` distributions), then either the emacs mode was not installed or the installation settings are being overwritten by other settings in your `.emacs` file or in some library. In any case, you can set things manually so that the Ciao mode is loaded by default in your system. This can be done by including in your `.emacs` file a line such as:

```
(load <CIAOLIBDIR>/ciao-mode-init)
```

This loads the above mentioned file from the Ciao library, which contains the following lines (except that the paths are changed during installation to appropriate values for your system):

```
; -*- mode: emacs-lisp; -*-
;;
;; Ciao/Prolog mode initialization
;; -------------------------------
;; (can normally be used with other Prolog modes and the default prolog.el)
;;
(setq load-path (cons <v>CIAOLIBDIR</v> load-path))
;; Java mode in ciao
(setq load-path
   (cons <v>CIAOLIBDIR</v> load-path))
(defun load-java-ciaopp-mode ()
  (require 'java-ciaopp)
  (java-ciaopp-setup))
(add-hook 'java-mode-hook 'load-java-ciaopp-mode)

(autoload 'run-ciao-toplevel "ciao"
          "Start a Ciao/Prolog top-level sub-process." t)
(autoload 'ciao-startup "ciao"
          "The Ciao/Prolog program development system startup screens." t)
(autoload 'ciao "ciao"
          "Start a Ciao/Prolog top-level sub-process." t)
(autoload 'prolog "ciao"
          "Start a Ciao/Prolog top-level sub-process." t)
(autoload 'run-ciao-preprocessor "ciao"
          "Start a Ciao/Prolog preprocessor sub-process." t)
(autoload 'ciaopp "ciao"
          "Start a Ciao/Prolog preprocessor sub-process." t)
(autoload 'ciao-mode "ciao"
          "Major mode for editing and running Ciao/Prolog" t)
(autoload 'ciao-inferior-mode "ciao"
          "Major mode for running Ciao/Prolog, CiaoPP, LPdoc, etc." t)
(setq auto-mode-alist (cons '("\\.pl$" . ciao-mode) auto-mode-alist))
(setq auto-mode-alist (cons '("\\.pls$" . ciao-mode) auto-mode-alist))
(setq auto-mode-alist (cons '("\\.lpdoc$" . ciao-mode) auto-mode-alist))
(setq completion-ignored-extensions
      (append '(".dep" ".itf" ".po" ".asr" ".cpx")
              completion-ignored-extensions))
;; ---------------------------------------------------------------------------
;; In Un*x, the following (or similar) lines should be included in your
;; .cshrc or .profile to find the manuals (the Ciao installation leaves
;; in the Ciao library directory 'DOTcshrc' and 'DOTprofile' files with
;; the right paths which can be included directly in your startup scripts):
;;
;; setenv INFOPATH /usr/local/info:/usr/info:<v>LPDOCDIR</v>
;; ---------------------------------------------------------------------------
```

If you would like to configure things in a different way, you can also copy the contents of this file to your `.emacs` file and make the appropriate changes. For example, if you do not want `.pl` files to be put automatically in Ciao mode, then comment out (or remove) the line:

```
(setq auto-mode-alist ... )
```

You will then need to switch manually to Ciao mode by typing `M-x ciao-mode` after opening a Ciao file.

If you are able to open the Ciao menu but the Ciao manuals are not found or the `ciao` command (the top-level) is not found when loading `.pl` files, the probable cause is that you do not have the Ciao paths in the `INFOPATH` and `MANPATH` *environment variables* (whether these variables are set automatically or not for users depends on how the Ciao system was installed). Under Un*x, you can add these paths easily by including the line:

```
source <CIAOLIBDIR>/DOTcshrc
```

in your `.login` or `.cshrc` files if you are using `csh` (or `tcsh`, etc.), or, alternatively, the line:

```
. <CIAOLIBDIR>/DOTprofile
```

in your `.login` or `.profile` files if you are using `sh` (or `bash`, etc.). See the Ciao installation instructions (Chapter 229 [Installing Ciao from the source distribution], page 1099 or Chapter 230 [Installing Ciao from a Win32 binary distribution], page 1109) for details.

10.22 Emacs version compatibility

This mode is currently being developed within `GNU emacs` version 21.3. It should also (hopefully) work with all other 21.XX, 20.XX, and later 19.XX versions. We also try our best to keep things working under `xemacs` and under the diverse emacs native ports for the mac.

10.23 Acknowledgments (ciao.el)

This code is derived from the 1993 version of the emacs interface for &-Prolog by M. Hermenegildo, itself derived from the original `prolog.el` by *Masanobu Umeda* with changes by *Johan Andersson*, *Peter Olin*, *Mats Carlsson*, and *Johan Bevemyr* of *SICS*, Sweden. Other changes also by Daniel Cabeza and Manuel C. Rodriguez. See the changelog for details.

PART II - The Ciao basic language (engine)

Author(s): The CLIP Group.

This part documents the *Ciao basic builtins*. These predefined predicates and declarations are available in every program, unless the `pure` package is used (by using a `:- module(_,_,[pure]).` declaration or `:- use_package(pure).`). These predicates are contained in the `engine` directory within the `lib` library. The rest of the library predicates, including the packages that provide most of the ISO-Prolog builtins, are documented in subsequent parts.

11 The module system

Author(s): Daniel Cabeza, The CLIP Group.

Modularity is a basic notion in a modern computer language. Modules allow dividing programs in several parts, which have its own independent name spaces. The module system in Ciao [CH00a], as in many other Prolog implementations, is procedure based. This means that predicate names are local to a module, but functor/atom names in data are shared (at least by default).

The predicates visible in a module are the predicates defined in that module, plus the predicates imported from other modules. Only predicates exported by a module can be imported from other modules. The default module of a given predicate name is the local one if the predicate is defined locally, else the last module from which the predicate is imported, where explicit imports have priority over implicit ones (that is, a predicate imported through a `use_module/2` declaration is always preferred over a predicate imported through a `use_module/1` declaration). To refer to a predicate from a module which is not the default module for that predicate the name has to be module qualified. A module qualified predicate name has the form `Module:Predicate` as in the call `debugger:debug_module(M)`. Note that in Ciao this module qualification cannot be used for gaining access to predicates that have not been imported, nor for defining clauses of other modules.

All predicates defined in files with no module declaration belong to a special module called `user`, from which they are all implicitly exported. This provides backward compatibility for programs written for implementations with no module system and allows dividing programs into several files without being aware of the module system at all. Note that this feature is only supported for the above-mentioned backward-compatibility reasons, and the use of `user` files is discouraged. Many attractive compilation features of Ciao cannot be supported for `user` modules.

The case of multifile predicates (defined with the declaration `multifile/1`) is also special. Multifile predicates can be defined by clauses distributed in several modules, and all modules which define a predicate as multifile can use that predicate. The name space of multifile predicates is independent, as if they belonged to the special module `multifile`.

Every `user` or module file imports implicitly a number of modules called builtin modules. They are imported before all other importations of the module, thus allowing the redefinition of any of their predicates (with the exception of `true/0`) by defining local versions or importing them from other modules. Importing explicitly from a builtin module, however, disables the implicit importation of the rest (this feature is used by package `library(pure)` to define pure Prolog code).

11.1 Usage and interface (`modules`)

- **Library usage:**
  Modules are an intrinsic feature of Ciao, so nothing special has to be done to use them.

11.2 Documentation on internals (`modules`)

module/3: DECLARATION

Usage: `:- module(Name,Exports,Packages).`

– *Description:* Declares a module of name `Name` which exports the predicates in `Exports`, and uses the packages in `Packages`. `Name` must match with the name of the file where the module resides, without extension. For each source in `Packages`, a package file is used. If the source is specified with a path alias, this is the file included, if it is an atom, the library paths are searched. See `package/1` for a brief description of package files.

  This directive must appear the first in the file.

  Also, if the compiler finds an unknown declaration as the first term in a file, the name of the declaration is regarded as a package library to be included, and the arguments of the declaration (if present) are interpreted like the arguments of `module/3`.

– *The following properties hold at call time:*

  `Name` is a module name (an atom). (modules:modulename/1)

  `Exports` is a list of `prednames`. (basic_props:list/2)

  `Packages` is a list of `sourcenames`. (basic_props:list/2)

module/2: DECLARATION

Usage: `:- module(Name,Exports).`

– *Description:* Same as directive `module/3`, with an implicit package `default`. This default package provides all the standard features provided by most Prolog systems so that Prolog programs with traditional `module/2` declarations can run without any change.

– *The following properties hold at call time:*

  `Name` is a module name (an atom). (modules:modulename/1)

  `Exports` is a list of `prednames`. (basic_props:list/2)

package/1: DECLARATION

Usage: `:- package(Name).`

– *Description:* Declares a package of name `Name`. Like in modules, `Name` must match with the name of the file where the package resides, without extension. This directive must appear the first in the file.

  Package files provide syntactic extensions and their related functionalities by defining operators, new declarations, code translations, etc., as well as declaring imports from other modules and defining additional code. Most Ciao syntactic and semantic extensions, such as functional syntax, constraint solving, or breadth-first search are implemented as packages.

– *The following properties hold at call time:*

  `Name` is a module name (an atom). (modules:modulename/1)

export/1: DECLARATION

Usage 1: `:- export(Pred).`

– *Description:* Adds `Pred` to the set of exported predicates.

– *The following properties hold at call time:*

  `Pred` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

Usage 2: :- `export(Exports)`.

- *Description:* Adds `Exports` to the set of exported predicates.
- *The following properties hold at call time:*

  `Exports` is a list of `prednames`. (basic_props:list/2)

use_module/2: DECLARATION

Usage: :- `use_module(Module,Imports)`.

- *Description:* Specifies that this code imports from the module defined in `Module` the predicates in `Imports`. The imported predicates must be exported by the other module.
- *The following properties hold at call time:*

  `Module` is a source name. (streams_basic:sourcename/1)

  `Imports` is a list of `prednames`. (basic_props:list/2)

use_module/1: DECLARATION

Usage: :- `use_module(Module)`.

- *Description:* Specifies that this code imports from the module defined in `Module` all the predicates exported by it. The previous version with the explicit import list is preferred to this as it minimizes the chances to have to recompile this code if the other module changes.
- *The following properties hold at call time:*

  `Module` is a source name. (streams_basic:sourcename/1)

import/2: DECLARATION

Usage: :- `import(Module,Imports)`.

- *Description:* Declares that this code imports from the module with name `Module` the predicates in `Imports`.

  Important note: this declaration is intended to be used when the current module or the imported module is going to be dynamically loaded, and so the compiler does not include the code of the imported module in the current executable (if only because the compiler cannot know the location of the module file at the time of compilation). For the same reason the predicates imported are not checked to be exported by `Module`. Its use in other cases is strongly discouraged, as it disallows many compiler optimizations.
- *The following properties hold at call time:*

  `Module` is a module name (an atom). (modules:modulename/1)

  `Imports` is a list of `prednames`. (basic_props:list/2)

reexport/2: DECLARATION

Usage: :- `reexport(Module,Preds)`.

- *Description:* Specifies that this code reexports from the module defined in `Module` the predicates in `Preds`. This implies that this module imports from the module defined in `Module` the predicates in `Preds`, an also that this module exports the predicates in `Preds` .
- *The following properties hold at call time:*

  `Module` is a source name. (streams_basic:sourcename/1)

  `Preds` is a list of `prednames`. (basic_props:list/2)

reexport/1: DECLARATION

Usage: :- `reexport(Module)`.

- *Description:* Specifies that this code reexports from the module defined in `Module` all the predicates exported by it. This implies that this module imports from the module defined in `Module` all the predicates exported by it, an also that this module exports all such predicates .
- *The following properties hold at call time:*

  `Module` is a source name. (streams_basic:sourcename/1)

meta_predicate/1: DECLARATION

Usage: :- `meta_predicate MetaSpecs`.

- *Description:* Specifies that the predicates in `MetaSpecs` have arguments which has to be module expanded (predicates, goals, etc). The directive is only mandatory for exported predicates (in modules). This directive is defined as a prefix operator in the compiler.
- *The following properties hold at call time:*

  `MetaSpecs` is a sequence of `metaspecs`. (basic_props:sequence/2)

modulename/1: REGTYPE

A module name is an atom, not containing characters ':' or '$'. Also, `user` and `multifile` are reserved, as well as the module names of all builtin modules (because in an executable all modules must have distinct names).

Usage: `modulename(M)`

- *Description:* `M` is a module name (an atom).

metaspec/1: REGTYPE

A meta-predicate specification for a predicate is the functor of that predicate applied to terms which represent the kind of module expansion that should be applied to each argument. Possible contents are represented as:

`?,+,-,_` These values denote that this argument is not module expanded.

`goal` This argument will be a term denoting a goal (either a simple or complex one) which will be called. For commpatibility reasons it can be named as `:` as well.

`clause` This argument will be a term denoting a clause.

`fact` This argument should be instantiated to a term denoting a fact (head-only clause).

`spec` This argument should be instantiated to a predicate name, as Functor/Arity.

`pred(`*N*`)` This argument should be instantiated to a predicate construct to be called by means of a `call/`*N* predicate call (see `call/2`).

`list(`*Meta*`)`
This argument should be instantiated to a list of terms as described by *Meta* (e.g. `list(goal)`).

`addterm(Meta)`
This argument should be instantiated to the meta-data specified by *Meta*, and an argument added after this one will carry the original data without module expansion. Not intended to be used by normal users.

`addmodule(Meta)`
This argument should be instantiated to the meta-data specified by *Meta*, and in an argument added after this one will be passed the calling module, for example to allow handling more involved meta-data by using conversion builtins. `addmodule` is an alias of `addmodule(?)`. Not intended to be used by normal users.

Usage: `metaspec(M)`

– *Description:* `M` is a meta-predicate specification.

12 Directives for using code in other files

Author(s): Daniel Cabeza.

Documentation for the directives used to load code into Ciao Prolog (both from the toplevel shell and by other modules).

12.1 Usage and interface (`loading_code`)

- **Library usage:**
  These directives are builtin in Ciao, so nothing special has to be done to use them.

12.2 Documentation on internals (`loading_code`)

ensure_loaded/1: DECLARATION

Usage: `:- ensure_loaded(File).` ⟨• ISO •⟩

- *Description:* Specifies that the code present in `File` will be included in the executable being prepared, in the `user` module. The file `File` cannot have a module declaration. This directive is intended to be used by programs not divided in modules. Dividing programs into modules is however strongly encouraged, since most of the attractive features of Ciao (such as static debugging and global optimization) are only partially available for `user` modules.
- *The following properties should hold at call time:*
  `File` is a source name. (streams_basic:sourcename/1)

include/1: DECLARATION

Usage: `:- include(File).` ⟨• ISO •⟩

- *Description:* The contents of the file `File` are included in the current program text exactly as if they had been written in place of this directive.
- *The following properties should hold at call time:*
  `File` is a source name. (streams_basic:sourcename/1)

use_package/1: DECLARATION

`:- use_package(Package).`

Specifies the use in this file of the packages defined in `Package`. See the description of the third argument of `module/3` for an explanation of package files.

This directive must appear the first in the file, or just after a `module/3` declaration. A file with no module declaration, in the absence of this directive, uses an implicit package `default` (see Chapter 31 [Other predicates and features defined by default], page 211).

Usage 1: `:- use_package(Package).`

- *The following properties should hold at call time:*
  `Package` is a source name. (streams_basic:sourcename/1)

Usage 2: `:- use_package(Package).`

- *The following properties should hold at call time:*
  `Package` is a list of `sourcenames`. (basic_props:list/2)

13 Control constructs/predicates

Author(s): Daniel Cabeza, Manuel Hermenegildo.

This module contains the set of basic control predicates, except the predicates dealing with exceptions, which are in Chapter 23 [Exception and Signal handling], page 177.

13.1 Usage and interface (basiccontrol)

- **Library usage:**
  These predicates/constructs are builtin in Ciao, so nothing special has to be done to use them. In fact, as they are hardwired in some parts of the system, most of them cannot be redefined.
- **Exports:**
  - *Predicates:*
    `,/2`, `;/2`, `->/2`, `!/0`, `\+/1`, `if/3`, `true/0`, `fail/0`, `repeat/0`, `false/0`, `otherwise/0`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`, `debugger/debugger`.

13.2 Documentation on exports (basiccontrol)

,/2: PREDICATE

`P,Q`

Conjunction (`P` *and* `Q`).

Meta-predicate with arguments: `goal,goal`.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
  `Q` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

;/2: PREDICATE

`P;Q`

Disjunction (`P` *or* `Q`). Note that in Ciao `|/2` is not equivalent to `;/2`.

Meta-predicate with arguments: `goal;goal`.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
  `Q` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

->/2: PREDICATE

`P->Q`

If `P` then `Q` else fail, using first solution of `P` only. Also, `(P -> Q ; R)`, if `P` then `Q` else `R`, using first solution of `P` only. No cuts are allowed in `P`.

Meta-predicate with arguments: `goal->goal`.

Usage: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`Q` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

!/0: PREDICATE

Usage: ⟨• ISO •⟩

– *Description:* Commit to any choices taken in the current predicate.

– *The following properties hold globally:*

All calls of the form `!` are deterministic. (native_props:is_det/1)

All the calls of the form `!` do not fail. (native_props:not_fails/1)

Goal `!` produces `1` solutions. (native_props:relations/2)

\+/1: PREDICATE

`\+P`

Goal `P` is not provable (negation by failure). Fails if `P` has a solution, and succeeds otherwise. No cuts are allowed in `P`.

Meta-predicate with arguments: `\+goal`.

Usage: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP as `not(X)`. (basic_props:native/2)

All calls of the form `\+P` are deterministic. (native_props:is_det/1)

if/3: PREDICATE

`if(P,Q,R)`

If `P` then `Q` else `R`, exploring all solutions of `P`. No cuts are allowed in `P`.

Meta-predicate with arguments: `if(goal,goal,goal)`.

Usage: `if(A,B,C)`

– *The following properties should hold at call time:*

`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`C` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`B` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`C` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties hold upon exit:*

`A` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`B` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`C` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

true/0: PREDICATE

General properties:

– *The following properties hold globally:*

`true` is evaluable at compile-time. (basic_props:eval/1)

Usage: ⟨• ISO •⟩

– *Description:* Succeed (noop).

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`true` is side-effect `free`. (basic_props:sideff/2)

All calls of the form `true` are deterministic. (native_props:is_det/1)

All the calls of the form `true` do not fail. (native_props:not_fails/1)

Goal `true` produces `1` solutions. (native_props:relations/2)

fail/0: PREDICATE

General properties:

– *The following properties hold globally:*

`fail` is evaluable at compile-time. (basic_props:eval/1)

– *The following properties hold globally:*

`fail` is equivalent to `fail`. (basic_props:equiv/2)

Usage: ⟨• ISO •⟩

– *Description:* Fail, backtrack immediately.

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`fail` is side-effect `free`. (basic_props:sideff/2)

All calls of the form `fail` are deterministic. (native_props:is_det/1)

Calls of the form `fail` fail. (native_props:fails/1)

Goal `fail` produces `0` solutions. (native_props:relations/2)

repeat/0: PREDICATE

Usage: ⟨• ISO •⟩

- *Description:* Generates an infinite sequence of backtracking choices.
- *The following properties hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

  `repeat` is side-effect `free`. (basic_props:sideff/2)

false/0: PREDICATE

General properties:

- *The following properties hold globally:*

  `false` is side-effect `free`. (basic_props:sideff/2)

  `false` is evaluable at compile-time. (basic_props:eval/1)

otherwise/0: PREDICATE

General properties:

- *The following properties hold globally:*

  `otherwise` is side-effect `free`. (basic_props:sideff/2)

  `otherwise` is evaluable at compile-time. (basic_props:eval/1)

13.3 Known bugs and planned improvements (`basiccontrol`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

14 Basic builtin directives

Author(s): Daniel Cabeza.

This chapter documents the basic builtin directives in Ciao, additional to the documented in other chapters. These directives are natively interpreted by the Ciao compiler (`ciaoc`).

Unlike in other Prolog systems, directives in Ciao are not goals to be *executed* by the compiler or top level. Instead, they are *read* and acted upon by these programs. The advantage of this is that the effect of the directives is consistent for executables, code loaded in the top level, code analyzed by the preprocessor, etc.

As a result, by default only the builtin directives or declarations defined in this manual can be used in user programs. However, it is possible to define new declarations using the `new_declaration/1` and `new_declaration/2` directives (or using packages including them). Also, packages may define new directives via code translations.

14.1 Usage and interface (`builtin_directives`)

- **Library usage:**
  These directives are builtin in Ciao, so nothing special has to be done to use them.

14.2 Documentation on internals (`builtin_directives`)

multifile/1: DECLARATION

Usage: :- `multifile Predicates.` ⟨• ISO •⟩

- *Description:* Specifies that each predicate in `Predicates` may have clauses in more than one file. Each file that contains clauses for a multifile predicate must contain a directive multifile for the predicate. The directive should precede all clauses of the affected predicates, and also dynamic/data declarations for the predicate. This directive is defined as a prefix operator in the compiler.
- *The following properties should hold at call time:*

  `Predicates` is a sequence or list of `prednames`. (basic_props:sequence_or_list/2)

discontiguous/1: DECLARATION

Usage: :- `discontiguous Predicates.` ⟨• ISO •⟩

- *Description:* Specifies that each predicate in `Predicates` may be defined in this file by clauses which are not in consecutive order. Otherwise, a warning is signaled by the compiler when clauses of a predicate are not consecutive (this behavior is controllable by the prolog flag *discontiguous_warnings*). The directive should precede all clauses of the affected predicates. This directive is defined as a prefix operator in the compiler.
- *The following properties should hold at call time:*

  `Predicates` is a sequence or list of `prednames`. (basic_props:sequence_or_list/2)

impl_defined/1: DECLARATION

Usage: :- `impl_defined(Predicates).`

– *Description:* Specifies that each predicate in `Predicates` is *impl*icitly *defined* in the current prolog source, either because it is a builtin predicate or because it is defined in a C file. Otherwise, a warning is signaled by the compiler when an exported predicate is not defined in the module or imported from other module.

– *The following properties should hold at call time:*

`Predicates` is a sequence or list of `prednames`. (basic_props:sequence_or_list/2)

redefining/1: DECLARATION

Usage: :- `redefining(Predicate).`

– *Description:* Specifies that this module redefines predicate `Predicate`, also imported from other module, or imports it from more than one module. This prevents the compiler giving warnings about redefinitions of that predicate. `Predicate` can be partially (or totally) uninstantiated, to allow disabling those warnings for several (or all) predicates at once.

– *The following properties should hold at call time:*

`Predicate` is *compatible* with `predname` (basic_props:compat/2)

initialization/1: DECLARATION

Usage: :- `initialization(Goal).` ⟨• ISO •⟩

– *Description:* `Goal` will be executed at the start of the execution of any program containing the current code. The initialization of a module/file never runs before the initializations of the modules from which the module/file imports (excluding circular dependences).

– *The following properties should hold at call time:*

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

on_abort/1: DECLARATION

Usage: :- `on_abort(Goal).`

– *Description:* `Goal` will be executed after an abort of the execution of any program containing the current code.

– *The following properties should hold at call time:*

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

15 Basic data types and properties

Author(s): Daniel Cabeza, Manuel Hermenegildo.

This library contains the set of basic properties used by the builtin predicates, and which constitute the basic data types and properties of the language. They can be used both as type testing builtins within programs (by calling them explicitly) and as properties in assertions.

15.1 Usage and interface (basic_props)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Properties:*
    `member/2`, `compat/2`, `inst/2`, `iso/1`, `deprecated/1`, `not_further_inst/2`, `sideff/2`, `regtype/1`, `native/1`, `native/2`, `no_rtcheck/1`, `eval/1`, `equiv/2`, `bind_ins/1`, `error_free/1`, `memo/1`, `filter/2`, `pe_type/1`.
  - *Regular Types:*
    `term/1`, `int/1`, `nnegint/1`, `flt/1`, `num/1`, `atm/1`, `struct/1`, `gnd/1`, `gndstr/1`, `constant/1`, `callable/1`, `operator_specifier/1`, `list/1`, `list/2`, `nlist/2`, `sequence/2`, `sequence_or_list/2`, `character_code/1`, `string/1`, `num_code/1`, `predname/1`, `atm_or_atm_list/1`, `flag_values/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`, `terms_check`.

15.2 Documentation on exports (basic_props)

term/1: REGTYPE

The most general type (includes all possible terms).

General properties: `term(X)`

- *The following properties hold globally:*
  `term(X)` is side-effect `free`. (basic_props:sideff/2)

`term(X)`

- *The following properties hold globally:*
  `term(X)` is evaluable at compile-time. (basic_props:eval/1)

`term(X)`

- *The following properties hold globally:*
  `term(X)` is equivalent to `true`. (basic_props:equiv/2)

Usage: `term(X)`

- *Description:* `X` is any term.
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

int/1: REGTYPE

The type of integers. The range of integers is `[-2^2147483616, 2^2147483616)`. Thus for all practical purposes, the range of integers can be considered infinite.

General properties: `int(T)`

– *The following properties hold globally:*

`int(T)` is side-effect `free`. (basic_props:sideff/2)

`int(T)`

– *If the following properties hold at call time:*

`T` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

`int(T)` is evaluable at compile-time. (basic_props:eval/1)

All calls of the form `int(T)` are deterministic. (native_props:is_det/1)

`int(T)`

– *The following properties hold upon exit:*

`T` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `int(T)`

– *Description:* `T` is an integer.

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

nnegint/1: REGTYPE

The type of non-negative integers, i.e., natural numbers.

General properties: `nnegint(T)`

– *The following properties hold globally:*

`nnegint(T)` is side-effect `free`. (basic_props:sideff/2)

`nnegint(T)`

– *If the following properties hold at call time:*

`T` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

`nnegint(T)` is evaluable at compile-time. (basic_props:eval/1)

`nnegint(T)`

– *The following properties hold upon exit:*

`T` is a non-negative integer. (basic_props:nnegint/1)

– *The following properties hold globally:*

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `nnegint(T)`

– *Description:* `T` is a non-negative integer.

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

flt/1: REGTYPE

The type of floating-point numbers. The range of floats is the one provided by the C `double` type, typically `[4.9e-324, 1.8e+308]` (plus or minus). There are also three special values: Infinity, either positive or negative, represented as `1.0e1000` and `-1.0e1000`; and Not-a-number, which arises as the result of indeterminate operations, represented as `0.Nan`

General properties: `flt(T)`

– *The following properties hold globally:*

`flt(T)` is side-effect `free`. (basic_props:sideff/2)

`flt(T)`

– *If the following properties hold at call time:*

`T` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

`flt(T)` is evaluable at compile-time. (basic_props:eval/1)

All calls of the form `flt(T)` are deterministic. (native_props:is_det/1)

`flt(T)`

– *The following properties hold upon exit:*

`T` is a float. (basic_props:flt/1)

– *The following properties hold globally:*

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `flt(T)`

– *Description:* `T` is a float.

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

num/1: REGTYPE

The type of numbers, that is, integer or floating-point.

General properties: `num(T)`

– *The following properties hold globally:*

`num(T)` is side-effect `free`. (basic_props:sideff/2)

`num(T)` is binding insensitive. (basic_props:bind_ins/1)

`num(T)`

– *If the following properties hold at call time:*

`T` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

`num(T)` is evaluable at compile-time. (basic_props:eval/1)

All calls of the form `num(T)` are deterministic. (native_props:is_det/1)

`num(T)`

– *The following properties hold upon exit:*

`T` is a number. (basic_props:num/1)

– *The following properties hold globally:*

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `num(T)`

- *Description:* `T` is a number.
- *The following properties hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

atm/1: REGTYPE

The type of atoms, or non-numeric constants. The size of atoms is unbound.

General properties: `atm(T)`

- *The following properties hold globally:*

  `atm(T)` is side-effect `free`. (basic_props:sideff/2)

`atm(T)`

- *If the following properties hold at call time:*

  `T` is currently a term which is not a free variable. (term_typing:nonvar/1)

  then the following properties hold globally:

  `atm(T)` is evaluable at compile-time. (basic_props:eval/1)

  All calls of the form `atm(T)` are deterministic. (native_props:is_det/1)

`atm(T)`

- *The following properties hold upon exit:*

  `T` is an atom. (basic_props:atm/1)
- *The following properties hold globally:*

  Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `atm(T)`

- *Description:* `T` is an atom.
- *The following properties hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

struct/1: REGTYPE

The type of compound terms, or terms with non-zeroary functors. By now there is a limit of 255 arguments.

General properties: `struct(T)`

- *The following properties hold globally:*

  `struct(T)` is side-effect `free`. (basic_props:sideff/2)

`struct(T)`

- *If the following properties hold at call time:*

  `T` is currently a term which is not a free variable. (term_typing:nonvar/1)

  then the following properties hold globally:

  `struct(T)` is evaluable at compile-time. (basic_props:eval/1)

`struct(T)`

- *The following properties hold upon exit:*

  `T` is a compound term. (basic_props:struct/1)

Usage: `struct(T)`

- *Description:* `T` is a compound term.
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

gnd/1: REGTYPE

The type of all terms without variables.

General properties: `gnd(T)`

- *The following properties hold globally:*
  `gnd(T)` is side-effect `free`. (basic_props:sideff/2)

`gnd(T)`

- *If the following properties hold at call time:*
  `T` is currently ground (it contains no variables). (term_typing:ground/1)
  then the following properties hold globally:
  `gnd(T)` is evaluable at compile-time. (basic_props:eval/1)
  All calls of the form `gnd(T)` are deterministic. (native_props:is_det/1)

`gnd(T)`

- *The following properties hold upon exit:*
  `T` is ground. (basic_props:gnd/1)
- *The following properties hold globally:*
  Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `gnd(T)`

- *Description:* `T` is ground.
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

gndstr/1: REGTYPE

General properties: `gndstr(T)`

- *The following properties hold globally:*
  `gndstr(T)` is side-effect `free`. (basic_props:sideff/2)

`gndstr(T)`

- *If the following properties hold at call time:*
  `T` is currently ground (it contains no variables). (term_typing:ground/1)
  then the following properties hold globally:
  `gndstr(T)` is evaluable at compile-time. (basic_props:eval/1)
  All calls of the form `gndstr(T)` are deterministic. (native_props:is_det/1)

`gndstr(T)`

- *The following properties hold upon exit:*
  `T` is a ground compound term. (basic_props:gndstr/1)

Usage: `gndstr(T)`

– *Description:* `T` is a ground compound term.
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

constant/1: REGTYPE

General properties: `constant(T)`

– *The following properties hold globally:*
`constant(T)` is side-effect `free`. (basic_props:sideff/2)

`constant(T)`

– *If the following properties hold at call time:*
`T` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`constant(T)` is evaluable at compile-time. (basic_props:eval/1)
All calls of the form `constant(T)` are deterministic. (native_props:is_det/1)

`constant(T)`

– *The following properties hold upon exit:*
`T` is an atomic term (an atom or a number). (basic_props:constant/1)

Usage: `constant(T)`

– *Description:* `T` is an atomic term (an atom or a number).

callable/1: REGTYPE

General properties: `callable(T)`

– *The following properties hold globally:*
`callable(T)` is side-effect `free`. (basic_props:sideff/2)

`callable(T)`

– *If the following properties hold at call time:*
`T` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`callable(T)` is evaluable at compile-time. (basic_props:eval/1)
All calls of the form `callable(T)` are deterministic. (native_props:is_det/1)

`callable(T)`

– *The following properties hold upon exit:*
`T` is currently a term which is not a free variable. (term_typing:nonvar/1)

Usage: `callable(T)`

– *Description:* `T` is a term which represents a goal, i.e., an atom or a structure.

operator_specifier/1: REGTYPE

The type and associativity of an operator is described by the following mnemonic atoms:

`xfx` Infix, non-associative: it is a requirement that both of the two subexpressions which are the arguments of the operator must be of *lower* precedence than the operator itself.

`xfy` Infix, right-associative: only the first (left-hand) subexpression must be of lower precedence; the right-hand subexpression can be of the *same* precedence as the main operator.

`yfx` Infix, left-associative: same as above, but the other way around.

`fx` Prefix, non-associative: the subexpression must be of *lower* precedence than the operator.

`fy` Prefix, associative: the subexpression can be of the *same* precedence as the operator.

`xf` Postfix, non-associative: the subexpression must be of *lower* precedence than the operator.

`yf` Postfix, associative: the subexpression can be of the *same* precedence as the operator.

General properties: `operator_specifier(X)`

– *The following properties hold globally:*

`operator_specifier(X)` is side-effect `free`. (basic_props:sideff/2)

`operator_specifier(X)`

– *If the following properties hold at call time:*

`X` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

`operator_specifier(X)` is evaluable at compile-time. (basic_props:eval/1)

All calls of the form `operator_specifier(X)` are deterministic. (native_props:is_det/1)

Goal `operator_specifier(X)` produces `7` solutions. (native_props:relations/2)

`operator_specifier(T)`

– *The following properties hold upon exit:*

`T` specifies the type and associativity of an operator. (basic_props:operator_specifier/1)

Usage: `operator_specifier(X)`

– *Description:* `X` specifies the type and associativity of an operator.

list/1: REGTYPE

A list is formed with successive applications of the functor `'.'/2`, and its end is the atom `[]`. Defined as

```
list([]).
list([_1|L]) :-
        list(L).
```

General properties: `list(L)`

– *The following properties hold globally:*

`list(L)` is side-effect `free`. (basic_props:sideff/2)

`list(L)`

– *If the following properties hold at call time:*

`L` is currently ground (it contains no variables). (term_typing:ground/1)

then the following properties hold globally:

`list(L)` is evaluable at compile-time. (basic_props:eval/1)

All calls of the form `list(L)` are deterministic. (native_props:is_det/1)

`list(T)`

– *The following properties hold upon exit:*
`T` is a list. (basic_props:list/1)

Usage: `list(L)`

– *Description:* `L` is a list.

list/2: REGTYPE

`list(L,T)`

`L` is a list, and for all its elements, `T` holds.

Meta-predicate with arguments: `list(?,(pred 1))`.

General properties: `list(L,T)`

– *The following properties hold globally:*
`list(L,T)` is side-effect `free`. (basic_props:sideff/2)

`list(L,T)`

– *If the following properties hold at call time:*
`L` is currently ground (it contains no variables). (term_typing:ground/1)
`T` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`list(L,T)` is evaluable at compile-time. (basic_props:eval/1)

`list(X,T)`

– *The following properties hold upon exit:*
`X` is a list. (basic_props:list/1)

Usage: `list(L,T)`

– *Description:* `L` is a list of `T`s.

nlist/2: REGTYPE

Meta-predicate with arguments: `nlist(?,(pred 1))`.

General properties: `nlist(L,T)`

– *The following properties hold globally:*
`nlist(L,T)` is side-effect `free`. (basic_props:sideff/2)

`nlist(L,T)`

– *If the following properties hold at call time:*
`L` is currently ground (it contains no variables). (term_typing:ground/1)
`T` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`nlist(L,T)` is evaluable at compile-time. (basic_props:eval/1)

`nlist(X,T)`

– *The following properties hold upon exit:*
`X` is any term. (basic_props:term/1)

Usage: `nlist(L,T)`

– *Description:* `L` is `T` or a nested list of `T`s. Note that if `T` is term, this type is equivalent to term, this fact explain why we do not have a `nlist/1` type

member/2: PROPERTY

General properties: `member(X,L)`

– *The following properties hold globally:*
`member(X,L)` is side-effect `free`. (basic_props:sideff/2)
`member(X,L)` is binding insensitive. (basic_props:bind_ins/1)

`member(X,L)`

– *If the following properties hold at call time:*
`L` is a list. (basic_props:list/1)
then the following properties hold globally:
`member(X,L)` is evaluable at compile-time. (basic_props:eval/1)

`member(_X,L)`

– *The following properties hold upon exit:*
`L` is a list. (basic_props:list/1)

`member(X,L)`

– *If the following properties hold at call time:*
`L` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold upon exit:
`X` is currently ground (it contains no variables). (term_typing:ground/1)

Usage: `member(X,L)`

– *Description:* `X` is an element of `L`.

sequence/2: REGTYPE

A sequence is formed with zero, one or more occurrences of the operator `','/2`. For example, `a, b, c` is a sequence of three atoms, `a` is a sequence of one atom.

Meta-predicate with arguments: `sequence(?,(pred 1))`.

General properties: `sequence(S,T)`

– *The following properties hold globally:*
`sequence(S,T)` is side-effect `free`. (basic_props:sideff/2)

`sequence(S,T)`

– *If the following properties hold at call time:*
`S` is currently ground (it contains no variables). (term_typing:ground/1)
`T` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`sequence(S,T)` is evaluable at compile-time. (basic_props:eval/1)

`sequence(E,T)`

– *The following properties hold upon exit:*
`E` is currently a term which is not a free variable. (term_typing:nonvar/1)
`T` is currently ground (it contains no variables). (term_typing:ground/1)

Usage: `sequence(S,T)`

– *Description:* `S` is a sequence of `T`s.

sequence_or_list/2: REGTYPE

Meta-predicate with arguments: `sequence_or_list(?,(pred 1))`.

General properties: `sequence_or_list(S,T)`

– *The following properties hold globally:*
`sequence_or_list(S,T)` is side-effect `free`. (basic_props:sideff/2)

`sequence_or_list(S,T)`

– *If the following properties hold at call time:*
`S` is currently ground (it contains no variables). (term_typing:ground/1)
`T` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`sequence_or_list(S,T)` is evaluable at compile-time. (basic_props:eval/1)

`sequence_or_list(E,T)`

– *The following properties hold upon exit:*
`E` is currently a term which is not a free variable. (term_typing:nonvar/1)
`T` is currently ground (it contains no variables). (term_typing:ground/1)

Usage: `sequence_or_list(S,T)`

– *Description:* `S` is a sequence or list of `T`s.

character_code/1: REGTYPE

General properties: `character_code(T)`

– *The following properties hold globally:*
`character_code(T)` is side-effect `free`. (basic_props:sideff/2)

`character_code(T)`

– *If the following properties hold at call time:*
`T` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`character_code(T)` is evaluable at compile-time. (basic_props:eval/1)

`character_code(I)`

– *The following properties hold upon exit:*
`I` is an integer which is a character code. (basic_props:character_code/1)

Usage: `character_code(T)`

– *Description:* `T` is an integer which is a character code.

string/1: REGTYPE

A string is a list of character codes. The usual syntax for strings `"string"` is allowed, which is equivalent to `[0's,0't,0'r,0'i,0'n,0'g]` or `[115,116,114,105,110,103]`. There is also a special Ciao syntax when the list is not complete: `"st"||R` is equivalent to `[0's,0't|R]`.

General properties: `string(T)`

– *The following properties hold globally:*
`string(T)` is side-effect `free`. (basic_props:sideff/2)

`string(T)`

– *If the following properties hold at call time:*
`T` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`string(T)` is evaluable at compile-time. (basic_props:eval/1)

`string(T)`

– *The following properties hold upon exit:*
`T` is a string (a list of character codes). (basic_props:string/1)

Usage: `string(T)`

– *Description:* `T` is a string (a list of character codes).

num_code/1: REGTYPE

These are the ASCII codes which can appear in decimal representation of floating point and integer numbers, including scientific notation and fractionary part.

predname/1: REGTYPE

General properties: `predname(P)`

– *The following properties hold globally:*
`predname(P)` is side-effect `free`. (basic_props:sideff/2)

`predname(P)`

– *If the following properties hold at call time:*
`P` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`predname(P)` is evaluable at compile-time. (basic_props:eval/1)

`predname(P)`

– *The following properties hold upon exit:*
`P` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

Usage: `predname(P)`

– *Description:* `P` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

atm_or_atm_list/1: REGTYPE

General properties: `atm_or_atm_list(T)`

– *The following properties hold globally:*
`atm_or_atm_list(T)` is side-effect `free`. (basic_props:sideff/2)

`atm_or_atm_list(T)`

– *If the following properties hold at call time:*
`T` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`atm_or_atm_list(T)` is evaluable at compile-time. (basic_props:eval/1)

`atm_or_atm_list(T)`

– *The following properties hold upon exit:*
`T` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

Usage: `atm_or_atm_list(T)`

– *Description:* `T` is an atom or a list of atoms.

compat/2: PROPERTY

This property captures the notion of type or property compatibility. The instantiation or constraint state of the term is compatible with the given property, in the sense that assuming that imposing that property on the term does not render the store inconsistent. For example, terms `X` (i.e., a free variable), `[Y|Z]`, and `[Y,Z]` are all compatible with the regular type `list/1`, whereas the terms `f(a)` and `[1|2]` are not.

Meta-predicate with arguments: `compat(?,(pred 1))`.

General properties: `compat(Term,Prop)`

– *If the following properties hold at call time:*
`Term` is currently ground (it contains no variables). (term_typing:ground/1)
`Prop` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`compat(Term,Prop)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `compat(Term,Prop)`

– *Description:* `Term` is *compatible* with `Prop`

inst/2: PROPERTY

Meta-predicate with arguments: `inst(?,(pred 1))`.

General properties: `inst(Term,Prop)`

– *The following properties hold globally:*
`inst(Term,Prop)` is side-effect `free`. (basic_props:sideff/2)

`inst(Term,Prop)`

– *If the following properties hold at call time:*
`Term` is currently ground (it contains no variables). (term_typing:ground/1)
`Prop` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`inst(Term,Prop)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `inst(Term,Prop)`

– *Description:* `Term` is instantiated enough to satisfy `Prop`.

iso/1: PROPERTY

Meta-predicate with arguments: `iso(goal)`.

General properties: `iso(G)`

– *The following properties hold globally:*
`iso(G)` is side-effect `free`. (basic_props:sideff/2)

Usage: `iso(G)`

– *Description: Complies with the ISO-Prolog standard.*

deprecated/1: PROPERTY

Specifies that the predicate marked with this global property has been deprecated, i.e., its use is not recommended any more since it will be deleted at a future date. Typically this is done because its functionality has been superseded by another predicate.

Meta-predicate with arguments: `deprecated(goal)`.

General properties: `deprecated(G)`

– *The following properties hold globally:*
`deprecated(G)` is side-effect `free`. (basic_props:sideff/2)

Usage: `deprecated(G)`

– *Description:* **DEPRECATED.**

not_further_inst/2: PROPERTY

Meta-predicate with arguments: `not_further_inst(goal,?)`.

General properties: `not_further_inst(G,V)`

– *The following properties hold globally:*
`not_further_inst(G,V)` is side-effect `free`. (basic_props:sideff/2)

Usage: `not_further_inst(G,V)`

– *Description:* `V` is not further instantiated.

sideff/2: PROPERTY

`sideff(G,X)`

Declares that `G` is side-effect free (if its execution has no observable result other than its success, its failure, or its abortion), soft (if its execution may have other observable results which, however, do not affect subsequent execution, e.g., input/output), or hard (e.g., assert/retract).

Meta-predicate with arguments: `sideff(goal,?)`.

General properties: `sideff(G,X)`

– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)
`sideff(G,X)` is side-effect `free`. (basic_props:sideff/2)

Usage: `sideff(G,X)`

– *Description:* `G` is side-effect `X`.

– *If the following properties hold at call time:*
`X` is an element of `[free,soft,hard]`. (basic_props:member/2)

regtype/1: PROPERTY

Meta-predicate with arguments: `regtype goal`.

General properties: `regtype G`

– *The following properties hold globally:*
`regtype G` is side-effect `free`. (basic_props:sideff/2)

Usage: `regtype G`

– *Description:* Defines a regular type.

native/1: PROPERTY

Meta-predicate with arguments: `native(goal)`.

General properties: `native(P)`

– *The following properties hold globally:*
`native(P)` is side-effect `free`. (basic_props:sideff/2)

Usage: `native(Pred)`

– *Description:* This predicate is understood natively by CiaoPP.

native/2: PROPERTY

Meta-predicate with arguments: `native(goal,?)`.

General properties: `native(P,K)`

– *The following properties hold globally:*
`native(P,K)` is side-effect `free`. (basic_props:sideff/2)

Usage: `native(Pred,Key)`

– *Description:* This predicate is understood natively by CiaoPP as `Key`.

no_rtcheck/1: PROPERTY

Meta-predicate with arguments: `no_rtcheck(goal)`.

General properties: `no_rtcheck(G)`

– *The following properties hold globally:*
`no_rtcheck(G)` is side-effect `free`. (basic_props:sideff/2)

Usage: `no_rtcheck(G)`

– *Description:* Declares that the assertion in which this comp property appears must not be checked at run-time.

eval/1: PROPERTY

Meta-predicate with arguments: `eval(goal)`.

Usage: `eval(Goal)`

– *Description:* `Goal` is evaluable at compile-time.

equiv/2: PROPERTY

Meta-predicate with arguments: `equiv(goal,goal)`.

Usage: `equiv(Goal1,Goal2)`

– *Description:* `Goal1` is equivalent to `Goal2`.

bind_ins/1: PROPERTY

Meta-predicate with arguments: `bind_ins(goal)`.

Usage: `bind_ins(Goal)`

– *Description:* `Goal` is binding insensitive.

error_free/1: PROPERTY

Meta-predicate with arguments: `error_free(goal)`.

Usage: `error_free(Goal)`

– *Description:* `Goal` is error free.

memo/1: PROPERTY

Meta-predicate with arguments: `memo(goal)`.

Usage: `memo(Goal)`

– *Description:* `Goal` should be memoized (not unfolded).

filter/2: PROPERTY

Usage: `filter(Vars,Goal)`

– *Description:* `Vars` should be filtered during global control).

flag_values/1: REGTYPE

Usage: `flag_values(X)`

– *Description:* Define the valid flag values

pe_type/1: PROPERTY

Meta-predicate with arguments: `pe_type(goal)`.

Usage: `pe_type(Goal)`

– *Description:* `Goal` will be filtered in partial evaluation time according to the PE types defined in the assertion.

15.3 Known bugs and planned improvements (basic_props)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

16 Extra-logical properties for typing

Author(s): Daniel Cabeza, Manuel Hermenegildo.

This library contains traditional Prolog predicates for testing types. They depend on the state of instantiation of their arguments, thus being of extra-logical nature.

16.1 Usage and interface (term_typing)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Properties:*
    `var/1`, `nonvar/1`, `atom/1`, `integer/1`, `float/1`, `number/1`, `atomic/1`, `ground/1`, `type/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

16.2 Documentation on exports (term_typing)

var/1: PROPERTY

General properties:

- *The following properties hold globally:*
  All calls of the form `var(Arg1)` are deterministic. (native_props:is_det/1)
  Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

`var(X)`

- *The following properties hold globally:*
  `X` is not further instantiated. (basic_props:not_further_inst/2)
  This predicate is understood natively by CiaoPP. (basic_props:native/1)
  `var(X)` is side-effect `free`. (basic_props:sideff/2)

`var(X)`

- *If the following properties hold at call time:*
  `X` is currently a term which is not a free variable. (term_typing:nonvar/1)
  then the following properties hold globally:
  `var(X)` is evaluable at compile-time. (basic_props:eval/1)

`var(X)`

- *If the following properties hold at call time:*
  `X` is currently a term which is not a free variable. (term_typing:nonvar/1)
  then the following properties hold globally:
  `var(X)` is equivalent to `fail`. (basic_props:equiv/2)

`var(X)`

– *If the following properties hold at call time:*
`X` is a free variable. (term_typing:var/1)
then the following properties hold globally:
`var(X)` is equivalent to `true`. (basic_props:equiv/2)

Usage: `var(X)`
– *Description:* `X` is a free variable.
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP as `free(X)`. (basic_props:native/2)

nonvar/1: PROPERTY

General properties:
– *The following properties hold globally:*
All calls of the form `nonvar(Arg1)` are deterministic. (native_props:is_det/1)

`nonvar(X)`
– *The following properties hold globally:*
`X` is not further instantiated. (basic_props:not_further_inst/2)
`nonvar(X)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

`nonvar(X)`
– *If the following properties hold at call time:*
`X` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`nonvar(X)` is evaluable at compile-time. (basic_props:eval/1)

`nonvar(T)`
– *If the following properties hold at call time:*
`T` is a free variable. (term_typing:var/1)
then the following properties hold globally:
`nonvar(T)` is equivalent to `fail`. (basic_props:equiv/2)

`nonvar(T)`
– *If the following properties hold at call time:*
`T` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`nonvar(T)` is equivalent to `true`. (basic_props:equiv/2)

Usage: `nonvar(X)`
– *Description:* `X` is currently a term which is not a free variable.
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP as `not_free(X)`. (basic_props:native/2)

atom/1: PROPERTY

General properties: `atom(X)`

– *The following properties hold upon exit:*

`X` is an atom. (basic_props:atm/1)

– *The following properties hold globally:*

All calls of the form `atom(Arg1)` are deterministic. (native_props:is_det/1)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

`atom(X)`

– *The following properties hold globally:*

`X` is not further instantiated. (basic_props:not_further_inst/2)

`atom(X)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`atom(X)`

– *If the following properties hold at call time:*

`X` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

`atom(X)` is evaluable at compile-time. (basic_props:eval/1)

`atom(T)`

– *If the following properties hold at call time:*

`T` is a free variable. (term_typing:var/1)

then the following properties hold globally:

`atom(T)` is equivalent to `fail`. (basic_props:equiv/2)

Usage: `atom(X)`

– *Description:* `X` is currently instantiated to an atom.

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

integer/1: PROPERTY

General properties: `integer(X)`

– *The following properties hold upon exit:*

`X` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

All calls of the form `integer(Arg1)` are deterministic. (native_props:is_det/1)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

`integer(X)`

– *The following properties hold globally:*

`X` is not further instantiated. (basic_props:not_further_inst/2)

`integer(X)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`integer(X)`

– *If the following properties hold at call time:*
`X` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`integer(X)` is evaluable at compile-time. (basic_props:eval/1)

`integer(T)`
– *If the following properties hold at call time:*
`T` is a free variable. (term_typing:var/1)
then the following properties hold globally:
`integer(T)` is equivalent to `fail`. (basic_props:equiv/2)

Usage: `integer(X)`
– *Description:* `X` is currently instantiated to an integer.
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

float/1: PROPERTY

General properties: `float(X)`
– *The following properties hold upon exit:*
`X` is a float. (basic_props:flt/1)
– *The following properties hold globally:*
All calls of the form `float(Arg1)` are deterministic. (native_props:is_det/1)
Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

`float(X)`
– *The following properties hold globally:*
`X` is not further instantiated. (basic_props:not_further_inst/2)
`float(X)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

`float(X)`
– *If the following properties hold at call time:*
`X` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`float(X)` is evaluable at compile-time. (basic_props:eval/1)

`float(T)`
– *If the following properties hold at call time:*
`T` is a free variable. (term_typing:var/1)
then the following properties hold globally:
`float(T)` is equivalent to `fail`. (basic_props:equiv/2)

Usage: `float(X)`
– *Description:* `X` is currently instantiated to a float.
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

number/1: PROPERTY

General properties: `number(X)`

– *The following properties hold upon exit:*

`X` is a number. (basic_props:num/1)

– *The following properties hold globally:*

All calls of the form `number(Arg1)` are deterministic. (native_props:is_det/1)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

`number(X)`

– *The following properties hold globally:*

`X` is not further instantiated. (basic_props:not_further_inst/2)

`number(X)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`number(X)`

– *If the following properties hold at call time:*

`X` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

`number(X)` is evaluable at compile-time. (basic_props:eval/1)

`number(T)`

– *If the following properties hold at call time:*

`T` is a free variable. (term_typing:var/1)

then the following properties hold globally:

`number(T)` is equivalent to `fail`. (basic_props:equiv/2)

Usage: `number(X)`

– *Description:* `X` is currently instantiated to a number.

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

atomic/1: PROPERTY

General properties: `atomic(T)`

– *The following properties hold upon exit:*

`T` is an atomic term (an atom or a number). (basic_props:constant/1)

– *The following properties hold globally:*

All calls of the form `atomic(Arg1)` are deterministic. (native_props:is_det/1)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

`atomic(X)`

– *The following properties hold globally:*

`X` is not further instantiated. (basic_props:not_further_inst/2)

`atomic(X)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`atomic(X)`

– *If the following properties hold at call time:*
`X` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`atomic(X)` is evaluable at compile-time. (basic_props:eval/1)

`atomic(T)`
– *If the following properties hold at call time:*
`T` is a free variable. (term_typing:var/1)
then the following properties hold globally:
`atomic(T)` is equivalent to `fail`. (basic_props:equiv/2)

Usage: `atomic(X)`
– *Description:* `X` is currently instantiated to an atom or a number.
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

ground/1: PROPERTY

General properties: `ground(X)`
– *The following properties hold upon exit:*
`X` is ground. (basic_props:gnd/1)
– *The following properties hold globally:*
All calls of the form `ground(Arg1)` are deterministic. (native_props:is_det/1)
Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

`ground(X)`
– *The following properties hold globally:*
`X` is not further instantiated. (basic_props:not_further_inst/2)
`ground(X)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

`ground(X)`
– *If the following properties hold at call time:*
`X` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`ground(X)` is evaluable at compile-time. (basic_props:eval/1)

`ground(X)`
– *If the following properties hold at call time:*
`X` is a free variable. (term_typing:var/1)
then the following properties hold globally:
`ground(X)` is equivalent to `fail`. (basic_props:equiv/2)

`ground(X)`
– *If the following properties hold at call time:*
`X` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`ground(X)` is equivalent to `true`. (basic_props:equiv/2)

Usage: `ground(X)`

- *Description:* `X` is currently ground (it contains no variables).
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

type/2: PROPERTY

General properties: `type(X,Y)`

- *The following properties hold upon exit:*
  `Y` is an atom. (basic_props:atm/1)
- *The following properties hold globally:*
  All calls of the form `type(Arg1,Arg2)` are deterministic. (native_props:is_det/1)
- *The following properties hold globally:*
  `type(Arg1,Arg2)` is side-effect `free`. (basic_props:sideff/2)
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

`type(X,Y)`

- *If the following properties hold at call time:*
  `X` is currently a term which is not a free variable. (term_typing:nonvar/1)
  then the following properties hold globally:
  `type(X,Y)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `type(X,Y)`

- *Description:* `X` is internally of type `Y` (`var`, `attv`, `float`, `integer`, `structure`, `atom` or `list`).
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

16.3 Known bugs and planned improvements (term_typing)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

17 Basic term manipulation

Author(s): Daniel Cabeza, Manuel Hermenegildo.
This module provides basic term manipulation.

17.1 Usage and interface (term_basic)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `\=/2`, `arg/3`, `functor/3`, `=../2`, `copy_term/2`, `copy_term_nat/2`, `C/3`.
  - *Properties:*
    `=/2`, `const_head/1`.
  - *Regular Types:*
    `non_empty_list/1`, `list_functor/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

17.2 Documentation on exports (term_basic)

=/2: PROPERTY

⟨• ISO •⟩ A property, defined as follows:

```
X=Y :-
        X=Y.
```

General properties: `X=Y`

- *Description:* `X` and `Y` unify.
- *The following properties hold globally:*
  `X=Y` is side-effect `free`. (basic_props:sideff/2)
  This predicate is understood natively by CiaoPP. (basic_props:native/1)
  `X=Y` is evaluable at compile-time. (basic_props:eval/1)
  All calls of the form `X=Y` are deterministic. (native_props:is_det/1)
  Goal `X=Y` produces `inf` solutions. (native_props:relations/2)
  Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

\=/2: PREDICATE

General properties: `X\=Y`

– *If the following properties hold at call time:*
`X` is currently ground (it contains no variables). (term_typing:ground/1)
`Y` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`X\=Y` is evaluable at compile-time. (basic_props:eval/1)

`X\=Y`
– *The following properties hold globally:*
`X\=Y` is side-effect `free`. (basic_props:sideff/2)

Usage: `X\=Y` ⟨• ISO •⟩
– *Description:* `X` and `Y` are not unifiable.
– *The following properties hold globally:*
`X\=Y` is side-effect `free`. (basic_props:sideff/2)
`X\=Y` is binding insensitive. (basic_props:bind_ins/1)
All calls of the form `X\=Y` are deterministic. (native_props:is_det/1)

arg/3: PREDICATE

Usage 1: `arg(ArgNo,Term,Arg)`
– *The following properties should hold at call time:*
`ArgNo` is a number. (basic_props:num/1)
– *The following properties hold globally:*
All calls of the form `arg(ArgNo,Term,Arg)` are deterministic. (native_props:is_det/1)
Goal `arg(ArgNo,Term,Arg)` produces `inf` solutions. (native_props:relations/2)

Usage 2: `arg(ArgNo,Term,Arg)`
– *The following properties should hold at call time:*
`ArgNo` is a number. (basic_props:num/1)
`Term` is ground. (basic_props:gnd/1)
– *The following properties hold upon exit:*
`Arg` is ground. (basic_props:gnd/1)

Usage 3: `arg(ArgNo,Term,Arg)` ⟨• ISO •⟩
– *Description:* Argument `ArgNo` of the term `Term` is `Arg`.
– *The following properties should hold at call time:*
`ArgNo` is a non-negative integer. (basic_props:nnegint/1)
`Term` is a compound term. (basic_props:struct/1)
– *The following properties hold globally:*
`arg(ArgNo,Term,Arg)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)
`arg(ArgNo,Term,Arg)` is binding insensitive. (basic_props:bind_ins/1)

Usage 4: `arg(ArgNo,Term,Arg)`
– *The following properties should hold at call time:*
`ArgNo` is a non-negative integer. (basic_props:nnegint/1)
`Term` is ground. (basic_props:gnd/1)
– *The following properties hold upon exit:*
`Arg` is ground. (basic_props:gnd/1)

functor/3: PREDICATE

⟨• ISO •⟩

General properties:

– *The following properties hold globally:*

`functor(Arg1,Arg2,Arg3)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

All calls of the form `functor(Arg1,Arg2,Arg3)` are deterministic. (native_props:is_det/1)

Usage 1: `functor(Term,Name,Arity)` ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

– *The following properties hold upon exit:*

`Name` is an atom. (basic_props:atm/1)

`Arity` is a non-negative integer. (basic_props:nnegint/1)

– *The following properties hold globally:*

`Term` is not further instantiated. (basic_props:not_further_inst/2)

`functor(Term,Name,Arity)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`functor(Term,Name,Arity)` is binding insensitive. (basic_props:bind_ins/1)

`functor(Term,Name,Arity)` is evaluable at compile-time. (basic_props:eval/1)

Usage 2: `functor(Term,Name,Arity)` ⟨• ISO •⟩

– *Description:* The principal functor of the term `Term` has name `Name` and arity `Arity`.

– *The following properties should hold at call time:*

`Name` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Arity` is currently a term which is not a free variable. (term_typing:nonvar/1)

– *The following properties hold upon exit:*

`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Name` is an atom. (basic_props:atm/1)

`Arity` is a non-negative integer. (basic_props:nnegint/1)

– *The following properties hold globally:*

`functor(Term,Name,Arity)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`functor(Term,Name,Arity)` is binding insensitive. (basic_props:bind_ins/1)

`functor(Term,Name,Arity)` is evaluable at compile-time. (basic_props:eval/1)

All the calls of the form `functor(Term,Name,Arity)` do not fail. (native_props:not_fails/1)

Usage 3: `functor(Term,Name,Arity)`

– *The following properties should hold at call time:*

`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Name` is a free variable. (term_typing:var/1)

`Arity` is a free variable. (term_typing:var/1)

`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

– *The following properties hold upon exit:*
`1` is the size of argument `Name`, for any approximation. (native_props:size/2)
`arity(Term)` is the size of argument `Arity`, for any approximation. (native_props:size/2)
– *The following properties hold globally:*
`arity` is the metric of the variable `Term`, for any approximation. (native_props:size_metric/3)

=../2: PREDICATE

General properties:

– *If the following properties hold at call time:*
`Arg1` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`Arg1=..Arg2` is evaluable at compile-time. (basic_props:eval/1)

`Arg1=..List`

– *If the following properties hold at call time:*
`List` is a list. (basic_props:list/1)
term_basic:const_head(List) (term_basic:const_head/1)
then the following properties hold globally:
`Arg1=..List` is evaluable at compile-time. (basic_props:eval/1)

Usage: `Term=..List` ⟨• ISO •⟩

– *Description:* The functor and arguments of the term `Term` comprise the list `List`.
– *The following properties hold upon exit:*
`List` is a list. (basic_props:list/1)
– *The following properties hold globally:*
`Term=..List` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

non_empty_list/1: REGTYPE

Usage: `non_empty_list(A)`

– *Description:* A list that is not the empty list [].

copy_term/2: PREDICATE

General properties: `copy_term(Term,Copy)`

– *If the following properties hold at call time:*
`Term` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`copy_term(Term,Copy)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `copy_term(Term,Copy)` ⟨• ISO •⟩

– *Description:* `Copy` is a renaming of `Term`, such that brand new variables have been substituted for all variables in `Term`. If any of the variables of `Term` have attributes, the copied variables will have copies of the attributes as well. It behaves as if defined by:

```
:- data 'copy of'/1.

copy_term(X, Y) :-
        asserta_fact('copy of'(X)),
        retract_fact('copy of'(Y)).
```

– *The following properties should hold globally:*

`copy_term(Term,Copy)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

copy_term_nat/2: PREDICATE

Usage: `copy_term_nat(Term,Copy)`

– *Description:* Same as `copy_term/2`, except that attributes of variables are not copied.

– *The following properties hold globally:*

`copy_term_nat(Term,Copy)` is side-effect `free`. (basic_props:sideff/2)

C/3: PREDICATE

General properties: `C(S1,Terminal,S2)`

– *If the following properties hold at call time:*

A list that is not the empty list []. (term_basic:non_empty_list/1)

then the following properties hold upon exit:

`S2` is a list. (basic_props:list/1)

– *If the following properties hold at call time:*

`Arg1` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

`C(Arg1,Arg2,Arg3)` is evaluable at compile-time. (basic_props:eval/1)

Usage 1: `C(S1,Terminal,S2)`

– *The following properties hold upon exit:*

term_basic:list_functor(S1) (term_basic:list_functor/1)

Usage 2: `C(S1,Terminal,S2)`

– *Description:* `S1` is connected by the terminal `Terminal` to `S2`. Internally used in *DCG grammar rules*. Defined as if by the single clause: `'C'([X|S], X, S).`

– *The following properties hold globally:*

`C(S1,Terminal,S2)` is side-effect `free`. (basic_props:sideff/2)

This predicate is understood natively by CiaoPP. (basic_props:native/1)

const_head/1: PROPERTY

A property, defined as follows:

```
const_head([Head|_1]) :-
        constant(Head).
```

list_functor/1: REGTYPE

A regular type, defined as follows:

```
list_functor([A|B]) :-
        term(A),
        term(B).
```

17.3 Known bugs and planned improvements (term_basic)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

18 Comparing terms

Author(s): Daniel Cabeza, Manuel Hermenegildo.

These built-in predicates are extra-logical. They treat uninstantiated variables as objects with values which may be compared, and they never instantiate those variables. They should *not* be used when what you really want is arithmetic comparison or unification.

The predicates make reference to a *standard total ordering* of terms, which is as follows:

- Variables, by age (roughly, oldest first – the order is *not* related to the names of variables).
- Floats, in numeric order (e.g. -1.0 is put before 1.0).
- Integers, in numeric order (e.g. -1 is put before 1).
- Atoms, in alphabetical (i.e. character code) order.
- Compound terms, ordered first by arity, then by the name of the principal functor, then by the arguments in left-to-right order. Recall that lists are equivalent to compound terms with principal functor `'.'/2`.

For example, here is a list of terms in standard order:

```
[ X, -1.0, -9, 1, bar, foo, [1], X = Y, foo(0,2), bar(1,1,1) ]
```

18.1 Usage and interface (term_compare)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `\==/2`, `@</2`, `@=</2`, `@>/2`, `@>=/2`, `compare/3`.
  - *Properties:*
    `==/2`.
  - *Regular Types:*
    `comparator/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

18.2 Documentation on exports (term_compare)

==/2: PROPERTY

General properties: `Term1==Term2`

- *The following properties hold globally:*
  `Term1` is not further instantiated. (basic_props:not_further_inst/2)
  `Term2` is not further instantiated. (basic_props:not_further_inst/2)
  `Term1==Term2` is side-effect `free`. (basic_props:sideff/2)
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

`Term1==Term2`

– *If the following properties hold at call time:*
  `Term1` is currently ground (it contains no variables). (term_typing:ground/1)
  `Term2` is currently ground (it contains no variables). (term_typing:ground/1)
  then the following properties hold globally:
  `Term1==Term2` is evaluable at compile-time. (basic_props:eval/1)

`Term1==Term2`

– *The following properties hold globally:*
  All calls of the form `Term1==Term2` are deterministic. (native_props:is_det/1)
  Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `Term1==Term2`

– *Description:* The terms `Term1` and `Term2` are strictly identical.

\==/2: PREDICATE

General properties: `Term1\==Term2`

– *If the following properties hold at call time:*
  `Term1` is currently ground (it contains no variables). (term_typing:ground/1)
  `Term2` is currently ground (it contains no variables). (term_typing:ground/1)
  then the following properties hold globally:
  `Term1\==Term2` is evaluable at compile-time. (basic_props:eval/1)

`Term1\==Term2`

– *The following properties hold globally:*
  All calls of the form `Term1\==Term2` are deterministic. (native_props:is_det/1)
  Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `Term1\==Term2`

– *Description:* The terms `Term1` and `Term2` are not strictly identical.
– *The following properties hold globally:*
  `Term1` is not further instantiated. (basic_props:not_further_inst/2)
  `Term2` is not further instantiated. (basic_props:not_further_inst/2)
  `Term1\==Term2` is side-effect `free`. (basic_props:sideff/2)
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

@</2: PREDICATE

General properties: `Term1@<Term2`

– *If the following properties hold at call time:*
  `Term1` is currently ground (it contains no variables). (term_typing:ground/1)
  `Term2` is currently ground (it contains no variables). (term_typing:ground/1)
  then the following properties hold globally:
  `Term1@<Term2` is evaluable at compile-time. (basic_props:eval/1)

Usage: `Term1@<Term2`

– *Description:* The term `Term1` precedes the term `Term2` in the standard order.
– *The following properties hold globally:*
`Term1` is not further instantiated. (basic_props:not_further_inst/2)
`Term2` is not further instantiated. (basic_props:not_further_inst/2)
`Term1@<Term2` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

@=</2: PREDICATE

General properties: `Term1@=<Term2`

– *If the following properties hold at call time:*
`Term1` is currently ground (it contains no variables). (term_typing:ground/1)
`Term2` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`Term1@=<Term2` is evaluable at compile-time. (basic_props:eval/1)

Usage: `Term1@=<Term2`

– *Description:* The term `Term1` precedes or is identical to the term `Term2` in the standard order.
– *The following properties hold globally:*
`Term1` is not further instantiated. (basic_props:not_further_inst/2)
`Term2` is not further instantiated. (basic_props:not_further_inst/2)
`Term1@=<Term2` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

@>/2: PREDICATE

General properties: `Term1@>Term2`

– *If the following properties hold at call time:*
`Term1` is currently ground (it contains no variables). (term_typing:ground/1)
`Term2` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`Term1@>Term2` is evaluable at compile-time. (basic_props:eval/1)

Usage: `Term1@>Term2`

– *Description:* The term `Term1` follows the term `Term2` in the standard order.
– *The following properties hold globally:*
`Term1` is not further instantiated. (basic_props:not_further_inst/2)
`Term2` is not further instantiated. (basic_props:not_further_inst/2)
`Term1@>Term2` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

@>=/2: PREDICATE

General properties: `Term1@>=Term2`

– *If the following properties hold at call time:*
`Term1` is currently ground (it contains no variables). (term_typing:ground/1)
`Term2` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`Term1@>=Term2` is evaluable at compile-time. (basic_props:eval/1)

Usage: `Term1@>=Term2`

– *Description:* The term `Term1` follows or is identical to the term `Term2` in the standard order.
– *The following properties hold globally:*
`Term1` is not further instantiated. (basic_props:not_further_inst/2)
`Term2` is not further instantiated. (basic_props:not_further_inst/2)
`Term1@>=Term2` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

compare/3: PREDICATE

`compare(Op,Term1,Term2)`

`Op` is the result of comparing the terms `Term1` and `Term2`.

General properties: `compare(Op,Term1,Term2)`

– *If the following properties hold at call time:*
`Term1` is currently ground (it contains no variables). (term_typing:ground/1)
`Term2` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`compare(Op,Term1,Term2)` is evaluable at compile-time. (basic_props:eval/1)

Usage:

– *Calls should, and exit will be compatible with:*
`Op` is an atom. (basic_props:atm/1)
– *The following properties should hold at call time:*
`Term1` is any term. (basic_props:term/1)
`Term2` is any term. (basic_props:term/1)
– *The following properties hold upon exit:*
`Op` is an atom. (basic_props:atm/1)
`Term1` is any term. (basic_props:term/1)
`Term2` is any term. (basic_props:term/1)
term_compare:comparator(Op) (term_compare:comparator/1)
`Term1` is any term. (basic_props:term/1)
`Term2` is any term. (basic_props:term/1)
– *The following properties hold globally:*
`Term1` is not further instantiated. (basic_props:not_further_inst/2)
`Term2` is not further instantiated. (basic_props:not_further_inst/2)
`compare(Op,Term1,Term2)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

comparator/1: REGTYPE

A regular type, defined as follows:

```
comparator(=).
comparator(>).
comparator(<).
```

18.3 Known bugs and planned improvements (term_compare)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

19 Basic predicates handling names of constants

Author(s): The CLIP Group.

The Ciao system provides builtin predicates which allow dealing with names of constants (atoms or numbers). Note that sometimes strings (character code lists) are more suitable to handle sequences of characters.

19.1 Usage and interface (atomic_basic)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `name/2`, `atom_codes/2`, `number_codes/2`, `number_codes/3`, `atom_number/2`, `atom_number/3`, `atom_length/2`, `atom_concat/3`, `sub_atom/4`.
  - *Properties:*
    `number_codes/3`.
  - *Regular Types:*
    `valid_base/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

19.2 Documentation on exports (atomic_basic)

name/2: PREDICATE

`name(Const,String)`

`String` is the list of the ASCII codes of the characters comprising the name of `Const`. Note that if `Const` is an atom whose name can be interpreted as a number (e.g. '96'), the predicate is not reversible, as that atom will not be constructed when `Const` is uninstantiated. Thus it is recommended that new programs use the ISO-compliant predicates `atom_codes/2` or `number_codes/2`, as these predicates do not have this inconsistency.

General properties:

- *The following properties hold globally:*
  `name(Const,String)` is side-effect `free`. (basic_props:sideff/2)
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

Usage 1:

- *Calls should, and exit will be compatible with:*
  `String` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*
  `Const` is an atomic term (an atom or a number). (basic_props:constant/1)
- *The following properties hold upon exit:*
  `String` is a string (a list of character codes). (basic_props:string/1)

– *The following properties hold globally:*
`name(Const,String)` is evaluable at compile-time. (basic_props:eval/1)

Usage 2:

– *Description:* If `String` can be interpreted as a number, `Const` is unified with that number, otherwise with the atom whose name is `String`.
– *The following properties should hold at call time:*
`Const` is a free variable. (term_typing:var/1)
`String` is a string (a list of character codes). (basic_props:string/1)
– *The following properties hold upon exit:*
`Const` is an atomic term (an atom or a number). (basic_props:constant/1)
– *The following properties hold globally:*
`name(Const,String)` is evaluable at compile-time. (basic_props:eval/1)

atom_codes/2: PREDICATE

`atom_codes(Atom,String)` ⟨• ISO •⟩

`String` is the list of the ASCII codes of the characters comprising the name of `Atom`.

General properties: `atom_codes(A,B)`

– *If the following properties should hold at call time:*
term_basic:A=ao (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B=[97,241,111] (term_basic:= /2)
then the following properties should hold globally:
All the calls of the form `atom_codes(A,B)` do not fail. (native_props:not_fails/1)
All calls of the form `atom_codes(A,B)` are deterministic. (native_props:is_det/1)
– *The following properties hold globally:*
`atom_codes(Atom,String)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)
All calls of the form `atom_codes(Atom,String)` are deterministic. (native_props:is_det/1)

Usage 1:

– *Calls should, and exit will be compatible with:*
`String` is a string (a list of character codes). (basic_props:string/1)
– *The following properties should hold at call time:*
`Atom` is an atom. (basic_props:atm/1)
– *The following properties hold upon exit:*
`String` is a string (a list of character codes). (basic_props:string/1)
– *The following properties hold globally:*
`atom_codes(Atom,String)` is evaluable at compile-time. (basic_props:eval/1)

Usage 2:

– *Calls should, and exit will be compatible with:*
`Atom` is an atom. (basic_props:atm/1)
– *The following properties should hold at call time:*
`String` is a string (a list of character codes). (basic_props:string/1)

– *The following properties hold upon exit:*
`Atom` is an atom. (basic_props:atm/1)
– *The following properties hold globally:*
`atom_codes(Atom,String)` is evaluable at compile-time. (basic_props:eval/1)

number_codes/2: PREDICATE

`number_codes(Number,String)` ⟨• ISO •⟩

`String` is the list of the ASCII codes of the characters comprising a representation of `Number`.

General properties:

– *The following properties hold globally:*
`number_codes(Number,String)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)

`number_codes(A,B)`

– *If the following properties hold at call time:*
`A` is an integer. (basic_props:int/1)
then the following properties hold upon exit:
`B` is a list of `num_codes`. (basic_props:list/2)

Usage 1:

– *Calls should, and exit will be compatible with:*
`String` is a string (a list of character codes). (basic_props:string/1)
– *The following properties should hold at call time:*
`Number` is a number. (basic_props:num/1)
– *The following properties hold upon exit:*
`String` is a string (a list of character codes). (basic_props:string/1)
– *The following properties hold globally:*
`number_codes(Number,String)` is evaluable at compile-time. (basic_props:eval/1)

Usage 2:

– *The following properties should hold at call time:*
`Number` is a free variable. (term_typing:var/1)
`String` is a string (a list of character codes). (basic_props:string/1)
– *The following properties hold upon exit:*
`Number` is a number. (basic_props:num/1)
– *The following properties hold globally:*
`number_codes(Number,String)` is evaluable at compile-time. (basic_props:eval/1)

atom_number/2: PREDICATE

`atom_number(Atom,Number)`

`Atom` can be read as a representation of `Number`.

General properties: `atom_number(A,B)`

– *If the following properties should hold at call time:*
term_basic:B=0.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=0.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:A=0.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B=0.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:B= -0.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=-0.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:A=-0.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B0= -0.0 (term_basic:= /2)
term_basic:B=B0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:B=1.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=1.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:A=1.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B=1.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:B=0.Inf (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=0.Inf (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:A=0.Inf (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B=0.Inf (term_basic:= /2)

`atom_number(A,B)`

– *If the following properties should hold at call time:*
term_basic:B= -1.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=-1.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:A=-1.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B= -1.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:B= -1.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=-1.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:A=-1.0 (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B= -1.0 (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:B= -0.Inf (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=-0.Inf (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:A=-0.Inf (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B= -0.Inf (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:B= -0.Inf (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=-0.Inf (term_basic:= /2)

`atom_number(A,B)`
– *If the following properties should hold at call time:*
term_basic:B=0.Nan (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:A=0.Nan (term_basic:= /2)

`atom_number(A,B)`

– *If the following properties should hold at call time:*
term_basic:A=0.Nan (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B=0.Nan (term_basic:= /2)
– *The following properties hold globally:*
`atom_number(Atom,Number)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)
All calls of the form `atom_number(Atom,Number)` are deterministic. (native_props:is_det/1)

Usage 1:
– *Call and exit should be compatible with:*
`Number` is a number. (basic_props:num/1)
– *The following properties should hold at call time:*
`Atom` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
`Number` is a number. (basic_props:num/1)
`Atom` is an atom. (basic_props:atm/1)
`Number` is a number. (basic_props:num/1)
– *The following properties should hold globally:*
`atom_number(Atom,Number)` is evaluable at compile-time. (basic_props:eval/1)

Usage 2:
– *The following properties should hold at call time:*
`Atom` is a free variable. (term_typing:var/1)
`Number` is a number. (basic_props:num/1)
– *The following properties should hold upon exit:*
`Atom` is an atom. (basic_props:atm/1)
`Atom` is an atom. (basic_props:atm/1)
`Number` is a number. (basic_props:num/1)
– *The following properties should hold globally:*
`atom_number(Atom,Number)` is evaluable at compile-time. (basic_props:eval/1)

atom_number/3: PREDICATE

`atom_number(Atom,Base,Number)`

`Atom` can be read as a representation of `Number` in base `Base`.

General properties:
– *The following properties hold globally:*
`atom_number(Atom,Base,Number)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)
All calls of the form `atom_number(Atom,Base,Number)` are deterministic. (native_props:is_det/1)

Usage 1:
– *Call and exit should be compatible with:*
`Base` is a number. (basic_props:num/1)

– *The following properties should hold at call time:*
`Atom` is an atom. (basic_props:atm/1)
`Number` is a number. (basic_props:num/1)
– *The following properties should hold upon exit:*
`Base` is a number. (basic_props:num/1)

Usage 2:
– *The following properties should hold at call time:*
`Atom` is a free variable. (term_typing:var/1)
`Base` is a number. (basic_props:num/1)
`Number` is a number. (basic_props:num/1)
– *The following properties should hold upon exit:*
`Atom` is an atom. (basic_props:atm/1)

atom_length/2: PREDICATE

`atom_length(Atom,Length)` ⟨• ISO •⟩

`Length` is the number of characters forming the name of `Atom`.

General properties:
– *The following properties hold globally:*
`atom_length(Atom,Length)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)
All calls of the form `atom_length(Atom,Length)` are deterministic. (native_props:is_det/1)

Usage:
– *Calls should, and exit will be compatible with:*
`Length` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`Atom` is an atom. (basic_props:atm/1)
– *The following properties hold upon exit:*
`Length` is an integer. (basic_props:int/1)
– *The following properties hold globally:*
`atom_length(Atom,Length)` is evaluable at compile-time. (basic_props:eval/1)

atom_concat/3: PREDICATE

`atom_concat(Atom_1,Atom_2,Atom_12)` ⟨• ISO •⟩

`Atom_12` is the result of concatenating `Atom_1` followed by `Atom_2`.

General properties:
– *The following properties hold globally:*
`atom_concat(Atom_1,Atom_2,Atom_12)` is side-effect `free`. (basic_props:sideff/2)
This predicate is understood natively by CiaoPP. (basic_props:native/1)
All calls of the form `atom_concat(Atom_1,Atom_2,Atom_12)` are deterministic. (native_props:is_det/1)

Usage 1:

- *Description:* Concatenate two atoms.
- *Calls should, and exit will be compatible with:*
  `Atom_12` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*
  `Atom_1` is an atom. (basic_props:atm/1)
  `Atom_2` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `Atom_12` is an atom. (basic_props:atm/1)
  `Atom_1` is an atom. (basic_props:atm/1)
  `Atom_2` is an atom. (basic_props:atm/1)
  `Atom_12` is an atom. (basic_props:atm/1)
- *The following properties hold globally:*
  `atom_concat(Atom_1,Atom_2,Atom_12)` is evaluable at compile-time. (basic_props:eval/1)

Usage 2:

- *Description:* Non-deterministically split an atom.
- *The following properties should hold at call time:*
  `Atom_1` is a free variable. (term_typing:var/1)
  `Atom_2` is a free variable. (term_typing:var/1)
  `Atom_12` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `Atom_1` is an atom. (basic_props:atm/1)
  `Atom_2` is an atom. (basic_props:atm/1)
  `Atom_1` is an atom. (basic_props:atm/1)
  `Atom_2` is an atom. (basic_props:atm/1)
  `Atom_12` is an atom. (basic_props:atm/1)
- *The following properties hold globally:*
  `atom_concat(Atom_1,Atom_2,Atom_12)` is evaluable at compile-time. (basic_props:eval/1)

Usage 3:

- *Description:* Take out of an atom a certain suffix (or fail if it cannot be done).
- *The following properties should hold at call time:*
  `Atom_1` is a free variable. (term_typing:var/1)
  `Atom_2` is an atom. (basic_props:atm/1)
  `Atom_12` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `Atom_1` is an atom. (basic_props:atm/1)
  `Atom_1` is an atom. (basic_props:atm/1)
  `Atom_2` is an atom. (basic_props:atm/1)
  `Atom_12` is an atom. (basic_props:atm/1)
- *The following properties hold globally:*
  `atom_concat(Atom_1,Atom_2,Atom_12)` is evaluable at compile-time. (basic_props:eval/1)

Usage 4:

- *Description:* Take out of an atom a certain prefix (or fail if it cannot be done).
- *The following properties should hold at call time:*

  `Atom_1` is an atom. (basic_props:atm/1)

  `Atom_2` is a free variable. (term_typing:var/1)

  `Atom_12` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*

  `Atom_2` is an atom. (basic_props:atm/1)

  `Atom_1` is an atom. (basic_props:atm/1)

  `Atom_2` is an atom. (basic_props:atm/1)

  `Atom_12` is an atom. (basic_props:atm/1)
- *The following properties hold globally:*

  `atom_concat(Atom_1,Atom_2,Atom_12)` is evaluable at compile-time. (basic_props:eval/1)

sub_atom/4: PREDICATE

`sub_atom(Atom,Before,Length,Sub_atom)`

`Sub_atom` is formed with `Length` consecutive characters of `Atom` after the `Before` character. For example, the goal `sub_atom(summer,1,4,umme)` succeeds.

General properties:

- *The following properties hold globally:*

  `sub_atom(Atom,Before,Length,Sub_atom)` is side-effect `free`. (basic_props:sideff/2)

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

Usage:

- *Calls should, and exit will be compatible with:*

  `Sub_atom` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `Atom` is an atom. (basic_props:atm/1)

  `Before` is an integer. (basic_props:int/1)

  `Length` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*

  `Sub_atom` is an atom. (basic_props:atm/1)
- *The following properties hold globally:*

  `sub_atom(Atom,Before,Length,Sub_atom)` is evaluable at compile-time. (basic_props:eval/1)

valid_base/1: REGTYPE

Usage:

- *Description:* Valid numeric base to convert numbers to strings or atoms

19.3 Known bugs and planned improvements (`atomic_basic`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

20 Arithmetic

Author(s): Daniel Cabeza, Manuel Hermenegildo.

Arithmetic is performed by built-in predicates which take as arguments arithmetic expressions (see `arithexpression/1`) and evaluate them. Terms representing arithmetic expressions can be created dynamically, but at the time of evaluation, each variable in an arithmetic expression must be bound to a non-variable expression (the term must be ground). For example, given the code in the first line a possible shell interaction follows:

```
evaluate(Expression, Answer) :- Answer is Expression.

?- _X=24*9, evaluate(_X+6, Ans).

Ans = 222 ?

yes
```

20.1 Usage and interface (`arithmetic`)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `is/2`, `</2`, `=</2`, `>/2`, `>=/2`, `=:=/2`, `=\=/2`.
  - *Regular Types:*
    `arithexpression/1`, `intexpression/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

20.2 Documentation on exports (`arithmetic`)

is/2: PREDICATE

`Val is Exp` ⟨• ISO •⟩

The arithmetic expression `Exp` is evaluated and the result is unified with `Val`

General properties: `X is Y`

- *Description:* is/2, sqrt test
- *If the following properties should hold at call time:*
  term_basic:Y=sqrt(4) (term_basic:= /2)
  then the following properties hold upon exit:
  term_basic:X=2.0 (term_basic:= /2)

`A is B`

- *The following properties hold globally:*
  `int` is the metric of the variable `A`, for any approximation. (native_props:size_metric/3)

`int` is the metric of the variable `B`, for any approximation. (native_props:size_metric/3)

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`Val is Exp` is side-effect `free`. (basic_props:sideff/2)

`Val is Exp` is binding insensitive. (basic_props:bind_ins/1)

All calls of the form `Val is Exp` are deterministic. (native_props:is_det/1)

Goal `Val is Exp` produces `inf` solutions. (native_props:relations/2)

Usage 1: `A is B`

– *The following properties should hold at call time:*

`A` is a free variable. (term_typing:var/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is a free variable. (term_typing:var/1)

`B` is an arithmetic expression. (arithmetic:arithexpression/1)

– *The following properties hold upon exit:*

`A` is a number. (basic_props:num/1)

`B` is an arithmetic expression. (arithmetic:arithexpression/1)

`int(B)` is the size of argument `A`, for any approximation. (native_props:size/2)

– *The following properties hold globally:*

All the calls of the form `A is B` do not fail. (native_props:not_fails/1)

`A is B` is evaluable at compile-time. (basic_props:eval/1)

Usage 2: `A is B`

– *The following properties should hold at call time:*

`A` is a free variable. (term_typing:var/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is a free variable. (term_typing:var/1)

`B` is an integer expression. (arithmetic:intexpression/1)

– *The following properties hold upon exit:*

`A` is an integer. (basic_props:int/1)

`B` is an integer expression. (arithmetic:intexpression/1)

`int(B)` is the size of argument `A`, for any approximation. (native_props:size/2)

– *The following properties hold globally:*

All the calls of the form `A is B` do not fail. (native_props:not_fails/1)

`A is B` is evaluable at compile-time. (basic_props:eval/1)

Usage 3: `A is B`

– *The following properties should hold at call time:*

`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is a number. (basic_props:num/1)

`B` is an arithmetic expression. (arithmetic:arithexpression/1)

– *The following properties hold globally:*

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage 4: `A is B`

– *The following properties should hold at call time:*

`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is an integer. (basic_props:int/1)

`B` is an integer expression. (arithmetic:intexpression/1)

– *The following properties hold globally:*

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

</2: PREDICATE

`Exp1<Exp2` ⟨• ISO •⟩

The numeric value of `Exp1` is less than the numeric value of `Exp2` when both are evaluated as arithmetic expressions.

General properties:

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`Exp1<Exp2` is side-effect `free`. (basic_props:sideff/2)

`Exp1<Exp2` is binding insensitive. (basic_props:bind_ins/1)

All calls of the form `Exp1<Exp2` are deterministic. (native_props:is_det/1)

Goal `Exp1<Exp2` produces `inf` solutions. (native_props:relations/2)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `A<B`

– *The following properties should hold at call time:*

`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is an arithmetic expression. (arithmetic:arithexpression/1)

`B` is an arithmetic expression. (arithmetic:arithexpression/1)

– *The following properties hold globally:*

`A<B` is evaluable at compile-time. (basic_props:eval/1)

`int` is the metric of the variable `A`, for any approximation. (native_props:size_metric/3)

`int` is the metric of the variable `B`, for any approximation. (native_props:size_metric/3)

=</2: PREDICATE

`Exp1=<Exp2` ⟨• ISO •⟩

The numeric value of `Exp1` is less than or equal to the numeric value of `Exp2` when both are evaluated as arithmetic expressions.

General properties:

– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)
`Exp1=<Exp2` is side-effect `free`. (basic_props:sideff/2)
`Exp1=<Exp2` is binding insensitive. (basic_props:bind_ins/1)
All calls of the form `Exp1=<Exp2` are deterministic. (native_props:is_det/1)
Goal `Exp1=<Exp2` produces `inf` solutions. (native_props:relations/2)
Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `A=<B`

– *The following properties should hold at call time:*
`A` is currently a term which is not a free variable. (term_typing:nonvar/1)
`B` is currently a term which is not a free variable. (term_typing:nonvar/1)
`A` is an arithmetic expression. (arithmetic:arithexpression/1)
`B` is an arithmetic expression. (arithmetic:arithexpression/1)

– *The following properties hold globally:*
`A=<B` is evaluable at compile-time. (basic_props:eval/1)
`int` is the metric of the variable `A`, for any approximation. (native_props:size_metric/3)
`int` is the metric of the variable `B`, for any approximation. (native_props:size_metric/3)

>/2: PREDICATE

`Exp1>Exp2` ⟨• ISO •⟩

The numeric value of `Exp1` is greater than the numeric value of `Exp2` when both are evaluated as arithmetic expressions.

General properties:

– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)
`Exp1>Exp2` is side-effect `free`. (basic_props:sideff/2)
`Exp1>Exp2` is binding insensitive. (basic_props:bind_ins/1)
All calls of the form `Exp1>Exp2` are deterministic. (native_props:is_det/1)
Goal `Exp1>Exp2` produces `inf` solutions. (native_props:relations/2)
Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `A>B`

– *The following properties should hold at call time:*
`A` is currently a term which is not a free variable. (term_typing:nonvar/1)
`B` is currently a term which is not a free variable. (term_typing:nonvar/1)
`A` is an arithmetic expression. (arithmetic:arithexpression/1)
`B` is an arithmetic expression. (arithmetic:arithexpression/1)

– *The following properties hold globally:*
`A>B` is evaluable at compile-time. (basic_props:eval/1)
`int` is the metric of the variable `A`, for any approximation. (native_props:size_metric/3)
`int` is the metric of the variable `B`, for any approximation. (native_props:size_metric/3)

>=/2: PREDICATE

`Exp1>=Exp2` ⟨• ISO •⟩

The numeric value of `Exp1` is greater than or equal to the numeric value of `Exp2` when both are evaluated as arithmetic expressions.

General properties:

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`Exp1>=Exp2` is side-effect `free`. (basic_props:sideff/2)

`Exp1>=Exp2` is binding insensitive. (basic_props:bind_ins/1)

All calls of the form `Exp1>=Exp2` are deterministic. (native_props:is_det/1)

Goal `Exp1>=Exp2` produces `inf` solutions. (native_props:relations/2)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `A>=B`

– *The following properties should hold at call time:*

`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is an arithmetic expression. (arithmetic:arithexpression/1)

`B` is an arithmetic expression. (arithmetic:arithexpression/1)

– *The following properties hold globally:*

`A>=B` is evaluable at compile-time. (basic_props:eval/1)

`int` is the metric of the variable `A`, for any approximation. (native_props:size_metric/3)

`int` is the metric of the variable `B`, for any approximation. (native_props:size_metric/3)

=:=/2: PREDICATE

`Exp1=:=Exp2` ⟨• ISO •⟩

The numeric values of `Exp1` and `Exp2` are equal when both are evaluated as arithmetic expressions.

General properties:

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`Exp1=:=Exp2` is side-effect `free`. (basic_props:sideff/2)

`Exp1=:=Exp2` is binding insensitive. (basic_props:bind_ins/1)

All calls of the form `Exp1=:=Exp2` are deterministic. (native_props:is_det/1)

Goal `Exp1=:=Exp2` produces `inf` solutions. (native_props:relations/2)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `A=:=B`

– *The following properties should hold at call time:*

`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is an arithmetic expression. (arithmetic:arithexpression/1)

`B` is an arithmetic expression. (arithmetic:arithexpression/1)

– *The following properties hold globally:*

`A=:=B` is evaluable at compile-time. (basic_props:eval/1)

`int` is the metric of the variable `A`, for any approximation. (native_props:size_metric/3)

`int` is the metric of the variable `B`, for any approximation. (native_props:size_metric/3)

=\=/2: PREDICATE

`Exp1=\=Exp2` ⟨• ISO •⟩

The numeric values of `Exp1` and `Exp2` are not equal when both are evaluated as arithmetic expressions.

General properties:

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

`Exp1=\=Exp2` is side-effect `free`. (basic_props:sideff/2)

`Exp1=\=Exp2` is binding insensitive. (basic_props:bind_ins/1)

All calls of the form `Exp1=\=Exp2` are deterministic. (native_props:is_det/1)

Goal `Exp1=\=Exp2` produces `inf` solutions. (native_props:relations/2)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `A=\=B`

– *The following properties should hold at call time:*

`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`B` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is an arithmetic expression. (arithmetic:arithexpression/1)

`B` is an arithmetic expression. (arithmetic:arithexpression/1)

– *The following properties hold globally:*

`A=\=B` is evaluable at compile-time. (basic_props:eval/1)

`int` is the metric of the variable `A`, for any approximation. (native_props:size_metric/3)

`int` is the metric of the variable `B`, for any approximation. (native_props:size_metric/3)

arithexpression/1: REGTYPE

An arithmetic expression is a term built from numbers and evaluable functors that represent arithmetic functions. An arithmetic expression evaluates to a number, which may be an integer (`int/1`) or a float (`flt/1`). The evaluable functors allowed in an arithmetic expression are listed below, together with an indication of the functions they represent. All evaluable functors defined in ISO-Prolog are implemented, as well as some other useful or traditional. Unless stated otherwise, an expression evaluates to a float if any of its arguments is a float, otherwise to an integer.

- `- /1`: sign reversal. ⟨• ISO •⟩
- `+ /1`: identity.
- `-- /1`: decrement by one.

- `++ /1`: increment by one.
- `+ /2`: addition. ⟨• ISO •⟩
- `- /2`: subtraction. ⟨• ISO •⟩
- `* /2`: multiplication. ⟨• ISO •⟩
- `// /2`: integer division. Float arguments are truncated to integers, result always integer. ⟨• ISO •⟩
- `/ /2`: division. Result always float. ⟨• ISO •⟩
- `rem/2`: integer remainder. The result is always an integer, its sign is the sign of the first argument. ⟨• ISO •⟩
- `mod/2`: modulo. The result is always a positive integer. ⟨• ISO •⟩
- `abs/1`: absolute value. ⟨• ISO •⟩
- `sign/1`: sign of. ⟨• ISO •⟩
- `float_integer_part/1`: float integer part. Result always float. ⟨• ISO •⟩
- `float_fractional_part/1`: float fractional part. Result always float. ⟨• ISO •⟩
- `truncate/1`: The result is the integer equal to the integer part of the argument. ⟨• ISO •⟩
- `integer/1`: same as `truncate/1`.
- `float/1`: conversion to float. ⟨• ISO •⟩
- `floor/1`: largest integer not greater than. ⟨• ISO •⟩
- `round/1`: integer nearest to. ⟨• ISO •⟩
- `ceiling/1`: smallest integer not smaller than. ⟨• ISO •⟩
- `** /2`: exponentiation. Result always float. ⟨• ISO •⟩
- `>> /2`: integer bitwise right shift. ⟨• ISO •⟩
- `<< /2`: integer bitwise left shift. ⟨• ISO •⟩
- `/\ /2`: integer bitwise and. ⟨• ISO •⟩
- `\/ /2`: integer bitwise or. ⟨• ISO •⟩
- `\ /1`: integer bitwise complement. ⟨• ISO •⟩
- `# /2`: integer bitwise exclusive or (xor).
- `exp/1`: exponential (e to the power of). Result always float. ⟨• ISO •⟩
- `log/1`: natural logarithm (base e). Result always float. ⟨• ISO •⟩
- `sqrt/1`: square root. Result always float. ⟨• ISO •⟩
- `sin/1`: sine. Result always float. ⟨• ISO •⟩
- `cos/1`: cosine. Result always float. ⟨• ISO •⟩
- `atan/1`: arc tangent. Result always float. ⟨• ISO •⟩
- `gcd/2`: Greatest common divisor. Arguments must evaluate to integers, result always integer.

In addition to these functors, a list of just a number evaluates to this number. Since a quoted string is just a list of integers, this allows a quoted character to be used in place of its ASCII code; e.g. `"A"` behaves within arithmetic expressions as the integer 65. Note that this is not ISO-compliant, and that can be achieved by using the ISO notation `0'A`.

Arithmetic expressions, as described above, are just data structures. If you want one evaluated you must pass it as an argument to one of the arithmetic predicates defined in this library.

General properties:

– *The following properties hold globally:*

`arithexpression(Arg1)` is side-effect `free`. (basic_props:sideff/2)

– *If the following properties hold at call time:*

`Arg1` is currently a term which is not a free variable. (term_typing:nonvar/1)

then the following properties hold globally:

All calls of the form `arithexpression(Arg1)` are deterministic. (native_props:is_det/1)

Indicates the type of test that a predicate performs. Required by the nonfailure analyisis. (native_props:test_type/2)

Usage: `arithexpression(E)`

– *Description:* `E` is an arithmetic expression.

intexpression/1: REGTYPE

General properties:

– *The following properties hold globally:*

`intexpression(Arg1)` is side-effect `free`. (basic_props:sideff/2)

Usage: `intexpression(E)`

– *Description:* `E` is an integer expression.

20.3 Known bugs and planned improvements (`arithmetic`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

21 Basic file/stream handling

Author(s): Daniel Cabeza, Mats Carlsson.

This module provides basic predicates for handling files and streams, in order to make input/output on them.

21.1 Usage and interface (streams_basic)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    open/3, open/4, close/1, set_input/1, current_input/1, set_output/1, current_output/1, character_count/2, line_count/2, line_position/2, flush_output/1, flush_output/0, clearerr/1, current_stream/3, stream_code/2, absolute_file_name/2, absolute_file_name/7, pipe/2.
  - *Regular Types:*
    open_option_list/1, sourcename/1, stream/1, stream_alias/1, io_mode/1, atm_or_int/1.
  - *Multifiles:*
    file_search_path/2, library_directory/1.

21.2 Documentation on exports (streams_basic)

open/3: PREDICATE

open(File,Mode,Stream)

Open File with mode Mode and return in Stream the stream associated with the file. No extension is implicit in File.

Usage 1: • ISO •

- *Description:* Normal use.
- *Call and exit should be compatible with:*
  Stream is an open stream. (streams_basic:stream/1)
- *The following properties should hold at call time:*
  File is a source name. (streams_basic:sourcename/1)
  Mode is an opening mode ('read', 'write' or 'append'). (streams_basic:io_mode/1)
- *The following properties should hold upon exit:*
  Stream is an open stream. (streams_basic:stream/1)
- *The following properties should hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

Usage 2:

- *Description:* In the special case that File is an integer, it is assumed to be a file descriptor passed to Prolog from a foreign function call. The file descriptor is connected to a Prolog stream (invoking the UNIX function fdopen) which is unified with Stream.

– *Call and exit should be compatible with:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties should hold at call time:*
`File` is an integer. (basic_props:int/1)
`Mode` is an opening mode ('read', 'write' or 'append'). (streams_basic:io_mode/1)
– *The following properties should hold upon exit:*
`Stream` is an open stream. (streams_basic:stream/1)

open/4: PREDICATE

`open(File,Mode,Stream,Options)`

Same as `open(File, Mode, Stream)` with options `Options`. See the definition of `open_option_list/1` for details.

Usage:

– *Call and exit should be compatible with:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties should hold at call time:*
`File` is a source name. (streams_basic:sourcename/1)
`Mode` is an opening mode ('read', 'write' or 'append'). (streams_basic:io_mode/1)
`Options` is a list of options for `open/4`. (streams_basic:open_option_list/1)
– *The following properties should hold upon exit:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

open_option_list/1: REGTYPE

A list of options for `open/4`, currently the meaningful options are:

`lock` Try to set an advisory lock for the file. If the open mode is `read`, the lock is a read (shared) lock, else it is a write (exclusive) lock. If the lock cannot be acquired, the call waits until it is released (but can fail in exceptional cases).

`lock_nb` Same as `lock`, but the call immediately fails if the lock cannot be acquired.

`lock(Lock_Mode)`
Same as `lock`, but specifying in `Lock_Mode` whether the lock is `read` (also `shared`) or `write` (also `exclusive`). This option has be included for compatibility with the SWI-Prolog locking options, because in general the type of lock should match the open mode as in the `lock` option.

`lock_nb(Lock_Mode)`
Same as the previous option but with the `lock_nb` behavior.

All file locking is implemented via the POSIX function fcntl(). Please refer to its manual page for details.

Usage: `open_option_list(L)`

– *Description:* `L` is a list of options for `open/4`.

close/1: PREDICATE

`close(Stream)`

Close the stream `Stream`.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

set_input/1: PREDICATE

`set_input(Stream)`

Set the current input stream to `Stream`. A notion of *current input stream* is maintained by the system, so that input predicates with no explicit stream operate on the current input stream. Initially it is set to `user_input`.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_input/1: PREDICATE

`current_input(Stream)`

Unify `Stream` with the current input stream. In addition to the ISO behavior, stream aliases are allowed. This is useful for most applications checking whether a stream is the standard input or output.

Usage: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

set_output/1: PREDICATE

`set_output(Stream)`

Set the current output stream to `Stream`. A notion of *current output stream* is maintained by the system, so that output predicates with no explicit stream operate on the current output stream. Initially it is set to `user_output`.

Usage: ⟨• ISO •⟩

– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_output/1: PREDICATE

`current_output(Stream)`

Unify `Stream` with the current output stream. The same comment as for `current_input/1` applies.

Usage: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold upon exit:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

character_count/2: PREDICATE

`character_count(Stream,Count)`

`Count` characters have been read from or written to `Stream`.

Usage:

– *Calls should, and exit will be compatible with:*
`Count` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold upon exit:*
`Count` is an integer. (basic_props:int/1)
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

line_count/2: PREDICATE

`line_count(Stream,Count)`

`Count` lines have been read from or written to `Stream`.

Usage:

– *Calls should, and exit will be compatible with:*
`Count` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold upon exit:*
`Count` is an integer. (basic_props:int/1)
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

line_position/2: PREDICATE

`line_position(Stream,Count)`

`Count` characters have been read from or written to the current line of `Stream`.

Usage:

- *Calls should, and exit will be compatible with:*
  `Count` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold upon exit:*
  `Count` is an integer. (basic_props:int/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

flush_output/1: PREDICATE

`flush_output(Stream)`

Flush any buffered data to output stream `Stream`.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

flush_output/0: PREDICATE

`flush_output`

Behaves like `current_output(S), flush_output(S)`

clearerr/1: PREDICATE

`clearerr(Stream)`

Clear the end-of-file and error indicators for input stream `Stream`.

Usage:

- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)

current_stream/3: PREDICATE

`current_stream(Filename,Mode,Stream)`

`Stream` is a stream which was opened in mode `Mode` and which is connected to the absolute file name `Filename` (an atom) or to the file descriptor `Filename` (an integer). This predicate can be used for enumerating all currently open streams through backtracking.

Usage:

– *Calls should, and exit will be compatible with:*
streams_basic:atm_or_int(Filename) (streams_basic:atm_or_int/1)
`Mode` is an opening mode ('read', 'write' or 'append'). (streams_basic:io_mode/1)
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold upon exit:*
streams_basic:atm_or_int(Filename) (streams_basic:atm_or_int/1)
`Mode` is an opening mode ('read', 'write' or 'append'). (streams_basic:io_mode/1)
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

stream_code/2: PREDICATE

`stream_code(Stream,StreamCode)`

`StreamCode` is the file descriptor (an integer) corresponding to the Prolog stream `Stream`.

Usage 1:
– *Calls should, and exit will be compatible with:*
`StreamCode` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold upon exit:*
`StreamCode` is an integer. (basic_props:int/1)

Usage 2:
– *The following properties should hold at call time:*
`Stream` is a free variable. (term_typing:var/1)
`StreamCode` is an integer. (basic_props:int/1)
– *The following properties hold upon exit:*
`Stream` is an open stream. (streams_basic:stream/1)

absolute_file_name/2: PREDICATE

`absolute_file_name(RelFileSpec,AbsFileSpec)`

If `RelFileSpec` is an absolute pathname then do an absolute lookup. If `RelFileSpec` is a relative pathname then prefix the name with the name of the current directory and do an absolute lookup. If `RelFileSpec` is a path alias, perform the lookup following the path alias rules (see `sourcename/1`). In all cases: if a matching file with suffix `.pl` exists, then `AbsFileSpec` will be unified with this file. Failure to open a file normally causes an exception. The behaviour can be controlled by the `fileerrors` prolog flag.

Usage: `absolute_file_name(RelFileSpec,AbsFileSpec)`
– *Description:* `AbsFileSpec` is the absolute name (with full path) of `RelFileSpec`.
– *Call and exit should be compatible with:*
`RelFileSpec` is a source name. (streams_basic:sourcename/1)
`AbsFileSpec` is an atom. (basic_props:atm/1)
– *The following properties should hold at call time:*
`RelFileSpec` is currently a term which is not a free variable. (term_typing:nonvar/1)
`AbsFileSpec` is a free variable. (term_typing:var/1)

– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

absolute_file_name/7: PREDICATE

`absolute_file_name(Spec,Opt,Suffix,CurrDir,AbsFile,AbsBase,AbsDir)`

`AbsFile` is the absolute name (with full path) of `Spec`, which has an optional first suffix `Opt` and an optional second suffix `Suffix`, when the current directory is `CurrDir`. `AbsBase` is the same as `AbsFile`, but without the second suffix, and `AbsDir` is the absolute path of the directory where `AbsFile` is. The Ciao compiler invokes this predicate with `Opt='_opt'` and `Suffix='.pl'` when searching source files.

Usage:

– *The following properties should hold at call time:*
`Spec` is a source name. (streams_basic:sourcename/1)
`Opt` is an atom. (basic_props:atm/1)
`Suffix` is an atom. (basic_props:atm/1)
`CurrDir` is an atom. (basic_props:atm/1)
`AbsFile` is a free variable. (term_typing:var/1)
`AbsBase` is a free variable. (term_typing:var/1)
`AbsDir` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*
`AbsFile` is an atom. (basic_props:atm/1)
`AbsBase` is an atom. (basic_props:atm/1)
`AbsDir` is an atom. (basic_props:atm/1)

– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

pipe/2: PREDICATE

Usage: ⟨• ISO •⟩

– *The following properties should hold at call time:*
`Arg1` is a free variable. (term_typing:var/1)
`Arg2` is a free variable. (term_typing:var/1)

– *The following properties hold upon exit:*
`Arg1` is an open stream. (streams_basic:stream/1)
`Arg2` is an open stream. (streams_basic:stream/1)

– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

sourcename/1: REGTYPE

A source name is a flexible way of referring to a concrete file. A source name is either a relative or absolute filename given as:

- an atom, or
- a unary functor (which represents a *path alias*, see below) applied to a *relative* path, the latter being given as an atom.

In all cases certain filename extensions (e.g., `.pl`) can be implicit. In the first form above, file names can be relative to the current directory. Also, file names beginning with `~` or `$` are treated specially. For example,

`'~/ciao/sample.pl'`
: is equivalent to `'/home/staff/herme/ciao/sample.pl'`, if `/home/staff/herme` is the user's home directory. (This is also equivalent to `'$HOME/ciao/sample.pl'` as explained below.)

`'~bardo/prolog/sample.pl'`
: is equivalent to `'/home/bardo/prolog/sample.pl'`, if `/home/bardo` is bardo's home directory.

`'$UTIL/sample.pl'`
: is equivalent to `'/usr/local/src/utilities/sample.pl'`, if `/usr/local/src/utilities` is the value of the environment variable `UTIL`.

The second form allows using path aliases. Such aliases allow refering to files not with absolute file system paths but with paths which are relative to predefined (or user-defined) abstract names. For example, given the path alias `myutils` which has been defined to refer to path `'/home/bardo/utilities'`, if that directory contains the file `stuff.pl` then the term `myutils(stuff)` in a `use_module/1` declaration would refer to the file `'/home/bardo/utilities/stuff.pl'` (the `.pl` extension is implicit in the `use_module/1` declaration). As a special case, if that directory contains a subdirectory named `stuff` which in turn contains the file `stuff.pl`, the same term would refer to the file `'/home/bardo/utilities/stuff/stuff.pl'`. If a path alias is related to several paths, all paths are scanned in sequence until a match is found. For information on predefined path aliases or how to define new path aliases, see `file_search_path/2`.

Usage: `sourcename(F)`

– *Description:* `F` is a source name.

stream/1: REGTYPE

Streams correspond to the file pointers used at the operating system level, and usually represent opened files. There are four special streams which correspond with the operating system standard streams:

`user_input`
: The standard input stream, i.e. the terminal, usually.

`user_output`
: The standard output stream, i.e. the terminal, usually.

`user_error`
: The standard error stream.

`user`
: The standard input or output stream, depending on context.

Usage: `stream(S)`

– *Description:* `S` is an open stream.

stream_alias/1: REGTYPE

Usage: `stream_alias(S)`

– *Description:* `S` is the alias of an open stream, i.e., an atom which represents a stream at Prolog level.

io_mode/1: REGTYPE

Can have the following values:

`read` Open the file for input.

`write` Open the file for output. The file is created if it does not already exist, the file will otherwise be truncated.

`append` Open the file for output. The file is created if it does not already exist, the file will otherwise be appended to.

Usage: `io_mode(M)`

– *Description:* `M` is an opening mode ('read', 'write' or 'append').

atm_or_int/1: REGTYPE

A regular type, defined as follows:

```
atm_or_int(X) :-
        atm(X).
atm_or_int(X) :-
        int(X).
```

21.3 Documentation on multifiles (`streams_basic`)

file_search_path/2: PREDICATE

`file_search_path(Alias,Path)`

The path alias `Alias` is linked to path `Path`. Both arguments must be atoms. New facts (or clauses) of this predicate can be asserted to define new path aliases. Predefined path aliases in Ciao are:

`library` Initially points to all Ciao library paths. See `library_directory/1`.

`engine` The path of the Ciao engine builtins.

`.` The current path (`'.'`).

The predicate is *multifile*.

The predicate is of type *dynamic*.

`file_search_path(X,Y)`

– *The following properties hold upon exit:*

`X` is ground. (basic_props:gnd/1)

`Y` is ground. (basic_props:gnd/1)

library_directory/1: PREDICATE

`library_directory(Path)`

`Path` is a library path (a path represented by the path alias `library`). Predefined library paths in Ciao are `'$CIAOLIB/lib'`, `'$CIAOLIB/library'`, and `'$CIAOLIB/contrib'`, given that `$CIAOLIB` is the path of the root ciao library directory. More library paths can be defined by asserting new facts (or clauses) of this predicate.

The predicate is *multifile*.

The predicate is of type *dynamic*.

`library_directory(X)`

– *The following properties hold upon exit:*
`X` is ground. (basic_props:gnd/1)

21.4 Known bugs and planned improvements (`streams_basic`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

22 Basic input/output

Author(s): Daniel Cabeza, Mats Carlsson.

This module provides predicates for character input/output and for canonical term output. From the ISO-Prolog predicates for character input/output, only the `_code` versions are provided, the rest are given by `library(iso_byte_char)`, using these. Most predicates are provided in two versions: one that specifies the input or output stream as the first argument and a second which omits this argument and uses the current input or output stream.

22.1 Usage and interface (io_basic)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `get_code/2`, `get_code/1`, `get1_code/2`, `get1_code/1`, `peek_code/2`, `peek_code/1`, `skip_code/2`, `skip_code/1`, `skip_line/1`, `skip_line/0`, `put_code/2`, `put_code/1`, `nl/1`, `nl/0`, `tab/2`, `tab/1`, `code_class/2`, `getct/2`, `getct1/2`, `display/2`, `display/1`, `displayq/2`, `displayq/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

22.2 Documentation on exports (io_basic)

get_code/2: PREDICATE

`get_code(Stream,Code)`

Reads from `Stream` the next character and unifies `Code` with its character code. At end of stream, unifies `Code` with the integer -1.

Usage: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*
  `Code` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties hold upon exit:*
  `Code` is an integer. (basic_props:int/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

get_code/1: PREDICATE

`get_code(Code)`

Behaves like `current_input(S), get_code(S,Code)`.

Usage: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*
`Code` is an integer. (basic_props:int/1)
– *The following properties hold upon exit:*
`Code` is an integer. (basic_props:int/1)
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

get1_code/2: PREDICATE

`get1_code(Stream,Code)`

Reads from `Stream` the next non-layout character (see `code_class/2`) and unifies `Code` with its character code. At end of stream, unifies `Code` with the integer -1.

Usage:

– *Calls should, and exit will be compatible with:*
`Code` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold upon exit:*
`Code` is an integer. (basic_props:int/1)
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

get1_code/1: PREDICATE

`get1_code(Code)`

Behaves like `current_input(S), get1_code(S,Code)`.

Usage:

– *Calls should, and exit will be compatible with:*
`Code` is an integer. (basic_props:int/1)
– *The following properties hold upon exit:*
`Code` is an integer. (basic_props:int/1)
– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

peek_code/2: PREDICATE

`peek_code(Stream,Code)`

Unifies `Code` with the character code of the next character of `Stream`, leaving the stream position unaltered. At end of stream, unifies `Code` with the integer -1.

Usage: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*
`Code` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties hold upon exit:*
`Code` is an integer. (basic_props:int/1)

peek_code/1: PREDICATE

`peek_code(Code)`

Behaves like `current_input(S), peek_code(S,Code)`.

Usage: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`Code` is an integer. (basic_props:int/1)

– *The following properties hold upon exit:*

`Code` is an integer. (basic_props:int/1)

skip_code/2: PREDICATE

`skip_code(Stream,Code)`

Skips just past the next character code `Code` from `Stream`.

Usage:

– *The following properties should hold at call time:*

`Stream` is an open stream. (streams_basic:stream/1)

`Code` is an integer. (basic_props:int/1)

skip_code/1: PREDICATE

`skip_code(Code)`

Behaves like `current_input(S), skip_code(S,Code)`.

Usage:

– *The following properties should hold at call time:*

`Code` is an integer. (basic_props:int/1)

skip_line/1: PREDICATE

`skip_line(Stream)`

Skips from `Stream` the remaining input characters on the current line. If the end of the stream is reached, the stream will stay at its end. Portable among different operating systems.

Usage:

– *The following properties should hold at call time:*

`Stream` is an open stream. (streams_basic:stream/1)

skip_line/0: PREDICATE

`skip_line`

Behaves like `current_input(S), skip_line(S)`.

put_code/2: PREDICATE

`put_code(Stream,Code)`

Outputs to `Stream` the character corresponding to character code `Code`.

Usage: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Stream` is an open stream. (streams_basic:stream/1)

`Code` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

All calls of the form `put_code(Stream,Code)` are deterministic. (native_props:is_det/1)

put_code/1: PREDICATE

`put_code(Code)`

Behaves like `current_output(S), put_code(S,Code)`.

Usage: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Code` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

All calls of the form `put_code(Code)` are deterministic. (native_props:is_det/1)

nl/1: PREDICATE

`nl(Stream)`

Outputs a newline character to `Stream`. Equivalent to `put_code(Stream, 0'\n)`.

Usage: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Stream` is an open stream. (streams_basic:stream/1)

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

All calls of the form `nl(Stream)` are deterministic. (native_props:is_det/1)

All the calls of the form `nl(Stream)` do not fail. (native_props:not_fails/1)

nl/0: PREDICATE

`nl`

Behaves like `current_output(S), nl(S)`.

Usage: ⟨• ISO •⟩

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

All calls of the form `nl` are deterministic. (native_props:is_det/1)

All the calls of the form `nl` do not fail. (native_props:not_fails/1)

Goal `nl` produces `1` solutions. (native_props:relations/2)

tab/2: PREDICATE

`tab(Stream,Num)`

Outputs `Num` spaces to `Stream`.

Usage:

- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
  `Num` is an integer. (basic_props:int/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)
  All calls of the form `tab(Stream,Num)` are deterministic. (native_props:is_det/1)

tab/1: PREDICATE

`tab(Num)`

Behaves like `current_output(S), tab(S,Num)`.

Usage:

- *The following properties should hold at call time:*
  `Num` is an integer. (basic_props:int/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)
  All calls of the form `tab(Num)` are deterministic. (native_props:is_det/1)

code_class/2: PREDICATE

`code_class(Code,Class)`

Unifies `Class` with an integer corresponding to the lexical class of the character whose code is `Code`, with the following correspondence:

```
0 - layout (includes space, newline, tab)
1 - small letter
2 - capital letter (including '_')
3 - digit
4 - graphic (includes #$&*+-./:<=>?@^\`~ )
5 - punctuation (includes !;"'%(),[]{|} )
```

Note that in ISO-Prolog the back quote ` is a punctuation character, whereas in Ciao it is a graphic character. Thus, if compatibility with ISO-Prolog is desired, the programmer should not use this character in unquoted names.

Usage:

- *Calls should, and exit will be compatible with:*
  `Class` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*
  `Code` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Class` is an integer. (basic_props:int/1)

getct/2: PREDICATE

`getct(Code,Type)`

Reads from the current input stream the next character, unifying `Code` with its character code, and `Type` with its lexical class. At end of stream, unifies both `Code` and `Type` with the integer -1. Equivalent to

```
get(Code), (Code = -1 -> Type = -1 ; code_class(Code,Type))
```

Usage:

- *Calls should, and exit will be compatible with:*
  `Code` is an integer. (basic_props:int/1)
  `Type` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Code` is an integer. (basic_props:int/1)
  `Type` is an integer. (basic_props:int/1)

getct1/2: PREDICATE

`getct1(Code,Type)`

Reads from the current input stream the next non-layout character, unifying `Code` with its character code, and `Type` with its lexical class (which will be nonzero). At end of stream, unifies both `Code` and `Type` with the integer -1. Equivalent to

```
get1(Code), (Code = -1 -> Type = -1 ; code_class(Code,Type))
```

Usage:

- *Calls should, and exit will be compatible with:*
  `Code` is an integer. (basic_props:int/1)
  `Type` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Code` is an integer. (basic_props:int/1)
  `Type` is an integer. (basic_props:int/1)

display/2: PREDICATE

`display(Stream,Term)`

Displays `Term` onto `Stream`. Lists are output using list notation, the other compound terms are output in functional notation. Similar to `write_term(Stream, Term, [ignore_ops(ops)])`, except that curly bracketed notation is not used with `{}/1`, and the `write_strings` flag is not honored.

Usage:

- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
  `Term` is any term. (basic_props:term/1)
- *The following properties hold upon exit:*
  `Term` is any term. (basic_props:term/1)
- *The following properties hold globally:*
  `Term` is not further instantiated. (basic_props:not_further_inst/2)
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

display/1: PREDICATE

`display(Term)`

Behaves like `current_output(S), display(S,Term)`.

Usage:

- *The following properties should hold at call time:*
  `Term` is any term. (basic_props:term/1)
- *The following properties hold upon exit:*
  `Term` is any term. (basic_props:term/1)
- *The following properties hold globally:*
  `Term` is not further instantiated. (basic_props:not_further_inst/2)
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

displayq/2: PREDICATE

`displayq(Stream,Term)`

Similar to `display(Stream, Term)`, but atoms and functors that can't be read back by `read_term/3` are quoted. Thus, similar to `write_term(Stream, Term, [quoted(true), ignore_ops(ops)])`, with the same exceptions as `display/2`.

Usage:

- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
  `Term` is any term. (basic_props:term/1)
- *The following properties hold upon exit:*
  `Term` is any term. (basic_props:term/1)
- *The following properties hold globally:*
  `Term` is not further instantiated. (basic_props:not_further_inst/2)

displayq/1: PREDICATE

`displayq(Term)`

Behaves like `current_output(S), displayq(S,Term)`.

Usage:

- *The following properties should hold at call time:*
  `Term` is any term. (basic_props:term/1)
- *The following properties hold upon exit:*
  `Term` is any term. (basic_props:term/1)
- *The following properties hold globally:*
  `Term` is not further instantiated. (basic_props:not_further_inst/2)

22.3 Known bugs and planned improvements (io_basic)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

23 Exception and Signal handling

Author(s): The CLIP Group.

This module includes predicates related to exceptions and signals, which alter the normal flow of Prolog.

23.1 Usage and interface (exceptions)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `catch/3`, `intercept/3`, `throw/1`, `send_signal/1`, `send_silent_signal/1`, `halt/0`, `halt/1`, `abort/0`.

23.2 Documentation on exports (exceptions)

catch/3: PREDICATE

`catch(Goal,Error,Handler)`

Executes `Goal`. If an exception is raised during its execution, `Error` is unified with the exception, and if the unification succeeds, the entire execution derived from `Goal` is aborted, and `Handler` is executed. The execution resumes with the continuation of the `catch/3` call. For example, given the code

```
p(X) :- throw(error), display('---').
p(X) :- display(X).
```

the execution of `"catch(p(0), E, display(E)), display(.), fail."` results in the output `"error."`.

Meta-predicate with arguments: `catch(goal,?,goal)`.

Usage: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*
  `Error` is any term. (basic_props:term/1)
  `Handler` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold at call time:*
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties hold upon exit:*
  `Error` is any term. (basic_props:term/1)
  `Handler` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

intercept/3: PREDICATE

`intercept(Goal,Signal,Handler)`

Executes `Goal`. If a signal is send during its execution, `Signal` is unified with the exception, and if the unification succeeds, `Handler` is executed and then the execution resumes after the point where the exception was thrown. To avoid infinite loops if `Handler` raises an exception which unifies with `Error`, the exception handler is deactivated before to execute `Handler`. Note the difference with builtin `catch/3`, given the code

```
p(X) :- send_signal(signal), display('---').
p(X) :- display(X).
```

the execution of `"intercept(p(0), E, display(E)), display(.), fail."` results in the output `"error---.0."`.

Meta-predicate with arguments: `intercept(goal,?,goal)`.

Usage:

- *Call and exit should be compatible with:*

  `Signal` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Handler` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `Signal` is any term. (basic_props:term/1)

throw/1: PREDICATE

`throw(Ball)`

Raises an error, throwing the exception `Ball`, to be caught by an ancestor `catch/3`. The closest matching ancestor is chosen. Exceptions are also thrown by other builtins in case of error.

Usage: `throw(Term)` ⟨• ISO •⟩

- *The following properties should hold at call time:*

  `Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

send_signal/1: PREDICATE

`send_signal(Signal)`

Emits a signal, to be intercept by an ancestor `intercept/3`. The closest matching ancestor is chosen. If the signal is not intercepted, throws the error `error(unintercepted_signal(Signal), send_signal/1-1)`.

Usage: `send_signal(Term)`

- *The following properties should hold at call time:*

  `Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

send_silent_signal/1: PREDICATE

`send_silent_signal(Signal)`

Emits a signal as `send_signal/1`, but do not throws an error if the signal is not intercepted (i.e. just suceeds silently)

Usage: `send_silent_signal(Term)`

– *The following properties should hold at call time:*

`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

halt/0: PREDICATE

`halt`

Halt the system, exiting to the invoking shell.

Usage: ⟨• ISO •⟩

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

halt/1: PREDICATE

`halt(Code)`

Halt the system, exiting to the invoking shell, returning exit code `Code`.

Usage: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Code` is an integer. (basic_props:int/1)

– *The following properties should hold upon exit:*

`Code` is an integer. (basic_props:int/1)

abort/0: PREDICATE

`abort`

Abort the current execution.

23.3 Known bugs and planned improvements (`exceptions`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

24 Changing system behaviour and various flags

Author(s): Daniel Cabeza, Mats Carlsson.

Flags define some parameters of the system and control the behavior of system or library predicates. Each flag has a name and an associated predefined value, and except some system flags which are fixed in general their associated value is changeable. Predefined flags in the system are:

`version` The Ciao version, as a term `ciao(Version,Patch)`. `Version` is a floating point number, `Patch` is an integer. Unchangeable.

`dialect` Value set to `ciao`. Used for compatibility with other systems when in Prolog mode. Unchangeable.

`argv` Its value is a list of atoms representing the program arguments supplied when the current executable was invoked. This is the value to which is instantiated the argument of the `main/1` predicate at executable startup. Unchangeable.

`bounded` It is `false`, to denote that the range of integers can be considered infinite (but see `int/1`). Unchangeable. ⟨• ISO •⟩

`fileerrors`
If `on`, predicates handling files give errors (throw exceptions) when a file is inexistent or an operation is not allowed. If `off`, fail in that conditions. Initially `on`.

`gc` Controls whether garbage collection is done. May be `on` (default) or `off`.

`gc_margin`
An integer `Margin`. If less than `Margin` kilobytes are reclaimed in a garbage collection then the size of the garbage collected area should be increased. Also, no garbage collection is attempted unless the garbage collected area has at least `Margin` kilobytes. Initially 500.

`gc_trace` Governs garbage collection trace messages. An element off `[on,off,terse,verbose]`. Initially `off`.

`integer_rounding_function`
It is `toward_zero`, so that `-1 =:= -3//2` succeeds. Unchangeable. ⟨• ISO •⟩

`max_arity`
It is 255, so that no compound term (or predicate) can have more than this number of arguments. Unchangeable. ⟨• ISO •⟩

`quiet` Controls which messages issued using `io_aux` are actually written. As the system uses that library to report its messages, this flag controls the *verbosity* of the system. Possible states of the flag are:

- `on` No messages are reported.
- `error` Only error messages are reported.
- `warning` Only error and warning messages are reported.
- `off` All messages are reported, except debug messages. This is the default state.
- `debug` All messages, including debug messages, are reported. This is only intended for the system implementators.

`unknown` Controls action on calls to undefined predicates. The possible states of the flag are:

- `error` An error is thrown with the error term `existence_error(procedure, F/A)`.

`fail` The call simply fails.

`warning` A warning is written and the call fails.

The state is initially `error`. ⟨• ISO •⟩

24.1 Usage and interface (`prolog_flags`)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `set_prolog_flag/2`, `current_prolog_flag/2`, `prolog_flag/3`, `push_prolog_flag/2`, `pop_prolog_flag/1`, `set_ciao_flag/2`, `current_ciao_flag/2`, `ciao_flag/3`, `push_ciao_flag/2`, `pop_ciao_flag/1`, `prompt/2`, `gc/0`, `nogc/0`, `fileerrors/0`, `nofileerrors/0`.
  - *Multifiles:*
    `define_flag/3`.

24.2 Documentation on exports (`prolog_flags`)

set_prolog_flag/2: PREDICATE

`set_prolog_flag(FlagName,Value)`

Set existing flag `FlagName` to `Value`.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `FlagName` is an atom. (basic_props:atm/1)
  `Value` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*
  `FlagName` is an atom. (basic_props:atm/1)
  `Value` is any term. (basic_props:term/1)

current_prolog_flag/2: PREDICATE

`current_prolog_flag(FlagName,Value)`

`FlagName` is an existing flag and `Value` is the value currently associated with it.

Usage:

- *The following properties should hold upon exit:*
  `FlagName` is an atom. (basic_props:atm/1)
  `Value` is any term. (basic_props:term/1)

prolog_flag/3: PREDICATE

`prolog_flag(FlagName,OldValue,NewValue)`

`FlagName` is an existing flag, unify `OldValue` with the value associated with it, and set it to new value `NewValue`.

Usage 1: `prolog_flag(A,B,C)`

- *The following properties should hold at call time:*

  `C` is any term. (basic_props:term/1)

  `C` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties should hold upon exit:*

  `A` is an atom. (basic_props:atm/1)

  `B` is any term. (basic_props:term/1)

Usage 2: `prolog_flag(FlagName,OldValue,NewValue)`

- *Description:* Same as `current_prolog_flag(FlagName, OldValue)`. `OldValue` and `NewValue` must be strictly identical variables.
- *The following properties should hold at call time:*

  `OldValue` is a free variable. (term_typing:var/1)

  `NewValue` is a free variable. (term_typing:var/1)

  `FlagName` is an atom. (basic_props:atm/1)
- *The following properties should hold upon exit:*

  `OldValue` is any term. (basic_props:term/1)

  `NewValue` is any term. (basic_props:term/1)

push_prolog_flag/2: PREDICATE

`push_prolog_flag(Flag,NewValue)`

Same as `set_prolog_flag/2`, but storing current value of `Flag` to restore it with `pop_prolog_flag/1`.

Usage:

- *The following properties should hold at call time:*

  `Flag` is an atom. (basic_props:atm/1)

  `NewValue` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*

  `Flag` is an atom. (basic_props:atm/1)

  `NewValue` is any term. (basic_props:term/1)

pop_prolog_flag/1: PREDICATE

`pop_prolog_flag(Flag)`

Restore the value of `Flag` previous to the last non-canceled `push_prolog_flag/2` on it.

Usage:

- *The following properties should hold at call time:*

  `Flag` is an atom. (basic_props:atm/1)
- *The following properties should hold upon exit:*

  `Flag` is an atom. (basic_props:atm/1)

set_ciao_flag/2: PREDICATE

Usage: `set_ciao_flag(FlagName,Value)`

– *The following properties should hold globally:*

`set_ciao_flag(FlagName,Value)` is equivalent to `set_prolog_flag(FlagName,Value)`. (basic_props:equiv/2)

current_ciao_flag/2: PREDICATE

Usage: `current_ciao_flag(FlagName,Value)`

– *The following properties should hold globally:*

`current_ciao_flag(FlagName,Value)` is equivalent to `current_prolog_flag(FlagName,Value)`. (basic_props:equiv/2)

ciao_flag/3: PREDICATE

Usage: `ciao_flag(Flag,Old,New)`

– *The following properties should hold globally:*

`ciao_flag(Flag,Old,New)` is equivalent to `prolog_flag(Flag,Old,New)`. (basic_props:equiv/2)

push_ciao_flag/2: PREDICATE

Usage: `push_ciao_flag(Flag,NewValue)`

– *The following properties should hold globally:*

`push_ciao_flag(Flag,NewValue)` is equivalent to `push_prolog_flag(Flag,NewValue)`. (basic_props:equiv/2)

pop_ciao_flag/1: PREDICATE

Usage: `pop_ciao_flag(Flag)`

– *The following properties should hold globally:*

`pop_ciao_flag(Flag)` is equivalent to `pop_prolog_flag(Flag)`. (basic_props:equiv/2)

prompt/2: PREDICATE

`prompt(Old,New)`

Unify `Old` with the current prompt for reading, change it to `New`.

Usage 1: `prompt(A,B)`

– *The following properties should hold at call time:*

`B` is an atom. (basic_props:atm/1)

– *The following properties should hold upon exit:*

`A` is an atom. (basic_props:atm/1)

Usage 2: `prompt(Old,New)`

- *Description:* Unify `Old` with the current prompt for reading without changing it. On calls, `Old` and `New` must be strictly identical variables.
- *The following properties should hold at call time:*

  `Old` is a free variable. (term_typing:var/1)

  `New` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Old` is an atom. (basic_props:atm/1)

  `New` is an atom. (basic_props:atm/1)

gc/0: PREDICATE

Usage:

- *Description:* Enable garbage collection. Equivalent to `set_prolog_flag(gc, on)`
- *The following properties should hold globally:*

  `gc` is equivalent to `set_prolog_flag(gc,on)`. (basic_props:equiv/2)

nogc/0: PREDICATE

Usage:

- *Description:* Disable garbage collection. Equivalent to `set_prolog_flag(gc, off)`
- *The following properties should hold globally:*

  `nogc` is equivalent to `set_prolog_flag(gc,off)`. (basic_props:equiv/2)

fileerrors/0: PREDICATE

Usage:

- *Description:* Enable reporting of file errors. Equivalent to `set_prolog_flag(fileerrors, on)`
- *The following properties should hold globally:*

  `fileerrors` is equivalent to `set_prolog_flag(fileerrors,on)`. (basic_props:equiv/2)

nofileerrors/0: PREDICATE

Usage:

- *Description:* Disable reporting of file errors. Equivalent to `set_prolog_flag(fileerrors, off)`
- *The following properties should hold globally:*

  `nofileerrors` is equivalent to `set_prolog_flag(fileerrors,off)`. (basic_props:equiv/2)

24.3 Documentation on multifiles (prolog_flags)

define_flag/3: PREDICATE

`define_flag(Flag,Values,Default)`

New flags can be defined by writing facts of this predicate. `Flag` is the name of the new flag, `Values` defines the posible values for the flag (see below) and `Default` defines the predefined value associated with the flag (which should be compatible with `Values`).

The predicate is *multifile*.

Usage: `define_flag(Flag,FlagValues,Default)`

– *The following properties hold upon exit:*

`Flag` is an atom. (basic_props:atm/1)

Define the valid flag values (basic_props:flag_values/1)

24.4 Documentation on internals (prolog_flags)

set_prolog_flag/1: PREDICATE

No further documentation available for this predicate.

24.5 Known bugs and planned improvements (prolog_flags)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

25 Fast/concurrent update of facts

Author(s): Daniel Cabeza, Manuel Carro.

Prolog implementations traditionally implement the concept of dynamic predicates: predicates which can be inspected or modified at run-time, adding or deleting individual clauses. The power of this feature comes at a cost: as new clause bodies can be arbitrarily added to the program, new predicate calls can arise which are not 'visible' at compile-time, thus complicating global analysis and optimization of the code. But it is the case that most of the time what the programmer wants is simply to store data, with the purpose of sharing it between search branches, predicates, or even execution threads. In Ciao the concept of data predicate serves this purpose: a data predicate is a predicate composed exclusively by facts, which can be inspected, and dynamically added or deleted, at run-time. Using data predicates instead of normal dynamic predicates brings benefits in terms of speed, but above all makes the code much easier to analyze automatically and thus allows better optimization.

Also, a special kind of data predicates exists, *concurrent predicates*, which can be used to communicate/synchronize among different execution threads (see Chapter 87 [Low-level concurrency/multithreading primitives], page 463).

Data predicates must be declared through a `data/1` declaration. Concurrent data predicates must be declared through a `concurrent/1` declaration.

25.1 Usage and interface (`data_facts`)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `asserta_fact/1`, `asserta_fact/2`, `assertz_fact/1`, `assertz_fact/2`, `current_fact/1`, `current_fact/2`, `retract_fact/1`, `retractall_fact/1`, `current_fact_nb/1`, `retract_fact_nb/1`, `close_predicate/1`, `open_predicate/1`, `set_fact/1`, `erase/1`.
  - *Regular Types:*
    `reference/1`.

25.2 Documentation on exports (`data_facts`)

asserta_fact/1: PREDICATE

`asserta_fact(Fact)`

`Fact` is added to the corresponding data predicate. The fact becomes the first clause of the predicate concerned.

Meta-predicate with arguments: `asserta_fact(fact)`.

Usage:

- *The following properties should hold at call time:*
  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

asserta_fact/2: PREDICATE

`asserta_fact(Fact,Ref)`

Same as `asserta_fact/1`, instantiating `Ref` to a unique identifier of the asserted fact.

Meta-predicate with arguments: `asserta_fact(fact,?)`.

Usage:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Ref` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Ref` is a reference of a dynamic or data clause. (data_facts:reference/1)

assertz_fact/1: PREDICATE

`assertz_fact(Fact)`

`Fact` is added to the corresponding data predicate. The fact becomes the last clause of the predicate concerned.

Meta-predicate with arguments: `assertz_fact(fact)`.

Usage:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

assertz_fact/2: PREDICATE

`assertz_fact(Fact,Ref)`

Same as `assertz_fact/1`, instantiating `Ref` to a unique identifier of the asserted fact.

Meta-predicate with arguments: `assertz_fact(fact,?)`.

Usage:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Ref` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Ref` is a reference of a dynamic or data clause. (data_facts:reference/1)

current_fact/1: PREDICATE

`current_fact(Fact)`

Gives on backtracking all the facts defined as data or concurrent which unify with `Fact`. It is faster than calling the predicate explicitly, which do invoke the meta-interpreter. If the `Fact` has been defined as concurrent and has not been closed, `current_fact/1` will wait (instead of failing) for more clauses to appear after the last clause of `Fact` is returned.

Meta-predicate with arguments: `current_fact(fact)`.

Usage:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

current_fact/2: PREDICATE

`current_fact(Fact,Ref)`

`Fact` is a fact of a data predicate and `Ref` is its reference identifying it uniquely.

Meta-predicate with arguments: `current_fact(fact,?)`.

Usage 1:

– *Description:* Gives on backtracking all the facts defined as data which unify with `Fact`, instantiating `Ref` to a unique identifier for each fact.

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`Ref` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Ref` is a reference of a dynamic or data clause. (data_facts:reference/1)

Usage 2:

– *Description:* Given `Ref`, unifies `Fact` with the fact identified by it.

– *Call and exit should be compatible with:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold at call time:*

`Ref` is a reference of a dynamic or data clause. (data_facts:reference/1)

– *The following properties should hold upon exit:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

retract_fact/1: PREDICATE

`retract_fact(Fact)`

Unifies `Fact` with the first matching fact of a data predicate, and then erases it. On backtracking successively unifies with and erases new matching facts. If `Fact` is declared as concurrent and is non- closed, `retract_fact/1` will wait for more clauses or for the closing of the predicate after the last matching clause has been removed.

Meta-predicate with arguments: `retract_fact(fact)`.

Usage:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

retractall_fact/1: PREDICATE

`retractall_fact(Fact)`

Erase all the facts of a data predicate unifying with `Fact`. Even if all facts are removed, the predicate continues to exist.

Meta-predicate with arguments: `retractall_fact(fact)`.

Usage:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

- *The following properties should hold upon exit:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

current_fact_nb/1: PREDICATE

`current_fact_nb(Fact)`

Behaves as `current_fact/1` but a fact is never waited on even if it is concurrent and non-closed.

Meta-predicate with arguments: `current_fact_nb(fact)`.

Usage:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

- *The following properties should hold upon exit:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

retract_fact_nb/1: PREDICATE

`retract_fact_nb(Fact)`

Behaves as `retract_fact/1`, but never waits on a fact, even if it has been declared as concurrent and is non- closed.

Meta-predicate with arguments: `retract_fact_nb(fact)`.

Usage:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

- *The following properties should hold upon exit:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

close_predicate/1: PREDICATE

`close_predicate(Pred)`

Changes the behavior of the predicate `Pred` if it has been declared as a concurrent predicate: calls to this predicate will fail (instead of wait) if no more clauses of `Pred` are available.

Meta-predicate with arguments: `close_predicate(fact)`.

Usage:

- *The following properties should hold at call time:*

  `Pred` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

- *The following properties should hold upon exit:*

  `Pred` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

open_predicate/1: PREDICATE

`open_predicate(Pred)`

Reverts the behavior of concurrent predicate `Pred` to waiting instead of failing if no more clauses of `Pred` are available.

Meta-predicate with arguments: `open_predicate(fact)`.

Usage:

- *The following properties should hold at call time:*

  `Pred` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

- *The following properties should hold upon exit:*

  `Pred` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

set_fact/1: PREDICATE

`set_fact(Fact)`

Sets `Fact` as the unique fact of the corresponding data predicate.

Meta-predicate with arguments: `set_fact(fact)`.

Usage:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

- *The following properties should hold upon exit:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

erase/1: PREDICATE

`erase(Ref)`

Deletes the clause referenced by `Ref`.

Usage:

- *The following properties should hold at call time:*

  `Ref` is a reference of a dynamic or data clause. (data_facts:reference/1)

- *The following properties should hold upon exit:*

  `Ref` is a reference of a dynamic or data clause. (data_facts:reference/1)

- *The following properties should hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

reference/1: REGTYPE

Usage: `reference(R)`

– *Description:* `R` is a reference of a dynamic or data clause.

25.3 Documentation on internals (`data_facts`)

data/1: DECLARATION

Usage: `:- data Predicates.`

– *Description:* Defines each predicate in `Predicates` as a data predicate. If a predicate is defined data in a file, it must be defined data in every file containing clauses for that predicate. The directive should precede all clauses of the affected predicates. This directive is defined as a prefix operator in the compiler.

– *The following properties hold at call time:*

`Predicates` is a sequence or list of `prednames`. (basic_props:sequence_or_list/2)

concurrent/1: DECLARATION

Usage: `:- concurrent Predicates.`

– *Description:* Defines each predicate in `Predicates` as a concurrent predicate. If a predicate is defined concurrent in a file, it must be defined concurrent in every file containing clauses for that predicate. The directive should precede all clauses of the affected predicates. This directive is defined as a prefix operator in the compiler.

– *The following properties hold at call time:*

`Predicates` is a sequence or list of `prednames`. (basic_props:sequence_or_list/2)

25.4 Known bugs and planned improvements (`data_facts`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

26 Extending the syntax

Author(s): Daniel Cabeza.

This chapter documents the builtin directives in Ciao for extending the syntax of source files.

Note that the ISO-Prolog directive `char_conversion/2` is not implemented, since Ciao does not (yet) have a character conversion table.

26.1 Usage and interface (`syntax_extensions`)

- **Library usage:**
  These directives are builtin in Ciao, so nothing special has to be done to use them.

26.2 Documentation on internals (`syntax_extensions`)

op/3: DECLARATION

Usage: `:- op(Priority,Op_spec,Operator).` ⟨• ISO •⟩

- *Description:* Updates the operator table for reading the terms in the rest of the current text, in the same way as the builtin `op/3` does. Its scope is local to the current text. Usually included in package files.
- *The following properties hold at call time:*

  `Priority` is an integer. (basic_props:int/1)

  `Op_spec` specifies the type and associativity of an operator. (basic_props:operator_specifier/1)

  `Operator` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

new_declaration/1: DECLARATION

Usage: `:- new_declaration(Predicate).`

- *Description:* Declares `Predicate` to be a valid declaration in the rest of the current text. Such declarations are simply ignored by the compiler or top level, but can be used by other code processing programs such as an automatic documentator. Also, they can easily translated into standard code (a set of facts and/or rules) by defining a suitable expansion (e.g., by `add_sentence_trans/1`, etc.). This is tipically done in package files.

  Equivalent to `new_declaration(Predicate, off)`.
- *The following properties hold at call time:*

  `Predicate` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

new_declaration/2: DECLARATION

Usage: :- `new_declaration(Predicate,In_Itf).`

- *Description:* Declares `Predicate` to be a valid declaration in the rest of the current text. Such declarations will be included in the interface file for this file if `In_Itf` is 'on', not if it is 'off'. Including such declarations in interface files makes them visible while processing other modules which make use of this one.
- *The following properties hold at call time:*

  `Predicate` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

  (basic_props:predname/1)

  `In_Itf` is 'on' or 'off' (syntax_extensions:switch/1)

load_compilation_module/1: DECLARATION

Usage: :- `load_compilation_module(File).`

- *Description:* Loads code defined in `File` into the compiler, usually including predicates which define translations of clauses, sentences, and terms, for use with the declarations `add_sentence_trans/2` and similar ones. The application order of translations is determined by ascending *priority* numbers. Normally included in package files.
- *The following properties hold at call time:*

  `File` is a source name. (streams_basic:sourcename/1)

add_sentence_trans/2: DECLARATION

Usage: :- `add_sentence_trans(Predicate,Priority).`

- *Description:* Starts a translation, defined by `Predicate`, of the terms read by the compiler in the rest of the current text. For each subsequent term read by the compiler, the translation predicate is called to obtain a new term which will be used by the compiler as if it where the term present in the file. If the call fails, the term is used as such. A list may be returned also, to translate a single term into several terms. Before calling the translation predicate with actual program terms, it is called with an input of `0` to give an opportunity of making initializations for the module, discarding the result (note that normally a 0 could not be there). `Predicate` must be exported by a module previously loaded with a `load_compilation_module/1` declaration. Normally included in package files.
- *The following properties hold at call time:*

  `Predicate` is a translation predicate spec (has arity 2 or 3). (syntax_extensions:translation_predname/1)

  `Priority` is an integer. (basic_props:int/1)

add_term_trans/2: DECLARATION

Usage: :- `add_term_trans(P,Priority).`

– *Description:* Starts a translation, defined by `Predicate`, of the terms and sub-terms read by the compiler in the rest of the current text. This translation is performed after all translations defined by `add_sentence_trans/1` are done. For each subsequent term read by the compiler, and recursively any subterm included, the translation predicate is called to possibly obtain a new term to replace the old one. Care must be taken of not introducing an endless loop of translations. `Predicate` must be exported by a module previously loaded with a `load_compilation_module/1` declaration. Normally included in package files.

– *The following properties hold at call time:*

`P` is a translation predicate spec (has arity 2 or 3). (syntax_extensions:translation_predname/1)

`Priority` is an integer. (basic_props:int/1)

add_goal_trans/2: DECLARATION

Usage: `:- add_goal_trans(Predicate,Priority).`

– *Description:* Declares a translation, defined by `Predicate`, of the goals present in the clauses of the current text. This translation is performed after all translations defined by `add_sentence_trans/1` and `add_term_trans/1` are done. For each clause read by the compiler, the translation predicate is called with each goal present in the clause to possibly obtain other goal to substitute the original one, and the translation is subsequently applied to the resulting goal. Care must be taken of not introducing an endless loop of translations. `Predicate` must be exported by a module previously loaded with a `load_compilation_module/1` declaration. Bear in mind that this type of translation noticeably slows down compilation. Normally included in package files.

– *The following properties hold at call time:*

`Predicate` is a translation predicate spec (has arity 2 or 3). (syntax_extensions:translation_predname/1)

`Priority` is an integer. (basic_props:int/1)

add_clause_trans/2: DECLARATION

Usage: `:- add_clause_trans(Predicate,Priority).`

– *Description:* Declares a translation, defined by `Predicate`, of the clauses of the current text. The translation is performed before `add_goal_trans/1` translations but after `add_sentence_trans/1` and `add_term_trans/1` translations. The usefulness of this translation is that information of the interface of related modules is available when it is performed. For each clause read by the compiler, the translation predicate is called with the first argument instantiated to a structure `clause(Head,Body)`, and the predicate must return in the second argument a similar structure, without changing the functor in `Head` (or fail, in which case the clause is used as is). Before executing the translation predicate with actual clauses it is called with an input of `clause(0,0)`, discarding the result.

– *The following properties hold at call time:*

`Predicate` is a translation predicate spec (has arity 2 or 3). (syntax_extensions:translation_predname/1)

`Priority` is an integer. (basic_props:int/1)

translation_predname/1: REGTYPE

A translation predicate is a predicate of arity 2 or 3 used to make compile-time translations. The compiler invokes a translation predicate instantiating its first argument with the item to be translated, and if the predicate is of arity 3 its third argument with the name of the module where the translation is done. If the call is successful, the second argument is used as if that item were in the place of the original, else the original item is used.

Usage: `translation_predname(P)`

– *Description:* `P` is a translation predicate spec (has arity 2 or 3).

27 Message printing primitives

Author(s): Daniel Cabeza, Edison Mera (improvements).

This module provides predicates for printing in a unified way informational messages, and also for printing some terms in a specific way.

27.1 Usage and interface (io_aux)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `message/2`, `message_lns/4`, `messages/1`, `error/1`, `warning/1`, `note/1`, `message/1`, `debug/1`, `inform_user/1`, `display_string/1`, `display_list/1`, `display_term/1`, `add_lines/4`.
  - *Regular Types:*
    `message_info/1`, `message_type/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

27.2 Documentation on exports (io_aux)

message/2: PREDICATE

Usage: `message(Type,Message)`

- *Description:* Output to standard error `Message`, which is of type `Type`. The `quiet` *prolog flag* (see Chapter 24 [Changing system behaviour and various flags], page 181) controls which messages are actually output, depending on its type. Also, for `error`, `warning` and `note` messages, a prefix is output which denotes the severity of the message.
- *The following properties should hold at call time:*
  Specifies the different types of messages. (io_aux:message_type/1)
  `Message` is an item or a list of items from this list:

  `$$(String)` `String` is a string, which is output with `display_string/1`.

  `''(Term)` `Term` is output quoted. If the module `write` is loaded, the term is output with `writeq/1`, else with `displayq/1`.

  `~~(Term)` `Term` is output unquoted. If the module `write` is loaded, the term is output with `write/1`, else with `display/1`.

  `[](Term)` `Term` is recursively output as a message, can be an item or a list of items from this list.

  `Term` Any other term is output with `display/1`.

  (io_aux:message_text/1)

message_lns/4: PREDICATE

Usage: `message_lns(Type,L0,L1,Message)`

– *Description:* Output to standard error `Message`, which is of type `Type`, and occurs between lines `L0` and `L1`. This is the same as `message/2`, but printing the lines where the message occurs in a unified way (this is useful because automatic tools such as the emacs mode know how to parse them).

– *The following properties should hold at call time:*

Specifies the different types of messages. (io_aux:message_type/1)

`L0` is a non-negative integer. (basic_props:nnegint/1)

`L1` is a non-negative integer. (basic_props:nnegint/1)

`Message` is an item or a list of items from this list:

`$$(String)`
: `String` is a string, which is output with `display_string/1`.

`''(Term)`
: `Term` is output quoted. If the module `write` is loaded, the term is output with `writeq/1`, else with `displayq/1`.

`~~(Term)`
: `Term` is output unquoted. If the module `write` is loaded, the term is output with `write/1`, else with `display/1`.

`[](Term)`
: `Term` is recursively output as a message, can be an item or a list of items from this list.

`Term`
: Any other term is output with `display/1`.

(io_aux:message_text/1)

messages/1: PREDICATE

Usage: `messages(Messages)`

– *Description:* Print each element in `Messages` using `message/2`, `message_lns/4`, `message/1`, `error/1`, `warning/1`, `note/1` or `debug/1` predicate. If the element should be printed using message_lns/4, it is printed in a compact way, avoiding to print the same file name several times.

– *The following properties should hold at call time:*

`Messages` is a list of `message_info`s. (basic_props:list/2)

error/1: PREDICATE

Defined as

```
error(Message) :-
        message(error,Message).
```

.

warning/1: PREDICATE

Defined as

```
warning(Message) :-
        message(warning,Message).
```

.

note/1: PREDICATE

Defined as

```
note(Message) :-
        message(note,Message).
```

.

message/1: PREDICATE

Defined as

```
message(Message) :-
        message(message,Message).
```

.

debug/1: PREDICATE

Defined as

```
debug(Message) :-
        message(debug,Message).
```

.

inform_user/1: PREDICATE

`inform_user(Message)`

Similar to `message/1`, but `Message` is output with `display_list/1`. This predicate is obsolete, and may disappear in future versions.

display_string/1: PREDICATE

`display_string(String)`

Output `String` as the sequence of characters it represents.

Usage: `display_string(String)`

– *The following properties should hold at call time:*

`String` is a string (a list of character codes). (basic_props:string/1)

display_list/1: PREDICATE

`display_list(List)`

Outputs `List`. If `List` is a list, do `display/1` on each of its elements, else do `display/1` on `List`.

display_term/1: PREDICATE

`display_term(Term)`

Output `Term` in a way that a `read/1` will be able to read it back, even if operators change.

message_info/1: REGTYPE

Usage:

– *Description:* The type of the elements to be printed using the `messages/1` predicate. Defined as

```
message_info(message_lns(Source,Ln0,Ln1,Type,Text)) :-
        atm(Source),
        nnegint(Ln0),
        nnegint(Ln1),
        message_type(Type),
        message_text(Text).
message_info(message(Type,Text)) :-
        atm(Type),
        message_text(Text).
message_info(error(Text)) :-
        message_text(Text).
message_info(warning(Text)) :-
        message_text(Text).
message_info(note(Text)) :-
        message_text(Text).
message_info(message(Text)) :-
        message_text(Text).
message_info(debug(Text)) :-
        message_text(Text).
```

.

message_type/1: REGTYPE

Usage:

– *Description:* Specifies the different types of messages.

add_lines/4: PREDICATE

No further documentation available for this predicate.

27.3 Known bugs and planned improvements (io_aux)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.
- `message/2` assumes that a module with name 'write' is library(write).

28 Attributed variables

Author(s): Christian Holzbaur, Daniel Cabeza, Manuel Carro.

These predicates allow the manipulation of *attributed variables*. Attributes are special terms which are attached to a (free) variable, and are hidden from the normal Prolog computation. They can only be treated by using the predicates below.

28.1 Usage and interface (`attributes`)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `attach_attribute/2`, `get_attribute/2`, `update_attribute/2`, `detach_attribute/1`.
  - *Multifiles:*
    `verify_attribute/2`, `combine_attributes/2`.

28.2 Documentation on exports (`attributes`)

attach_attribute/2: PREDICATE

Usage: `attach_attribute(Var,Attr)`

- *Description:* Attach attribute `Attr` to `Var`.
- *The following properties should hold at call time:*
  `Var` is a free variable. (term_typing:var/1)
  `Attr` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties hold upon exit:*
  `Var` is a free variable. (term_typing:var/1)
  `Attr` is currently a term which is not a free variable. (term_typing:nonvar/1)

get_attribute/2: PREDICATE

Usage: `get_attribute(Var,Attr)`

- *Description:* Unify `Attr` with the attribute of `Var`, or fail if `Var` has no attribute.
- *The following properties should hold at call time:*
  `Var` is a free variable. (term_typing:var/1)
- *The following properties hold upon exit:*
  `Attr` is currently a term which is not a free variable. (term_typing:nonvar/1)

update_attribute/2: PREDICATE

Usage: `update_attribute(Var,Attr)`

- *Description:* Change the attribute of attributed variable `Var` to `Attr`.

– *The following properties should hold at call time:*
`Var` is a free variable. (term_typing:var/1)
`Attr` is currently a term which is not a free variable. (term_typing:nonvar/1)
– *The following properties hold upon exit:*
`Var` is a free variable. (term_typing:var/1)
`Attr` is currently a term which is not a free variable. (term_typing:nonvar/1)

detach_attribute/1: PREDICATE

Usage: `detach_attribute(Var)`

– *Description:* Take out the attribute from the attributed variable `Var`.
– *The following properties should hold at call time:*
`Var` is a free variable. (term_typing:var/1)
– *The following properties hold upon exit:*
`Var` is a free variable. (term_typing:var/1)

28.3 Documentation on multifiles (`attributes`)

verify_attribute/2: PREDICATE

The predicate is *multifile*.

Usage: `verify_attribute(Attr,Term)`

– *Description: A user defined predicate.* This predicate is called when an attributed variable with attribute `Attr` is about to be unified with the non-variable term `Term`. The user should define this predicate (as multifile) in the modules implementing special unification.
– *The following properties should hold at call time:*
`Attr` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)
– *The following properties hold upon exit:*
`Attr` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

combine_attributes/2: PREDICATE

The predicate is *multifile*.

Usage: `combine_attributes(Var1,Var2)`

– *Description: A user defined predicate.* This predicate is called when two attributed variables with attributes `Var1` and `Var2` are about to be unified. The user should define this predicate (as multifile) in the modules implementing special unification.
– *The following properties should hold at call time:*
`Var1` is a free variable. (term_typing:var/1)
`Var2` is a free variable. (term_typing:var/1)
– *The following properties hold upon exit:*
`Var1` is a free variable. (term_typing:var/1)
`Var2` is a free variable. (term_typing:var/1)

28.4 Other information (`attributes`)

Note that `combine_attributes/2` and `verify_attribute/2` are not called with the attributed variables involved, but with the corresponding attributes instead. The reasons are:

- There are simple applications which only refer to the attributes.
- If the application wants to refer to the attributed variables themselves, they can be made part the attribute term. The implementation of `freeze/2` utilizes this technique. Note that this does not lead to cyclic structures, as the connection between an attributed variable and its attribute is invisible to the pure parts of the Prolog implementation.
- If attributed variables were passed as arguments, the user code would have to refer to the attributes through an extra call to `get_attribute/2`.
- As the/one attribute is the first argument to each of the two predicates, indexing applies. Note that attributed variables themselves look like variables to the indexing mechanism.

However, future improvements may change or extend the interface to attributed variables in order to provide a richer and more expressive interface.

For customized output of attributed variables, please refer to the documentation of the predicate `portray_attribute/2`.

28.5 Known bugs and planned improvements (`attributes`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

29 Gathering some basic internal info

Author(s): Daniel Cabeza, Manuel Carro.

This module provides predicates which return basic internal info.

29.1 Usage and interface (system_info)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `get_arch/1`, `get_os/1`, `get_platform/1`, `get_debug/1`, `get_eng_location/1`, `get_ciao_ext/1`, `get_exec_ext/1`, `get_so_ext/1`, `this_module/1`, `current_module/1`, `ciao_c_headers_dir/1`, `ciao_lib_dir/1`.
  - *Regular Types:*
    `internal_module_id/1`.

29.2 Documentation on exports (system_info)

get_arch/1: PREDICATE

This predicate will describe the computer architecture wich is currently executing the predicate.

Computer architectures are identified by a simple atom. This atom is implementation-defined, and may suffer any change from one Ciao Prolog version to another.

For example,Ciao Prolog running on an Intel-based machine will retrieve:

```
?- get_arch(I).

I = i86 ? ;

no
?-
```

Usage: `get_arch(ArchDescriptor)`

- *Description:* Unifies `ArchDescriptor` with a simple atom which describes the computer architecture currently executing the predicate.
- *The following properties hold upon exit:*
  `ArchDescriptor` is an atom. (basic_props:atm/1)

get_os/1: PREDICATE

This predicate will describe the Operating System which is running on the machine currently executing the Prolog program.

Operating Systems are identified by a simple atom. This atom is implementation-defined, and may suffer any change from one Ciao Prolog version to another.

For example,Ciao Prolog running on Linux will retrieve:

```
?- get_os(I).

I = 'LINUX' ? ;

no
?-
```

Usage: `get_os(OsDescriptor)`

- *Description:* Unifies `OsDescriptor` with a simple atom which describes the running Operating System when predicate was called.
- *The following properties hold upon exit:*

  `OsDescriptor` is an atom. (basic_props:atm/1)

get_platform/1: PREDICATE

Usage: `get_platform(Platform)`

- *Description:* Unifies `Platform` with an atom that describes the Operating System and the computer architecture which is currently executing the predicate.
- *The following properties hold upon exit:*

  `Platform` is an atom. (basic_props:atm/1)

get_debug/1: PREDICATE

Usage: `get_debug(Debug)`

- *Description:* Unifies `Debug` with an atom that indicates if the emulator has been compiled with debug information
- *The following properties hold upon exit:*

  `Debug` is an atom. (basic_props:atm/1)

get_eng_location/1: PREDICATE

Usage: `get_eng_location(Ext)`

- *Description:* Unifies `Ext` with an atom that indicates if the engine is located in a library (dyn) or in an executable (empty).
- *Calls should, and exit will be compatible with:*

  `Ext` is an atom. (basic_props:atm/1)

get_ciao_ext/1: PREDICATE

Usage: `get_ciao_ext(Ext)`

- *Description:* Unifies `Ext` with an atom that indicates the default extension for the executable prolog programs.
- *The following properties hold upon exit:*

  `Ext` is an atom. (basic_props:atm/1)

get_exec_ext/1: PREDICATE

Usage: `get_exec_ext(Ext)`

- *Description:* Unifies `Ext` with an atom that indicates the default extension for the binary executables.
- *The following properties hold upon exit:*

  `Ext` is an atom. (basic_props:atm/1)

get_so_ext/1: PREDICATE

Usage: `get_so_ext(Ext)`

- *Description:* Unifies `Ext` with an atom that indicates the default extension for the shared libraries. For example, .dll in windows and .so in most unix systems.
- *Calls should, and exit will be compatible with:*

  `Ext` is an atom. (basic_props:atm/1)

this_module/1: PREDICATE

Meta-predicate with arguments: `this_module(addmodule(?))`.

Usage: `this_module(Module)`

- *Description:* `Module` is the internal module identifier for current module.
- *The following properties hold upon exit:*

  `Module` is an internal module identifier (system_info:internal_module_id/1)

current_module/1: PREDICATE

This predicate will successively unify its argument with all module names currently loaded. Module names will be simple atoms.

When called using a free variable as argument, it will retrieve on backtracking all modules currently loaded. This is usefull when called from the Ciao `toplevel`.

When called using a module name as argument it will check whether the given module is loaded or not. This is usefull when called from user programs.

Usage: `current_module(Module)`

- *Description:* Retrieves (on backtracking) all currently loaded modules into your application.
- *The following properties should hold upon exit:*

  `Module` is an internal module identifier (system_info:internal_module_id/1)
- *The following properties should hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

ciao_c_headers_dir/1: PREDICATE

Usage: `ciao_c_headers_dir(CiaoPath)`

- *Description:* `CiaoPath` is the path to the root of the installed Ciao header C files (.h), typically used for interfacing Ciao and C.
- *The following properties hold upon exit:*

  `CiaoPath` is an atom. (basic_props:atm/1)

ciao_lib_dir/1: PREDICATE

Usage: `ciao_lib_dir(CiaoPath)`

- *Description:* `CiaoPath` is the path to the root of the Ciao libraries. Inside this directory, there are the directories 'lib', 'library' and 'contrib', which contain library modules.
- *The following properties hold upon exit:*

  `CiaoPath` is an atom. (basic_props:atm/1)

internal_module_id/1: REGTYPE

For a user file it is a term user/1 with an argument different for each user file, for other modules is just the name of the module (as an atom).

Usage: `internal_module_id(M)`

- *Description:* `M` is an internal module identifier

29.3 Known bugs and planned improvements (`system_info`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

30 Conditional Compilation

Author(s): Jose F. Morales.

This package defines a serie of directives for conditional compilation that allow the inclusion or exclusion of code blocks (which may contain nested conditional directives) based on the truth value at compile time of special goals called *conditions*. The syntax for conditional directives is:

```
:- if(Cond1).
  <<Block1>>
:- elif(Cond2).
  <<Block2>>
:- else.
  <<BlockN>>
:- endif.
```

where `elif(_)` can appear zero or more times and the `else` part is optional. The valid conditions are:

- calls to `current_prolog_flag/2`.
- conjunctions, disjunctions, or negations of conditions.

The sentences in `Block1` are included if the condition in `Cond1` is satisfied, else `Block2` is included if `Cond2` is satisfied (and so on for each `elif`), and `BlockN` if no previous condition is satisfied.

30.1 Usage and interface (`condcomp_doc`)

- **Library usage:**
  The conditional compilation directives are enabled by including the `condcomp` package in the package list of a module or by means of an explicit `:- use_package(condcomp)`

30.2 Known bugs and planned improvements (`condcomp_doc`)

- This package implements a `:- define(X)` directive and `defined(X)` condition. However, the syntax and semantic of this feature has still to be decided. Do not use it.
- Errors do not show line numbers

31 Other predicates and features defined by default

Author(s): Daniel Cabeza.

To simplify the use of Ciao Prolog to the first-timers, some other predicates and features are defined by default in normal cases, to provide more or less what other prologs define by default. Here are explicitly listed the predicates defined, coming from several libraries. Apart from those, the features defined in Chapter 41 [Definite clause grammars], page 271 and Chapter 53 [Enabling operators at run-time], page 335 are also activated.

31.1 Usage and interface (`default_predicates`)

- **Library usage:**
  No need of explicit loading. It is included by default in modules starting with a `module/2` declaration or user files without a starting `use_package/1` declaration. In the Ciao shell, it is loaded by default when no `~/.ciaorc` exists. Note that `:- module(`*modulename*`,`*exports*`)` is equivalent to `:- module(`*modulename*`,`*exports*`,[default])` If you do not want these predicates/features loaded for a given file (in order to make the executable smaller) you can ask for this explicitly using `:- module(`*modulename*`,`*exports*`,[])` or in a user file `:- use_package([])`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `read`, `write`, `operators`, `iso_byte_char`, `iso_misc`, `format`, `lists`, `sort`, `between`, `compiler/compiler`, `system`, `prolog_sys`, `dec10_io`, `old_database`, `ttyout`.

31.2 Documentation on exports (`default_predicates`)

op/3: (UNDOC_REEXPORT)
Imported from `operators` (see the corresponding documentation for details).

current_op/3: (UNDOC_REEXPORT)
Imported from `operators` (see the corresponding documentation for details).

append/3: (UNDOC_REEXPORT)
Imported from `lists` (see the corresponding documentation for details).

delete/3: (UNDOC_REEXPORT)
Imported from `lists` (see the corresponding documentation for details).

select/3: (UNDOC_REEXPORT)
Imported from `lists` (see the corresponding documentation for details).

nth/3: (UNDOC_REEXPORT)
Imported from `lists` (see the corresponding documentation for details).

last/2: (UNDOC_REEXPORT)
Imported from `lists` (see the corresponding documentation for details).

reverse/2: (UNDOC_REEXPORT)
Imported from `lists` (see the corresponding documentation for details).

length/2: (UNDOC_REEXPORT)
Imported from `lists` (see the corresponding documentation for details).

use_module/1: (UNDOC_REEXPORT)
Imported from `compiler` (see the corresponding documentation for details).

use_module/2: (UNDOC_REEXPORT)
Imported from `compiler` (see the corresponding documentation for details).

ensure_loaded/1: (UNDOC_REEXPORT)
Imported from `compiler` (see the corresponding documentation for details).

^/2: (UNDOC_REEXPORT)
Imported from `aggregates` (see the corresponding documentation for details).

findnsols/5: (UNDOC_REEXPORT)
Imported from `aggregates` (see the corresponding documentation for details).

findnsols/4: (UNDOC_REEXPORT)
Imported from `aggregates` (see the corresponding documentation for details).

findall/4: (UNDOC_REEXPORT)
Imported from `aggregates` (see the corresponding documentation for details).

findall/3: (UNDOC_REEXPORT)
Imported from `aggregates` (see the corresponding documentation for details).

bagof/3: (UNDOC_REEXPORT)
Imported from `aggregates` (see the corresponding documentation for details).

setof/3: (UNDOC_REEXPORT)
Imported from `aggregates` (see the corresponding documentation for details).

wellformed_body/3: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

data/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

dynamic/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

current_predicate/2: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

current_predicate/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

clause/3: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

clause/2: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

abolish/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

retractall/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

retract/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

assert/2: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

assert/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

assertz/2: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

assertz/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

asserta/2: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

asserta/1: (UNDOC_REEXPORT)
Imported from `dynamic` (see the corresponding documentation for details).

read_option/1: (UNDOC_REEXPORT)
Imported from `read` (see the corresponding documentation for details).

second_prompt/2: (UNDOC_REEXPORT)
Imported from `read` (see the corresponding documentation for details).

read_top_level/3: (UNDOC_REEXPORT)
Imported from `read` (see the corresponding documentation for details).

read_term/3: (UNDOC_REEXPORT)
Imported from `read` (see the corresponding documentation for details).

read_term/2: (UNDOC_REEXPORT)
Imported from `read` (see the corresponding documentation for details).

read/2: (UNDOC_REEXPORT)
Imported from `read` (see the corresponding documentation for details).

read/1: (UNDOC_REEXPORT)
Imported from `read` (see the corresponding documentation for details).

write_attribute/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

printable_char/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

prettyvars/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

numbervars/3: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

portray_clause/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

portray_clause/2: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

write_list1/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

print/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

print/2: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

write_canonical/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

write_canonical/2: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

writeq/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

writeq/2: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

write/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

write/2: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

write_option/1: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

write_term/2: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

write_term/3: (UNDOC_REEXPORT)
Imported from `write` (see the corresponding documentation for details).

put_char/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

put_char/1: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

peek_char/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

peek_char/1: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

get_char/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

get_char/1: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

put_byte/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

put_byte/1: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

peek_byte/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

peek_byte/1: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

get_byte/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

get_byte/1: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

char_codes/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

number_chars/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

atom_chars/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

char_code/2: (UNDOC_REEXPORT)
Imported from `iso_byte_char` (see the corresponding documentation for details).

unify_with_occurs_check/2: (UNDOC_REEXPORT)
Imported from `iso_misc` (see the corresponding documentation for details).

sub_atom/5: (UNDOC_REEXPORT)
Imported from `iso_misc` (see the corresponding documentation for details).

compound/1: (UNDOC_REEXPORT)
Imported from `iso_misc` (see the corresponding documentation for details).

once/1: (UNDOC_REEXPORT)
Imported from `iso_misc` (see the corresponding documentation for details).

format_control/1: (UNDOC_REEXPORT)
Imported from `format` (see the corresponding documentation for details).

format_to_string/3: (UNDOC_REEXPORT)
Imported from `format` (see the corresponding documentation for details).

sformat/3: (UNDOC_REEXPORT)
Imported from `format` (see the corresponding documentation for details).

format/3: (UNDOC_REEXPORT)
Imported from `format` (see the corresponding documentation for details).

format/2: (UNDOC_REEXPORT)
Imported from `format` (see the corresponding documentation for details).

keypair/1: (UNDOC_REEXPORT)
Imported from `sort` (see the corresponding documentation for details).

keylist/1: (UNDOC_REEXPORT)
Imported from `sort` (see the corresponding documentation for details).

keysort/2: (UNDOC_REEXPORT)
Imported from `sort` (see the corresponding documentation for details).

sort/2: (UNDOC_REEXPORT)
Imported from `sort` (see the corresponding documentation for details).

between/3: (UNDOC_REEXPORT)
Imported from `between` (see the corresponding documentation for details).

system_error_report/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

replace_characters/4: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

no_swapslash/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

cyg2win/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

winpath_c/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

winpath/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

winpath/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

using_windows/0: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

rename_file/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

delete_directory/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

delete_file/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

set_exec_mode/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

chmod/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

chmod/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

fmode/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

modif_time0/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

modif_time/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_properties/6: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_property/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_exists/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_exists/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

mktemp_in_tmp/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

mktemp/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

directory_files/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

wait/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

exec/8: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

exec/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

exec/4: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

popen_mode/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

popen/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

system/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

system/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

shell/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

shell/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

shell/0: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

cd/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

working_directory/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

make_dirpath/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

make_dirpath/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

make_directory/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

make_directory/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

umask/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

current_executable/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

current_host/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_address/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_tmp_dir/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_grnam/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_pwnam/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_gid/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_uid/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_pid/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_dir_name/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

extract_paths/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

dir_path/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

copy_file/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

copy_file/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

c_errno/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

del_env/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

set_env/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

current_env/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

setenvstr/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

getenvstr/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

datime_struct/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

datime/9: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

datime/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

time/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

pause/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

time_option/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

tick_option/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

clockfreq_option/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

memory_option/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

garbage_collection_option/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

symbol_option/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

time_result/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

memory_result/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

gc_result/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

symbol_result/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

new_atom/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

tick_result/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

clockfreq_result/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

garbage_collect/0: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

current_atom/1: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

predicate_property/2: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

statistics/2: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

statistics/0: (UNDOC_REEXPORT)
Imported from `prolog_sys` (see the corresponding documentation for details).

close_file/1: (UNDOC_REEXPORT)
Imported from `dec10_io` (see the corresponding documentation for details).

told/0: (UNDOC_REEXPORT)
Imported from `dec10_io` (see the corresponding documentation for details).

telling/1: (UNDOC_REEXPORT)
Imported from `dec10_io` (see the corresponding documentation for details).

tell/1: (UNDOC_REEXPORT)
Imported from `dec10_io` (see the corresponding documentation for details).

seen/0: (UNDOC_REEXPORT)
Imported from `dec10_io` (see the corresponding documentation for details).

seeing/1: (UNDOC_REEXPORT)
Imported from `dec10_io` (see the corresponding documentation for details).

see/1: (UNDOC_REEXPORT)
Imported from `dec10_io` (see the corresponding documentation for details).

current_key/2: (UNDOC_REEXPORT)
Imported from `old_database` (see the corresponding documentation for details).

recorded/3: (UNDOC_REEXPORT)
Imported from `old_database` (see the corresponding documentation for details).

recordz/3: (UNDOC_REEXPORT)
Imported from `old_database` (see the corresponding documentation for details).

recorda/3: (UNDOC_REEXPORT)
Imported from `old_database` (see the corresponding documentation for details).

ttydisplay_string/1: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttyskipeol/0: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttydisplayq/1: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttydisplay/1: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttyflush/0: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttytab/1: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttyskip/1: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttyput/1: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttynl/0: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttyget1/1: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

ttyget/1: (UNDOC_REEXPORT)
Imported from `ttyout` (see the corresponding documentation for details).

PART III - ISO-Prolog library (iso)

Author(s): The CLIP Group.

This part documents the *iso* package which provides to Ciao programs (most of) the ISO-Prolog functionality, including the *ISO-Prolog builtins* not covered by the basic library.

32 ISO-Prolog package

Author(s): The CLIP Group.

This library package allows the use of the ISO-Prolog predicates in Ciao programs. The compatibility is not at 100% yet.

32.1 Usage and interface (`iso_doc`)

- **Library usage:**
  `:- use_package(iso).`
  or
  `:- module(...,...,[iso]).`
- **New operators defined:**
  `-->/2` [1200,xfx], `|/2` [1100,xfy].
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`.

33 All solutions predicates

Author(s): Richard A. O'Keefe (first version), David H.D. Warren (first version), Mats Carlsson (changes), Daniel Cabeza, Manuel Hermenegildo.

This module implements the standard solution aggregation predicates.

When there are many solutions to a problem, and when all those solutions are required to be collected together, this can be achieved by repeatedly backtracking and gradually building up a list of the solutions. The following built-in predicates are provided to automate this process.

33.1 Usage and interface (aggregates)

- **Library usage:**
  `:- use_module(library(aggregates)).`
- **Exports:**
  - *Predicates:*
    `setof/3`, `bagof/3`, `findall/3`, `findall/4`, `findnsols/4`, `findnsols/5`, `^/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`, `sort`, `lists`.

33.2 Documentation on exports (aggregates)

setof/3: PREDICATE

`setof(Template,Generator,Set)`

Finds the `Set` of instances of the `Template` satisfying `Generator`. The set is in ascending order (see Chapter 18 [Comparing terms], page 135 for a definition of this order) without duplicates, and is non-empty. If there are no solutions, `setof` fails. `setof` may succeed in more than one way, binding free variables in `Generator` to different values. This can be avoided by using existential quantifiers on the free variables in front of `Generator`, using `^/2`. For example, given the clauses:

```
father(bill, tom).
father(bill, ann).
father(bill, john).
father(harry, july).
father(harry, daniel).
```

The following query produces two alternative solutions via backtracking:

```
?- setof(X,father(F,X),Sons).

F = bill,
Sons = [ann,john,tom] ? ;

F = harry,
Sons = [daniel,july] ? ;

no
```

```
?-
```

Meta-predicate with arguments: `setof(?,goal,?)`.

General properties: `setof(X,Y,Z)`

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP as `findall(X,Y,Z)`. (basic_props:native/2)

Usage: ⟨• ISO •⟩

– *Call and exit should be compatible with:*

`Set` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Template` is any term. (basic_props:term/1)

`Generator` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`Template` is any term. (basic_props:term/1)

`Set` is a list. (basic_props:list/1)

– *The following properties should hold globally:*

`Template` is not further instantiated. (basic_props:not_further_inst/2)

bagof/3: PREDICATE

`bagof(Template,Generator,Bag)`

Finds all the instances of the `Template` produced by the `Generator`, and returns them in the `Bag` in the order in which they were found. If the `Generator` contains free variables which are not bound in the `Template`, it assumes that this is like any other Prolog question and that you want bindings for those variables. This can be avoided by using existential quantifiers on the free variables in front of the `Generator`, using `^/2`.

Meta-predicate with arguments: `bagof(?,goal,?)`.

General properties: `bagof(X,Y,Z)`

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP as `findall(X,Y,Z)`. (basic_props:native/2)

Usage: ⟨• ISO •⟩

– *Call and exit should be compatible with:*

`Bag` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Template` is any term. (basic_props:term/1)

`Generator` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`Template` is any term. (basic_props:term/1)

`Bag` is a list. (basic_props:list/1)

– *The following properties should hold globally:*

`Template` is not further instantiated. (basic_props:not_further_inst/2)

findall/3: PREDICATE

`findall(Template,Generator,List)`

A special case of bagof, where all free variables in the `Generator` are taken to be existentially quantified. Faster than the other aggregation predicates.

Meta-predicate with arguments: `findall(?,goal,?)`.

Usage: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*

  `List` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `Template` is any term. (basic_props:term/1)

  `Generator` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties hold upon exit:*

  `Template` is any term. (basic_props:term/1)

  `List` is a list. (basic_props:list/1)
- *The following properties hold globally:*

  `Template` is not further instantiated. (basic_props:not_further_inst/2)

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

  All the calls of the form `findall(Template,Generator,List)` do not fail. (native_props:not_fails/1)

  All calls of the form `findall(Template,Generator,List)` are deterministic. (native_props:is_det/1)

findall/4: PREDICATE

Meta-predicate with arguments: `findall(?,goal,?,?)`.

Usage:

- *Description:* As `findall/3`, but returning in `Tail` the tail of `List` (findall(`Template`, `Generator`, `List`, `Tail`)).
- *Call and exit should be compatible with:*

  `Arg3` is any term. (basic_props:term/1)

  `Arg4` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `Arg1` is any term. (basic_props:term/1)

  `Arg2` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `Arg1` is any term. (basic_props:term/1)

  `Arg3` is any term. (basic_props:term/1)

  `Arg4` is any term. (basic_props:term/1)
- *The following properties should hold globally:*

  `Arg1` is not further instantiated. (basic_props:not_further_inst/2)

findnsols/4: PREDICATE

`findnsols(N,Template,Generator,List)`

As `findall/3`, but generating at most `N` solutions of `Generator`. Thus, the length of `List` will not be greater than `N`. If `N=<0`, returns directly an empty list. This predicate is especially useful if `Generator` may have an infinite number of solutions.

Meta-predicate with arguments: `findnsols(?,?,goal,?)`.

Usage:

- *Call and exit should be compatible with:*

  `List` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `N` is an integer. (basic_props:int/1)

  `Template` is any term. (basic_props:term/1)

  `Generator` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `Template` is any term. (basic_props:term/1)

  `List` is a list. (basic_props:list/1)
- *The following properties should hold globally:*

  `Template` is not further instantiated. (basic_props:not_further_inst/2)

findnsols/5: PREDICATE

`findnsols(N,Template,Generator,List,Tail)`

As `findnsols/4`, but returning in `Tail` the tail of `List`.

Meta-predicate with arguments: `findnsols(?,?,goal,?,?)`.

Usage:

- *The following properties should hold at call time:*

  `N` is an integer. (basic_props:int/1)

  `Template` is any term. (basic_props:term/1)

  `Generator` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `Template` is any term. (basic_props:term/1)
- *The following properties should hold globally:*

  `Template` is not further instantiated. (basic_props:not_further_inst/2)

^/2: PREDICATE

Meta-predicate with arguments: `(?)^goal`.

General properties: `_X^Y`

- *The following properties hold globally:*

  This predicate is understood natively by CiaoPP as `call(Y)`. (basic_props:native/2)

Usage: `X^P`

- *Description:* Existential quantification: `X` is existentially quantified in `P`. E.g., in `A^p(A,B)`, `A` is existentially quantified. Used only within aggregation predicates. In all other contexts, simply, execute the procedure call `P`.

– *The following properties should hold at call time:*
  `X` is a free variable. (term_typing:var/1)
  `P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

33.3 Known bugs and planned improvements (`aggregates`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

34 Dynamic predicates

Author(s): Daniel Cabeza, The CLIP Group.

The package `dynamic_clauses` provides the assert/retract family of predicates to manipulate dynamic predicates.

The defined predicates allow modification of the program as it is actually running. Clauses can be added to the program (*asserted*) or removed from the program (*retracted*), as well as inspected. Note that in Ciao only the dynamic predicates of the current module (or accessible dynamic multifile predicates) can be accessed and modified. This limits the bad impact to global analysis of this dynamic modification of the program. Thus, if dynamic predicates are exported, to be able to inspect or modify them externally some accessing predicates need to be implemented and exported alongside.

For the inspecting/manipulating predicates, the argument which corresponds to the clause head must be instantiated to an atom or a compound term. The argument corresponding to the clause must be instantiated either to a term `Head :- Body` or, if the body part is empty, to `Head`. An empty body part is represented as `true`.

Note that using this library is very detrimental to global analysis, and that for most uses the predicates listed in Chapter 25 [Fast/concurrent update of facts], page 187 suffice.

34.1 Usage and interface (`dynamic_rt`)

- **Library usage:**
  To be able to handle dynamic predicates in a module, load the library package `dynamic_clauses`, either by putting it in the package list of the module or using the `use_package/1` directive. Do not load directly the `dynamic_rt` module.
- **Exports:**
  - *Predicates:*
    `asserta/1`, `asserta/2`, `assertz/1`, `assertz/2`, `assert/1`, `assert/2`, `retract/1`, `retractall/1`, `abolish/1`, `clause/2`, `mfclause/2`, `current_predicate/1`, `current_predicate/2`, `dynamic/1`, `data/1`, `wellformed_body/3`.
  - *Multifiles:*
    `do_on_abolish/1`.
- **Other modules used:**
  - *System library modules:*
    `prolog_sys`, `iso_misc`.

34.2 Documentation on exports (`dynamic_rt`)

asserta/1: PREDICATE

Usage: `asserta(Clause)` ⟨• ISO •⟩

- *Description:* The current instance of `Clause` is interpreted as a clause and is added to the current program. The predicate concerned must be dynamic. The new clause becomes the *first* clause for the predicate concerned. Any uninstantiated variables in `Clause` will be replaced by new private variables.

– *The following properties should hold at call time:*
`Clause` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Clause` is a well-formed clause (dynamic_rt:clause/1)
– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

asserta/2: PREDICATE

Usage: `asserta(Clause,Ref)`

– *Description:* Like `asserta/1`. `Ref` is a unique identifier of the asserted clause.
– *The following properties should hold at call time:*
`Clause` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Ref` is a free variable. (term_typing:var/1)
`Clause` is a well-formed clause (dynamic_rt:clause/1)
– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

assertz/1: PREDICATE

Usage: `assertz(Clause)` ⟨• ISO •⟩

– *Description:* Like `asserta/1`, except that the new clause becomes the *last* clause for the predicate concerned.
– *The following properties should hold at call time:*
`Clause` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Clause` is a well-formed clause (dynamic_rt:clause/1)
– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

assertz/2: PREDICATE

Usage: `assertz(Clause,Ref)`

– *Description:* Like `assertz/1`. `Ref` is a unique identifier of the asserted clause.
– *The following properties should hold at call time:*
`Clause` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Ref` is a free variable. (term_typing:var/1)
`Clause` is a well-formed clause (dynamic_rt:clause/1)
– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

assert/1: PREDICATE

Usage: `assert(Clause)`

– *Description:* Identical to `assertz/1`. Included for compatibility.

– *The following properties should hold at call time:*

`Clause` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Clause` is a well-formed clause (dynamic_rt:clause/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

assert/2: PREDICATE

Usage: `assert(Clause,Ref)`

– *Description:* Identical to `assertz/2`. Included for compatibility.

– *The following properties should hold at call time:*

`Clause` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Ref` is a free variable. (term_typing:var/1)

`Clause` is a well-formed clause (dynamic_rt:clause/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

retract/1: PREDICATE

Usage: `retract(Clause)` ⟨• ISO •⟩

– *Description:* The first clause in the program that matches `Clause` is erased. The predicate concerned must be dynamic.

The predicate `retract/1` may be used in a non-determinate fashion, i.e., it will successively retract clauses matching the argument through backtracking. If reactivated by backtracking, invocations of the predicate whose clauses are being retracted will proceed unaffected by the retracts. This is also true for invocations of `clause` for the same predicate. The space occupied by a retracted clause will be recovered when instances of the clause are no longer in use.

– *The following properties should hold at call time:*

`Clause` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Clause` is a well-formed clause (dynamic_rt:clause/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

retractall/1: PREDICATE

Usage: `retractall(Head)`

– *Description:* Erase all clauses whose head matches `Head`, where `Head` must be instantiated to an atom or a compound term. The predicate concerned must be dynamic. The predicate definition is retained.

– *The following properties should hold at call time:*

`Head` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Head` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

abolish/1: PREDICATE

Meta-predicate with arguments: `abolish(spec)`.

Usage: `abolish(Spec)` ⟨• ISO •⟩

- *Description:* Erase all clauses of the predicate specified by the predicate spec `Spec`. The predicate definition itself is also erased (the predicate is deemed undefined after execution of the abolish). The predicates concerned must all be user defined.
- *The following properties should hold at call time:*

  `Spec` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Spec` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

  (basic_props:predname/1)
- *The following properties should hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

clause/2: PREDICATE

Usage: `clause(Head,Body)` ⟨• ISO •⟩

- *Description:* The clause '`Head :- Body`' exists in the current module. The predicate concerned must be dynamic.
- *The following properties should hold at call time:*

  `Head` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Head` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `Body` is a clause body (dynamic_rt:body/1)
- *The following properties should hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

mfclause/2: PREDICATE

Usage: `mfclause(Head,Body)` ⟨• ISO •⟩

- *Description:* There is a clause '`Head :- Body`' of a dynamic multifile predicate accessible from this module.
- *The following properties should hold at call time:*

  `Head` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Head` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `Body` is a clause body (dynamic_rt:body/1)
- *The following properties should hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_predicate/1: PREDICATE

Usage: `current_predicate(Spec)` ⟨• ISO •⟩

– *Description:* A predicate in the current module is named `Spec`.

– *The following properties should hold upon exit:*

`Spec` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_predicate/2: PREDICATE

Usage: `current_predicate(Spec,Module)`

– *Description:* A predicate in `Module` is named `Spec`. `Module` never is an engine module.

– *The following properties should hold upon exit:*

`Spec` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

`Module` is an internal module identifier (system_info:internal_module_id/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

dynamic/1: PREDICATE

`dynamic Spec`

`Spec` is of the form `F/A`. The predicate named `F` with arity `A` is made dynamic in the current module at runtime (useful for predicate names generated on-the-fly). If the predicate functor name `F` is uninstatiated, a new, unique, predicate name is generated at runtime.

Usage: `dynamic Spec`

– *The following properties should hold at call time:*

`Spec` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Spec` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

data/1: PREDICATE

`data Spec`

`Spec` is of the form `F/A`. The predicate named `F` with arity `A` is made data in the current module at runtime (useful for predicate names generated on-the-fly). If the predicate functor name `F` is uninstatiated, a new, unique, predicate name is generated at runtime.

Usage: `data Spec`

– *The following properties should hold at call time:*

`Spec` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Spec` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

erase/1: PREDICATE

`erase(Ref)`

Deletes the clause referenced by `Ref`, the identifier obtained by using `asserta/2` or `assertz/2`.

wellformed_body/3: PREDICATE

`wellformed_body(BodyIn,Env,BodyOut)`

`BodyIn` is a well-formed clause body. `BodyOut` is its counterpart with no single-variable meta-goals (i.e., with `call(X)` for `X`). `Env` denotes if global cuts are admissible in `BodyIn` (`+` if they are, `-` if they are not).

34.3 Documentation on multifiles (dynamic_rt)

do_on_abolish/1: PREDICATE

`do_on_abolish(Head)`

A hook predicate which will be called when the definition of the predicate of `Head` is abolished.

The predicate is *multifile*.

Usage: `do_on_abolish(G)`

– *The following properties should hold at call time:*

`G` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

34.4 Known bugs and planned improvements (dynamic_rt)

- Package dynamic_clauses cannot be loaded into the shell.

35 Term input

Author(s): Daniel Cabeza (modifications and documentation, adapted from SICStus 0.6 code), Manuel Carro (modifications and documentation).

This module provides falicities to read terms in Prolog syntax. This is very convenient in many cases (and not only if you are writing a Prolog compiler), because Prolog terms are easy to write and can convey a lot of information in a human-readable fashion.

35.1 Usage and interface (read)

- **Library usage:**
  `:- use_module(library(read)).`
- **Exports:**
  - *Predicates:*
    `read/1`, `read/2`, `read_term/2`, `read_term/3`, `read_top_level/3`, `second_prompt/2`.
  - *Regular Types:*
    `read_option/1`.
  - *Multifiles:*
    `define_flag/3`.
- **Other modules used:**
  - *System library modules:*
    `tokenize`, `operators`, `lists`.

35.2 Documentation on exports (read)

read/1: PREDICATE

`read(Term)`

Like `read(Stream,Term)` with `Stream` associated to the current input stream.

Usage: ⟨• ISO •⟩

- *Call and exit should be compatible with:*
  `Term` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*
  `Term` is any term. (basic_props:term/1)

read/2: PREDICATE

Usage: `read(Stream,Term)` ⟨• ISO •⟩

- *Description:* The next term, delimited by a full-stop (i.e., a `.` followed by either a space or a control character), is read from `Stream` and is unified with `Term`. The syntax of the term must agree with current operator declarations. If the end of `Stream` has been reached, `Term` is unified with the term `end_of_file`. Further calls to `read/2` for the same stream will then cause an error, unless the stream is connected to the terminal (in which case a prompt is opened on the terminal).

– *The following properties should hold at call time:*

`Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Stream` is an open stream. (streams_basic:stream/1)

`Term` is any term. (basic_props:term/1)

read_term/2: PREDICATE

Usage: `read_term(Term,Options)` ⟨• ISO •⟩

– *Description:* Like `read_term/3`, but reading from the current input

– *The following properties should hold at call time:*

`Options` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Term` is any term. (basic_props:term/1)

`Options` is a list of `read_options`. (basic_props:list/2)

read_term/3: PREDICATE

Usage: `read_term(Stream,Term,Options)` ⟨• ISO •⟩

– *Description:* Reads a `Term` from `Stream` with the ISO-Prolog `Options`. These options can control the behavior of read term (see `read_option/1`).

– *The following properties should hold at call time:*

`Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Options` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Stream` is an open stream. (streams_basic:stream/1)

`Term` is any term. (basic_props:term/1)

`Options` is a list of `read_options`. (basic_props:list/2)

read_top_level/3: PREDICATE

`read_top_level(Stream,Data,Variables)`

Predicate used to read in the Top Level.

second_prompt/2: PREDICATE

Usage: `second_prompt(Old,New)`

– *Description:* Changes the prompt (the *second prompt*, as opposed to the first one, used by the toplevel) used by `read/2` and friends to `New`, and returns the current one in `Old`.

– *The following properties should hold upon exit:*

`Old` is currently instantiated to an atom. (term_typing:atom/1)

`New` is currently instantiated to an atom. (term_typing:atom/1)

read_option/1: REGTYPE

Usage: `read_option(Option)`

– *Description:* `Option` is an allowed `read_term/[2,3]` option. These options are:

```
read_option(variables(_V)).
read_option(variable_names(_N)).
read_option(singletons(_S)).
read_option(lines(_StartLine,_EndLine)).
read_option(dictionary(_Dict)).
```

They can be used to return the singleton variables in the term, a list of variables, etc.

– *The following properties should hold upon exit:*

`Option` is currently instantiated to an atom. (term_typing:atom/1)

35.3 Documentation on multifiles (`read`)

define_flag/3: PREDICATE

Defines flags as follows:

```
define_flag(read_hiord,[on,off],off).
define_flag(read_curly_blocks,[on,off],off).
define_flag(read_postfix_blocks,[on,off],off).
```

(See Chapter 24 [Changing system behaviour and various flags], page 181).

If flag is `on` (it is `off` by default), a variable followed by a parenthesized lists of arguments is read as a `call/N` term, except if the variable is anonymous, in which case it is read as an anonymous predicate abstraction head. For example, `P(X)` is read as `call(P,X)` and `_(X,Y)` as `''(X,Y)`.

The predicate is *multifile*.

Usage: `define_flag(Flag,FlagValues,Default)`

– *The following properties hold upon exit:*

`Flag` is an atom. (basic_props:atm/1)

Define the valid flag values (basic_props:flag_values/1)

35.4 Known bugs and planned improvements (`read`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.
- The comma cannot be redefined as an operator, it is defined in any case as op(1000, xfy,[',']).

36 Term output

Author(s): Richard A. O'Keefe (original version), Mats Carlsson (changes), Daniel Cabeza (changes), Manuel Hermenegildo (changes), Manuel Carro (changes).

This library provides different predicates for term output, additional to the kernel predicates `display/1`- `display/2` and `displayq/1`-`displayq/2`. All the predicates defined in ISO-Prolog are included, plus other traditionally provided by Prolog Implementations. Output predicates are provided in two versions: one that uses the current output stream and other in which the stream is specified explicitly, as an additional first argument.

36.1 Usage and interface (`write`)

- **Library usage:**
  `:- use_module(library(write)).`
- **Exports:**
  - *Predicates:*
    `write_term/3`, `write_term/2`, `write/2`, `write/1`, `writeq/2`, `writeq/1`, `write_canonical/2`, `write_canonical/1`, `print/2`, `print/1`, `write_list1/1`, `portray_clause/2`, `portray_clause/1`, `numbervars/3`, `prettyvars/1`, `printable_char/1`, `write_attribute/1`.
  - *Properties:*
    `write_option/1`.
  - *Multifiles:*
    `define_flag/3`, `portray_attribute/2`, `portray/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`, `operators`, `sort`.

36.2 Documentation on exports (`write`)

write_term/3: PREDICATE

Usage: `write_term(Stream,Term,OptList)` ⟨• ISO •⟩

- *Description:* Outputs the term `Term` to the stream `Stream`, with the list of write-options `OptList`. See `write_option/1` type for default options.
- *The following properties should hold at call time:*
  `OptList` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Stream` is an open stream. (streams_basic:stream/1)
  `Term` is any term. (basic_props:term/1)
  `OptList` is a list of `write_options`. (basic_props:list/2)
- *The following properties should hold globally:*
  `Stream` is not further instantiated. (basic_props:not_further_inst/2)

write_term/2: PREDICATE

Usage: `write_term(Term,OptList)` ⟨• ISO •⟩

– *Description:* Behaves like `current_output(S), write_term(S,Term,OptList)`.

– *The following properties should hold at call time:*

`OptList` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Term` is any term. (basic_props:term/1)

`OptList` is a list of `write_options`. (basic_props:list/2)

write_option/1: PROPERTY

`Opt` is a valid write option which affects the predicate `write_term/3` and similar ones. Possible write_options are:

- **quoted(*bool*):** If *bool* is `true`, atoms and functors that can't be read back by `read_term/3` are quoted, if it is `false`, each atom and functor is written as its name. Default value is `false`.
- **ignore_ops(*flag*):** If *flag* is `true`, each compound term is output in functional notation, if it is `ops`, curly bracketed notation and list notation is enabled when outputing compound terms, if it is `false`, also operator notation is enabled when outputing compound terms. Default value is `false`.
- **numbervars(*bool*):** If *bool* is `true`, a term of the form `'$VAR'(N)` where `N` is an integer, is output as a variable name consisting of a capital letter possibly followed by an integer, a term of the form `'$VAR'(Atom)` where `Atom` is an atom, as this atom (without quotes), and a term of the form `'$VAR'(String)` where `String` is a character string, as the atom corresponding to this character string. See predicates `numbervars/3` and `prettyvars/1`. If *bool* is `false` this cases are not treated in any special way. Default value is `false`.
- **portrayed(*bool*):** If *bool* is `true`, then call multifile predicates `portray/1` and `portray_attribute/2`, to provide the user handlers for pretty printing some terms. `portray_attribute/2` is called whenever an attributed variable is to be printed, `portray/1` is called whenever a non-variable term is to be printed. If either call succeeds, then it is assumed that the term has been output, else it is printed as usual. If *bool* is `false`, these predicates are not called. Default value is `false`. This option is set by the toplevel when writting the final values of variables, and by the debugging package when writting the goals in the tracing messages. Thus you can vary the forms of these messages if you wish.
- **max_depth(*depth*):** *depth* is a positive integer or cero. If it is positive, it denotes the depth limit on printing compound terms. If it is cero, there is no limit. Default value is `0` (no limit).
- **priority(*prio*):** *prio* is an integer between 1 and 1200. If the term to be printed has higher priority than *prio*, it will be printed parenthesized. Default value is 1200 (no term parenthesized).

.

Usage: `write_option(Opt)`

– *Description:* `Opt` is a valid write option.

write/2: PREDICATE

Usage: `write(Stream,Term)` ⟨• ISO •⟩

– *Description:* Behaves like `write_term(Stream, Term, [numbervars(true)])`.

– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
`Term` is any term. (basic_props:term/1)
– *The following properties hold globally:*
`Stream` is not further instantiated. (basic_props:not_further_inst/2)
All calls of the form `write(Stream,Term)` are deterministic. (native_props:is_det/1)

write/1: PREDICATE
Usage: `write(Term)` ⟨• ISO •⟩
– *Description:* Behaves like `current_output(S), write(S,Term)`.
– *The following properties should hold at call time:*
`Term` is any term. (basic_props:term/1)
– *The following properties hold globally:*
All calls of the form `write(Term)` are deterministic. (native_props:is_det/1)

writeq/2: PREDICATE
Usage: `writeq(Stream,Term)` ⟨• ISO •⟩
– *Description:* Behaves like `write_term(Stream, Term, [quoted(true), numbervars(true)])`.
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
`Term` is any term. (basic_props:term/1)
– *The following properties hold globally:*
`Stream` is not further instantiated. (basic_props:not_further_inst/2)
All calls of the form `writeq(Stream,Term)` are deterministic. (native_props:is_det/1)

writeq/1: PREDICATE
Usage: `writeq(Term)` ⟨• ISO •⟩
– *Description:* Behaves like `current_output(S), writeq(S,Term)`.
– *The following properties should hold at call time:*
`Term` is any term. (basic_props:term/1)
– *The following properties hold globally:*
All calls of the form `writeq(Term)` are deterministic. (native_props:is_det/1)

write_canonical/2: PREDICATE
Usage: `write_canonical(Stream,Term)` ⟨• ISO •⟩
– *Description:* Behaves like `write_term(Stream, Term, [quoted(true), ignore_ops(true)])`. The output of this predicate can always be parsed by `read_term/2` even if the term contains special characters or if operator declarations have changed.
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
`Term` is any term. (basic_props:term/1)

– *The following properties should hold globally:*
`Stream` is not further instantiated. (basic_props:not_further_inst/2)

write_canonical/1: PREDICATE
Usage: `write_canonical(Term)` ⟨• ISO •⟩
– *Description:* Behaves like `current_output(S), write_canonical(S,Term)`.
– *The following properties should hold at call time:*
`Term` is any term. (basic_props:term/1)

print/2: PREDICATE
Usage: `print(Stream,Term)`
– *Description:* Behaves like `write_term(Stream, Term, [numbervars(true), portrayed(true)])`.
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
`Term` is any term. (basic_props:term/1)
– *The following properties should hold globally:*
`Stream` is not further instantiated. (basic_props:not_further_inst/2)

print/1: PREDICATE
Usage: `print(Term)`
– *Description:* Behaves like `current_output(S), print(S,Term)`.
– *The following properties should hold at call time:*
`Term` is any term. (basic_props:term/1)

write_list1/1: PREDICATE
Usage:
– *Description:* Writes a list to current output one element in each line.
– *The following properties should hold at call time:*
`Arg1` is a list. (basic_props:list/1)

portray_clause/2: PREDICATE
Usage: `portray_clause(Stream,Clause)`
– *Description:* Outputs the clause `Clause` onto `Stream`, pretty printing its variables and using indentation, including a period at the end. This predicate is used by `listing/0`.
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
`Clause` is any term. (basic_props:term/1)
– *The following properties should hold globally:*
`Stream` is not further instantiated. (basic_props:not_further_inst/2)

portray_clause/1: PREDICATE

Usage: `portray_clause(Clause)`

- *Description:* Behaves like `current_output(S), portray_clause(S,Term)`.
- *The following properties should hold at call time:*

  `Clause` is any term. (basic_props:term/1)

numbervars/3: PREDICATE

Usage: `numbervars(Term,N,M)`

- *Description:* Unifies each of the variables in term `Term` with a term of the form `'$VAR'(I)` where `I` is an integer from `N` onwards. `M` is unified with the last integer used plus 1. If the resulting term is output with a write option `numbervars(true)`, in the place of the variables in the original term will be printed a variable name consisting of a capital letter possibly followed by an integer. When `N` is 0 you will get the variable names A, B, ..., Z, A1, B1, etc.
- *The following properties should hold at call time:*

  `N` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Term` is any term. (basic_props:term/1)

  `N` is an integer. (basic_props:int/1)

  `M` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*

  `Term` is any term. (basic_props:term/1)

  `N` is an integer. (basic_props:int/1)

  `M` is an integer. (basic_props:int/1)

prettyvars/1: PREDICATE

Usage: `prettyvars(Term)`

- *Description:* Similar to `numbervars(Term,0,_)`, except that singleton variables in `Term` are unified with `'$VAR'('_')`, so that when the resulting term is output with a write option `numbervars(true)`, in the place of singleton variables `_` is written. This predicate is used by `portray_clause/2`.
- *The following properties should hold at call time:*

  `Term` is any term. (basic_props:term/1)

printable_char/1: PREDICATE

Usage: `printable_char(Char)`

- *Description:* `Char` is the code of a character which can be printed.
- *The following properties should hold at call time:*

  `Char` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Char` is an integer which is a character code. (basic_props:character_code/1)

write_attribute/1: PREDICATE

No further documentation available for this predicate.

36.3 Documentation on multifiles (`write`)

define_flag/3: PREDICATE

Defines flags as follows:

```
define_flag(write_strings,[on,off],off).
```

(See Chapter 24 [Changing system behaviour and various flags], page 181).

If flag is `on`, lists which may be written as strings are.

The predicate is *multifile*.

Usage: `define_flag(Flag,FlagValues,Default)`

- *The following properties hold upon exit:*

  `Flag` is an atom. (basic_props:atm/1)

  Define the valid flag values (basic_props:flag_values/1)

portray_attribute/2: PREDICATE

The predicate is *multifile*.

Usage: `portray_attribute(Attr,Var)`

- *Description: A user defined predicate.* When an attributed variable `Var` is about to be printed, this predicate receives the variable and its attribute `Attr`. The predicate should either print something based on `Attr` or `Var`, or do nothing and fail. In the latter case, the default printer (`write/1`) will print the attributed variable like an unbound variable, e.g. `_673`.
- *The following properties should hold at call time:*

  `Attr` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Var` is a free variable. (term_typing:var/1)

portray/1: PREDICATE

The predicate is *multifile*.

Usage: `portray(T)`

- *Description: A user defined predicate.* This should either print the `Term` and succeed, or do nothing and fail. In the latter case, the default printer (`write/1`) will print the `Term`.
- *The following properties should hold at call time:*

  `T` is any term. (basic_props:term/1)
- *The following properties hold upon exit:*

  `T` is any term. (basic_props:term/1)

36.4 Known bugs and planned improvements (`write`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

37 Defining operators

Author(s): Daniel Cabeza (modifications and documentation, adapted from SICStus 0.6 code), Manuel Carro (modifications and documentation).

Operators allow writting terms in a more clear way than the standard functional notation. Standard operators in Ciao are defined by this predicate (but note that the compiler itself defines more operators at compile time):

```
standard_ops :-
        op(1200,xfx,[:-]),
        op(1200,fx,[:-,?-]),
        op(1100,xfy,[;]),
        op(1050,xfy,[->]),
        op(1000,xfy,[',']),
        op(900,fy,[\+]),
        op(700,xfx,[=,\=,==,\==,@<,@>,@=<,@>=,=..,is,=:=,=\=,<,=<,>,>=]),
        op(550,xfx,[:]),
        op(500,yfx,[+,-,/\,\/,#]),
        op(500,fy,[++,--]),
        op(400,yfx,[*,/,//,rem,mod,<<,>>]),
        op(200,fy,[+,-,\]),
        op(200,xfx,[**]),
        op(200,xfy,[^]).
```

37.1 Usage and interface (operators)

- **Library usage:**
  `:- use_module(library(operators)).`
- **Exports:**
  - *Predicates:*
    `op/3`,
    `current_op/3`, `current_prefixop/3`, `current_infixop/4`, `current_postfixop/3`, `standard_ops/0`.

37.2 Documentation on exports (operators)

op/3: PREDICATE

`op(Precedence,Type,Name)`

Declares the atom `Name` to be an operator of the stated `Type` and `Precedence` (0 =< `Precedence` =< 1200). `Name` may also be a list of atoms in which case all of them are declared to be operators. If `Precedence` is 0 then the operator properties of `Name` (if any) are cancelled. Note that, unlike in ISO-Prolog, it is allowed to define two operators with the same name, one infix and the other postfix.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `Precedence` is an integer. (basic_props:int/1)

`Type` specifies the type and associativity of an operator. (basic_props:operator_specifier/1)

`Name` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_op/3: PREDICATE

`current_op(Precedence,Type,Op)`

The atom `Op` is currently an operator of type `Type` and precedence `Precedence`. Neither `Op` nor the other arguments need be instantiated at the time of the call; i.e., this predicate can be used to generate as well as to test.

Usage: ⟨• ISO •⟩

– *Call and exit should be compatible with:*

`Precedence` is an integer. (basic_props:int/1)

`Type` specifies the type and associativity of an operator. (basic_props:operator_specifier/1)

`Op` is an atom. (basic_props:atm/1)

– *The following properties should hold upon exit:*

`Precedence` is an integer. (basic_props:int/1)

`Type` specifies the type and associativity of an operator. (basic_props:operator_specifier/1)

`Op` is an atom. (basic_props:atm/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_prefixop/3: PREDICATE

`current_prefixop(Op,Less,Precedence)`

Similar to `current_op/3`, but it concerns only the prefix operators. It returns **only one solution**. Not a predicate for general use.

Usage:

– *Call and exit should be compatible with:*

`Op` is an atom. (basic_props:atm/1)

`Less` is an integer. (basic_props:int/1)

`Precedence` is an integer. (basic_props:int/1)

– *The following properties should hold upon exit:*

`Op` is an atom. (basic_props:atm/1)

`Less` is an integer. (basic_props:int/1)

`Precedence` is an integer. (basic_props:int/1)

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_infixop/4: PREDICATE

`current_infixop(Op,LeftLess,Prec,RightLess)`

Similar to `current_op/3`, but it concerns only infix operators. It returns **only one solution**. Not a predicate for general use.

Usage:

- *Call and exit should be compatible with:*
  - `Op` is an atom. (basic_props:atm/1)
  - `LeftLess` is an integer. (basic_props:int/1)
  - `Prec` is an integer. (basic_props:int/1)
  - `RightLess` is an integer. (basic_props:int/1)
- *The following properties should hold upon exit:*
  - `Op` is an atom. (basic_props:atm/1)
  - `LeftLess` is an integer. (basic_props:int/1)
  - `Prec` is an integer. (basic_props:int/1)
  - `RightLess` is an integer. (basic_props:int/1)
- *The following properties should hold globally:*
  - This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_postfixop/3: PREDICATE

`current_postfixop(Op,Less,Precedence)`

Similar to `current_op/3`, but it concerns only the postfix operators. It returns **only one solution**. Not a predicate for general use.

Usage:

- *Call and exit should be compatible with:*
  - `Op` is an atom. (basic_props:atm/1)
  - `Less` is an integer. (basic_props:int/1)
  - `Precedence` is an integer. (basic_props:int/1)
- *The following properties should hold upon exit:*
  - `Op` is an atom. (basic_props:atm/1)
  - `Less` is an integer. (basic_props:int/1)
  - `Precedence` is an integer. (basic_props:int/1)
- *The following properties should hold globally:*
  - This predicate is understood natively by CiaoPP. (basic_props:native/1)

standard_ops/0: PREDICATE

No further documentation available for this predicate.

38 The Iso Byte Char module

Author(s): The CLIP Group, Daniel Cabeza, Edison Mera (documentation), Manuel Hermenegildo (minor mods).

This module provides some basic predicates according to the ISO specification of byte and char manipulation.

38.1 Usage and interface (`iso_byte_char`)

- **Library usage:**
  `:- use_module(library(iso_byte_char)).`
- **Exports:**
  - *Predicates:*
    `char_code/2`, `atom_chars/2`, `number_chars/2`, `char_codes/2`, `get_byte/1`, `get_byte/2`, `peek_byte/1`, `peek_byte/2`, `put_byte/1`, `put_byte/2`, `get_char/1`, `get_char/2`, `peek_char/1`, `peek_char/2`, `put_char/1`, `put_char/2`.

38.2 Documentation on exports (`iso_byte_char`)

char_code/2: PREDICATE

`char_code(Char,Code)`

Succeeds iff the character code of the one char atom `Char` is `Code`.

Usage 1: ⟨• ISO •⟩

- *Call and exit should be compatible with:*
  `Code` is an integer which is a character code. (basic_props:character_code/1)
- *The following properties should hold at call time:*
  `Char` is an atom. (basic_props:atm/1)
- *The following properties should hold upon exit:*
  `Code` is an integer which is a character code. (basic_props:character_code/1)

Usage 2: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `Char` is a free variable. (term_typing:var/1)
  `Code` is an integer which is a character code. (basic_props:character_code/1)
- *The following properties should hold upon exit:*
  `Char` is an atom. (basic_props:atm/1)

atom_chars/2: PREDICATE

`atom_chars(Atom,Chars)`

Succeeds iff `Chars` is a list whose elements are the one-char atoms whose names are the successive characters of the name of atom `Atom`

Usage 1: ⟨• ISO •⟩

– *Call and exit should be compatible with:*
`Chars` is a list of `atms`. (basic_props:list/2)
– *The following properties should hold at call time:*
`Atom` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
`Chars` is a list of `atms`. (basic_props:list/2)

Usage 2: ⟨• ISO •⟩
– *The following properties should hold at call time:*
`Atom` is a free variable. (term_typing:var/1)
`Chars` is a list of `atms`. (basic_props:list/2)
– *The following properties should hold upon exit:*
`Atom` is an atom. (basic_props:atm/1)

number_chars/2: PREDICATE

`number_chars(Number,Chars)`

Success iff `Chars` is a list whose elements are the one-char atoms corresponding to a character sequence of `Number` which could be output

Usage 1: ⟨• ISO •⟩
– *Call and exit should be compatible with:*
`Chars` is a list of `atms`. (basic_props:list/2)
– *The following properties should hold at call time:*
`Number` is a number. (basic_props:num/1)
– *The following properties should hold upon exit:*
`Chars` is a list of `atms`. (basic_props:list/2)

Usage 2: ⟨• ISO •⟩
– *The following properties should hold at call time:*
`Number` is a free variable. (term_typing:var/1)
`Chars` is a list of `atms`. (basic_props:list/2)
– *The following properties should hold upon exit:*
`Number` is a number. (basic_props:num/1)

char_codes/2: PREDICATE

Usage 1:
– *Call and exit should be compatible with:*
`Arg2` is a list of `character_codes`. (basic_props:list/2)
– *The following properties should hold at call time:*
`Arg1` is a list of `atms`. (basic_props:list/2)
– *The following properties should hold upon exit:*
`Arg2` is a list of `character_codes`. (basic_props:list/2)

Usage 2:

- *The following properties should hold at call time:*
  `Arg1` is a free variable. (term_typing:var/1)
  `Arg2` is a list of `character_codes`. (basic_props:list/2)
- *The following properties should hold upon exit:*
  `Arg1` is a list of `atms`. (basic_props:list/2)

get_byte/1: PREDICATE

Usage: ⟨• ISO •⟩

- *Description:* Same as `get_byte/2`, but use the current input.
- *Call and exit should be compatible with:*
  `Arg1` is an integer. (basic_props:int/1)
- *The following properties should hold upon exit:*
  `Arg1` is an integer. (basic_props:int/1)

get_byte/2: PREDICATE

`get_byte(Stream,Byte)`

Is true iff `Byte` unifies with the next byte to be input from the target `Stream`.

Usage: ⟨• ISO •⟩

- *Call and exit should be compatible with:*
  `Byte` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties should hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)
  `Byte` is an integer. (basic_props:int/1)
- *The following properties should hold globally:*
  `Stream` is not further instantiated. (basic_props:not_further_inst/2)

peek_byte/1: PREDICATE

Usage: ⟨• ISO •⟩

- *Description:* Same as `peek_byte/2`, but use the current input.
- *Call and exit should be compatible with:*
  `Arg1` is an integer. (basic_props:int/1)
- *The following properties should hold upon exit:*
  `Arg1` is an integer. (basic_props:int/1)

peek_byte/2: PREDICATE

Usage: ⟨• ISO •⟩

- *Description:* Is true iff `Byte` unifies with the next byte to be input from the target `Stream`.

– *Call and exit should be compatible with:*
`Arg2` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`Arg1` is an open stream. (streams_basic:stream/1)
– *The following properties should hold upon exit:*
`Arg1` is an open stream. (streams_basic:stream/1)
`Arg2` is an integer. (basic_props:int/1)
– *The following properties should hold globally:*
`Arg1` is not further instantiated. (basic_props:not_further_inst/2)

put_byte/1: PREDICATE
Usage: ⟨• ISO •⟩
– *Description:* Same as `put_byte/2`, but use the current input.
– *The following properties should hold at call time:*
`Arg1` is an integer. (basic_props:int/1)

put_byte/2: PREDICATE
`put_byte(Stream,Byte)`
Is true. Procedurally, `putbyte/2` is executed as follows:
a) Outputs the byte `Byte` to the target stream.
b) Changes the stream position of the target stream to take account of the byte which has been output.
c) The goal succeeds.
Usage: ⟨• ISO •⟩
– *The following properties should hold at call time:*
`Stream` is an open stream. (streams_basic:stream/1)
`Byte` is an integer. (basic_props:int/1)
– *The following properties should hold upon exit:*
`Stream` is an open stream. (streams_basic:stream/1)
– *The following properties should hold globally:*
`Stream` is not further instantiated. (basic_props:not_further_inst/2)

get_char/1: PREDICATE
Usage: ⟨• ISO •⟩
– *Description:* Same as `get_char/2`, but use the current input.
– *Call and exit should be compatible with:*
`Arg1` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
`Arg1` is an atom. (basic_props:atm/1)

get_char/2: PREDICATE

`get_char(Stream,Char)`

Is true iif `Char` unifies with the next character to be input from the target `Stream`.

Usage: ⟨• ISO •⟩

- *Call and exit should be compatible with:*
  `Char` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties should hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)
  `Char` is an atom. (basic_props:atm/1)
- *The following properties should hold globally:*
  `Stream` is not further instantiated. (basic_props:not_further_inst/2)

peek_char/1: PREDICATE

Usage: ⟨• ISO •⟩

- *Description:* Similar to `peek_code/1`, but using char instead of code.
- *Call and exit should be compatible with:*
  `Arg1` is an atom. (basic_props:atm/1)
- *The following properties should hold upon exit:*
  `Arg1` is an atom. (basic_props:atm/1)

peek_char/2: PREDICATE

Usage: ⟨• ISO •⟩

- *Description:* Similar to `peek_code/2`, but using char instead of code.
- *Call and exit should be compatible with:*
  `Arg2` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*
  `Arg1` is an open stream. (streams_basic:stream/1)
- *The following properties should hold upon exit:*
  `Arg1` is an open stream. (streams_basic:stream/1)
  `Arg2` is an atom. (basic_props:atm/1)
- *The following properties should hold globally:*
  `Arg1` is not further instantiated. (basic_props:not_further_inst/2)

put_char/1: PREDICATE

Usage: ⟨• ISO •⟩

- *Description:* Similar to `put_code/1`, but using char instead of code.
- *The following properties should hold at call time:*
  `Arg1` is an atom. (basic_props:atm/1)

put_char/2: PREDICATE

Usage: ⟨• ISO •⟩

- *Description:* Similar to `put_code/2`, but using char instead of code.
- *The following properties should hold at call time:*

  `Arg1` is an open stream. (streams_basic:stream/1)

  `Arg2` is an atom. (basic_props:atm/1)
- *The following properties should hold upon exit:*

  `Arg1` is an open stream. (streams_basic:stream/1)
- *The following properties should hold globally:*

  `Arg1` is not further instantiated. (basic_props:not_further_inst/2)

39 Miscellaneous ISO Prolog predicates

Author(s): Daniel Cabeza.

This module implements some miscellaneous ISO Prolog predicates.

39.1 Usage and interface (iso_misc)

- **Library usage:**
  `:- use_module(library(iso_misc)).`
- **Exports:**
  - *Predicates:*
    `once/1`, `compound/1`, `sub_atom/5`, `unify_with_occurs_check/2`.
- **Other modules used:**
  - *System library modules:*
    `between`.

39.2 Documentation on exports (iso_misc)

once/1: PREDICATE

`once(G)`

Finds the first solution of goal `G` (if any). `once/1` behaves as `call/1`, except that no further solutions are explored on backtracking.

Meta-predicate with arguments: `once(goal)`.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `G` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

compound/1: PREDICATE

`compound(T)`

`T` is currently instantiated to a compound term.

Usage: ⟨• ISO •⟩

- *Call and exit should be compatible with:*
  `T` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*
  `T` is any term. (basic_props:term/1)
  `T` is a compound term. (basic_props:struct/1)

sub_atom/5: PREDICATE

`sub_atom(Atom,Before,Length,After,Sub_atom)`

Is true iff atom `Atom` can be broken into three pieces, `AtomL`, `Sub_atom` and `AtomR` such that `Before` is the number of characters of the name of `AtomL`, `Length` is the number of characters of the name of `Sub_atom` and `After` is the number of characters of the name of `AtomR`

Usage: ⟨• ISO •⟩

– *Call and exit should be compatible with:*

`Before` is an integer. (basic_props:int/1)

`Length` is an integer. (basic_props:int/1)

`After` is an integer. (basic_props:int/1)

`Sub_atom` is an atom. (basic_props:atm/1)

– *The following properties should hold at call time:*

`Atom` is an atom. (basic_props:atm/1)

– *The following properties should hold upon exit:*

`Before` is an integer. (basic_props:int/1)

`Length` is an integer. (basic_props:int/1)

`After` is an integer. (basic_props:int/1)

`Sub_atom` is an atom. (basic_props:atm/1)

unify_with_occurs_check/2: PREDICATE

`unify_with_occurs_check(X,Y)`

Attempts to compute and apply a most general unifier of the two terms `X` and `Y`. Is true iff `X` and `Y` are unifiable.

Usage: ⟨• ISO •⟩

– *Call and exit should be compatible with:*

`X` is any term. (basic_props:term/1)

`Y` is any term. (basic_props:term/1)

– *The following properties should hold upon exit:*

`X` is any term. (basic_props:term/1)

`Y` is any term. (basic_props:term/1)

39.3 Known bugs and planned improvements (`iso_misc`)

- There is a naive implementation of compound/1, perhaps is better to implement it as a builtin – EMM.

40 Incomplete ISO Prolog predicates

Author(s): The CLIP Group.

This module implements some ISO Prolog predicates, but that are not complete yet.

40.1 Usage and interface (`iso_incomplete`)

- **Library usage:**
  `:- use_module(library(iso_incomplete)).`
- **Exports:**
  - *Predicates:*
    `close/2`, `stream_property/2`.

40.2 Documentation on exports (`iso_incomplete`)

close/2: PREDICATE

Usage:

- *The following properties should hold at call time:*
  `Arg1` is an open stream. (streams_basic:stream/1)
  iso_incomplete:close_options(Arg2) (iso_incomplete:close_options/1)
- *The following properties should hold upon exit:*
  `Arg1` is an open stream. (streams_basic:stream/1)
  iso_incomplete:close_options(Arg2) (iso_incomplete:close_options/1)
- *The following properties should hold globally:*
  `Arg1` is not further instantiated. (basic_props:not_further_inst/2)
  `Arg2` is not further instantiated. (basic_props:not_further_inst/2)

stream_property/2: PREDICATE

Usage:

- *Call and exit should be compatible with:*
  `Arg1` is an open stream. (streams_basic:stream/1)
  `Arg2` is a valid stream property. (iso_incomplete:stream_prop/1)
- *The following properties should hold upon exit:*
  `Arg1` is an open stream. (streams_basic:stream/1)
  `Arg2` is a valid stream property. (iso_incomplete:stream_prop/1)

PART IV - Classic Prolog library (classic)

Author(s): The CLIP Group.

This part documents some Ciao libraries which provide additional predicates and functionalities that, despite not being in the ISO standard, are present in many popular Prolog systems. This includes definite clause grammars (DCGs), "Quintus-style" internal database, list processing predicates, DEC-10 Prolog-style input/output, formatted output, dynamic loading of modules, activation of operators at run-time, etc.

41 Definite clause grammars

Author(s): The CLIP Group.

This library package allows the use of DCGs (Definite Clause Grammars) [Col78,PW80] in a Ciao module/program.

Definite clause grammars are an extension of the well-known context-free grammars. Prolog's grammar rules provide a convenient notation for expressing definite clause grammars. A DCG rule in Prolog takes the general form

```
head --> body.
```

meaning "a possible form for `head` is `body`". Both `body` and `head` are sequences of one or more items linked by the standard Prolog conjunction operator `","`.

Definite clause grammars extend context-free grammars in the following ways:

1. A non-terminal symbol may be any Prolog term (other than a variable or number).
2. A terminal symbol may be any Prolog term. To distinguish terminals from non-terminals, a sequence of one or more terminal symbols is written within a grammar rule as a Prolog list. An empty sequence is written as the empty list `[]`. If the terminal symbols are ASCII character codes, such lists can be written (as elsewhere) as strings. An empty sequence is written as the empty list, `[]` or `""`.
3. Extra conditions, in the form of Prolog procedure calls, may be included in the right-hand side of a grammar rule. Such procedure calls are written enclosed in `{}` brackets.
4. The left-hand side of a grammar rule consists of a non-terminal, optionally followed by a sequence of terminals (again written as a Prolog list).
5. Alternatives may be stated explicitly in the right-hand side of a grammar rule, using the disjunction operator `;`, or, also, as traditionally in Prolog, using `|` (which is treated specially when this package is loaded).
6. The cut symbol may be included in the right-hand side of a grammar rule, as in a Prolog clause. The cut symbol does not need to be enclosed in `{}` brackets.

As an example, here is a simple grammar which parses an arithmetic expression (made up of digits and operators) and computes its value.

```
expr(Z) --> term(X), "+", expr(Y), {Z is X + Y}.
expr(Z) --> term(X), "-", expr(Y), {Z is X - Y}.
expr(X) --> term(X).

term(Z) --> number(X), "*", term(Y), {Z is X * Y}.
term(Z) --> number(X), "/", term(Y), {Z is X / Y}.
term(Z) --> number(Z).

number(C) --> "+", number(C).
number(C) --> "-", number(X), {C is -X}.
number(X) --> [C], {0'0=<C, C=<0'9, X is C - 0'0}.
```

In the last rule, `C` is the ASCII code of some digit.

The query

```
?- expr(Z, "-2+3*5+1", []).
```

will compute `Z`=14. The two extra arguments are explained below.

Now, in fact, grammar rules are merely a convenient "syntactic sugar" for ordinary Prolog clauses. Each grammar rule takes an input string, analyses some initial portion, and produces the remaining portion (possibly enlarged) as output for further analysis. The arguments required for the input and output strings are not written explicitly in a grammar rule, but the syntax

implicitly defines them. We now show how to translate grammar rules into ordinary clauses by making explicit the extra arguments.

A rule such as

```
p(X) --> q(X).
```

translates into

```
p(X, S0, S) :- q(X, S0, S).
```

If there is more than one non-terminal on the right-hand side, as in

```
p(X, Y) -->
        q(X),
        r(X, Y),
        s(Y).
```

then corresponding input and output arguments are identified, as in

```
p(X, Y, S0, S) :-
        q(X, S0, S1),
        r(X, Y, S1, S2),
        r(Y, S2, S).
```

Terminals are translated using the built-in predicate `'C'/3` (this predicate is not normally useful in itself; it has been given the name `'C'` simply to avoid using up a more useful name). Then, for instance

```
p(X) --> [go,to], q(X), [stop].
```

is translated by

```
p(X, S0, S) :-
        'C'(S0, go, S1),
        'C'(S1, to, S2),
        q(X, S2, S3),
        'C'(S3, stop, S).
```

Extra conditions expressed as explicit procedure calls naturally translate as themselves, e.g.

```
p(X) --> [X], {integer(X), X>0}, q(X).
```

translates to

```
p(X, S0, S) :-
        'C'(S0, X, S1),
        integer(X),
        X>0,
        q(X, S1, S).
```

Similarly, a cut is translated literally.

Terminals on the left-hand side of a rule translate into an explicit list in the output argument of the main non-terminal, e.g.

```
is(N), [not] --> [aint].
```

becomes

```
is(N, S0, [not|S]) :- 'C'(S0, aint, S).
```

Disjunction has a fairly obvious translation, e.g.

```
args(X, Y) -->
        (   dir(X), [to], indir(Y)
        ;   indir(Y), dir(X)
        ).
```

translates to

```
args(X, Y, S0, S) :-
        (   dir(X, S0, S1),
            'C'(S1, to, S2),
            indir(Y, S2, S)
        ;   indir(Y, S0, S1),
            dir(X, S1, S)
        ).
```

41.1 Usage and interface (dcg_doc)

- **Library usage:**
  `:- use_package(dcg).`
  or
  `:- module(...,...,[dcg]).`

42 Definite Clause Grammars (expansion)

Author(s): Daniel Cabeza.
This module implements the translation for Definite Clause Grammars (DCGs) (expansion).

42.1 Usage and interface (dcg_tr)

- **Library usage:**
  `:- use_module(library(dcg_tr)).`
- **Exports:**
  - *Predicates:*
    `phrase/2`, `phrase/3`, `dcg_translation/2`.
- **Other modules used:**
  - *System library modules:*
    `terms`, `assertions/doc_props`.

42.2 Documentation on exports (dcg_tr)

phrase/2: PREDICATE

`phrase(Phrase,List)`
Like `phrase(Phrase,List,[])`.
Meta-predicate with arguments: `phrase(goal,?)`.

phrase/3: PREDICATE

Meta-predicate with arguments: `phrase(goal,?,?)`.
Usage: `phrase(Phrase,List,Remainder)`

- *Description:* The list `List` is a phrase of type `Phrase` (according to the current grammar rules), where `Phrase` is either a non-terminal or more generally a grammar rule body. `Remainder` is what remains of the list after a phrase has been found.
- *The following properties should hold at call time:*
  `Phrase` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties should hold globally:*
  Documentation is still incomplete: `phrase(Phrase,List,Remainder)` may not conform the functionality documented. (doc_props:doc_incomplete/1)

dcg_translation/2: PREDICATE

Performs the code expansion of source clauses that use DCGs.

42.3 Known bugs and planned improvements (dcg_tr)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

43 Formatted output

Author(s): The CLIP Group.

The `format` family of predicates is due to Quintus Prolog. They act as a Prolog interface to the C `stdio` function `printf()`, allowing formatted output.

Output is formatted according to an output pattern which can have either a format control sequence or any other character, which will appear verbatim in the output. Control sequences act as place-holders for the actual terms that will be output. Thus

```
?- format("Hello ~q!",world).
```

will print `Hello world!`.

If there is only one item to print it may be supplied alone. If there are more they have to be given as a list. If there are none then an empty list should be supplied. There has to be as many items as control characters.

The character ~ introduces a control sequence. To print a ~ verbatim just repeat it:

```
?- format("Hello ~~world!", []).
```

will result in `Hello ~world!`.

A format may be spread over several lines. The control sequence `\c` followed by a ⟨LFD⟩ will translate to the empty string:

```
?- format("Hello \c
world!", []).
```

will result in `Hello world!`.

43.1 Usage and interface (`format`)

- **Library usage:**
  `:- use_module(library(format)).`
- **Exports:**
  - *Predicates:*
    `format/2`, `format/3`, `sformat/3`, `format_to_string/3`.
  - *Regular Types:*
    `format_control/1`.
- **Other modules used:**
  - *System library modules:*
    `write`, `system`, `assertions/doc_props`.

43.2 Documentation on exports (`format`)

format/2: PREDICATE

General properties: `format(C,A)`

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP as `format(C,A)`. (basic_props:native/2)

Usage: `format(Format,Arguments)`

– *Description:* Print `Arguments` onto current output stream according to format `Format`.

– *The following properties should hold at call time:*

`Format` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

format/3: PREDICATE

General properties: `format(S,C,A)`

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP as `format(S,C,A)`. (basic_props:native/2)

Usage: `format(Stream,Format,Arguments)`

– *Description:* Print `Arguments` onto `Stream` according to format `Format`.

– *The following properties should hold at call time:*

`Stream` is an open stream. (streams_basic:stream/1)

`Format` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

sformat/3: PREDICATE

Usage: `sformat(String,Format,Arguments)`

– *Description:* Same as `format_to_string(Format, Arguments, String)` (note the different argument order).

– *The following properties should hold at call time:*

`Format` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

– *The following properties should hold upon exit:*

`String` is a string (a list of character codes). (basic_props:string/1)

format_to_string/3: PREDICATE

Usage: `format_to_string(Format,Arguments,String)`

– *Description:* Print `Arguments` onto current string `String` according to format `Format`. This predicate is similar to the format/2, but the result is stored in a string.

– *The following properties should hold at call time:*

`Format` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

`Arguments` is a list. (basic_props:list/1)

– *The following properties should hold upon exit:*

`String` is a string (a list of character codes). (basic_props:string/1)

format_control/1: REGTYPE

The general format of a control sequence is `~NC`. The character `C` determines the type of the control sequence. `N` is an optional numeric argument. An alternative form of `N` is `*`. `*` implies that the next argument in `Arguments` should be used as a numeric argument in the control sequence. Example:

```
?- format("Hello~4cworld!", [0'x]).
```

and

```
?- format("Hello~*cworld!", [4,0'x]).
```

both produce

```
Helloxxxxworld!
```

The following control sequences are available.

- `~a` The argument is an atom. The atom is printed without quoting.
- `~Nc` (Print character.) The argument is a number that will be interpreted as an ASCII code. `N` defaults to one and is interpreted as the number of times to print the character.
- `~Ne`
- `~NE`
- `~Nf`
- `~Ng`
- `~NG` (Print float). The argument is a float. The float and `N` will be passed to the C `printf()` function as

  ```
  printf("%.Ne", Arg)
  printf("%.NE", Arg)
  printf("%.Nf", Arg)
  printf("%.Ng", Arg)
  printf("%.NG", Arg)
  ```

  If `N` is not supplied the action defaults to

  ```
  printf("%e", Arg)
  printf("%E", Arg)
  printf("%f", Arg)
  printf("%g", Arg)
  printf("%G", Arg)
  ```
- `~Nd` (Print decimal.) The argument is an integer. `N` is interpreted as the number of digits after the decimal point. If `N` is 0 or missing, no decimal point will be printed. Example:

  ```
  ?- format("Hello ~1d world!", [42]).
  ?- format("Hello ~d world!", [42]).
  ```

  will print as

  ```
  Hello 4.2 world!
  Hello 42 world!
  ```

  respectively.
- `~ND` (Print decimal.) The argument is an integer. Identical to `~Nd` except that `,` will separate groups of three digits to the left of the decimal point. Example:

  ```
  ?- format("Hello ~1D world!", [12345]).
  ```

  will print as

  ```
  Hello 1,234.5 world!
  ```

- ~Nr (Print radix.) The argument is an integer. N is interpreted as a radix. N should be >= 2 and <= 36. If N is missing the radix defaults to 8. The letters a-z will denote digits larger than 9. Example:

```
?- format("Hello ~2r world!", [15]).
?- format("Hello ~16r world!", [15]).
```

will print as

```
Hello 1111 world!
Hello f world!
```

respectively.

- ~NR (Print radix.) The argument is an integer. Identical to ~Nr except that the letters A-Z will denote digits larger than 9. Example:

```
?- format("Hello ~16R world!", [15]).
```

will print as

```
Hello F world!
```

- ~Ns (Print string.) The argument is a list of ASCII codes. Exactly N characters will be printed. N defaults to the length of the string. Example:

```
?- format("Hello ~4s ~4s!", ["new","world"]).
?- format("Hello ~s world!", ["new"]).
```

will print as

```
Hello new  worl!
Hello new world!
```

respectively.

- ~i (Ignore argument.) The argument may be of any type. The argument will be ignored. Example:

```
?- format("Hello ~i~s world!", ["old","new"]).
```

will print as

```
Hello new world!
```

- ~k (Print canonical.) The argument may be of any type. The argument will be passed to write_canonical/2 (Chapter 36 [Term output], page 249). Example:

```
?- format("Hello ~k world!", [[a,b,c]]).
```

will print as

```
Hello .(a,.(b,.(c,[]))) world!
```

- ~p (print.) The argument may be of any type. The argument will be passed to print/2 (Chapter 36 [Term output], page 249). Example:

suposing the user has defined the predicate

```
:- multifile portray/1.
portray([X|Y]) :- print(cons(X,Y)).
```

then

```
?- format("Hello ~p world!", [[a,b,c]]).
```

will print as

```
Hello cons(a,cons(b,cons(c,[]))) world!
```

- ~q (Print quoted.) The argument may be of any type. The argument will be passed to writeq/2 (Chapter 36 [Term output], page 249). Example:

```
?- format("Hello ~q world!", [['A','B']]).
```

will print as

```
Hello ['A','B'] world!
```

- ~w (write.) The argument may be of any type. The argument will be passed to `write/2` (Chapter 36 [Term output], page 249). Example:

```
?- format("Hello ~w world!", [['A','B']]).
```

will print as

```
Hello [A,B] world!
```

- ~Nn (Print newline.) Print `N` newlines. `N` defaults to 1. Example:

```
?- format("Hello ~n world!", []).
```

will print as

```
Hello
 world!
```

- ~N (Fresh line.) Print a newline, if not already at the beginning of a line.
- ~~ (Print tilde.) Prints ~

The following control sequences are also available for compatibility, but do not perform any useful functions.

- ~N| (Set tab.) Set a tab stop at position `N`, where `N` defaults to the current position, and advance the current position there.
- ~N+ (Advance tab.) Set a tab stop at `N` positions past the current position, where `N` defaults to 8, and advance the current position there.
- ~Nt (Set fill character.) Set the fill character to be used in the next position movement to `N`, where `N` defaults to ⟨SPC⟩.

Usage: `format_control(C)`

– *Description:* `C` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`.

– *The following properties should hold globally:*

Documentation is still incomplete: `format_control(C)` may not conform the functionality documented. (doc_props:doc_incomplete/1)

43.3 Known bugs and planned improvements (`format`)

- `format_to_string/3` is extremelly slow in its current implementation. It writes an intermediate file which is immediately removed, if possible. It is not very fast. In case there are no permissions, writing is attempted through an internal pipe, which may hang if the string is too long (this is O.S. dependant).

44 List processing

Author(s): The CLIP Group.
This module provides a set of predicates for list processing.

44.1 Usage and interface (lists)

- **Library usage:**
  `:- use_module(library(lists)).`
- **Exports:**
  - *Predicates:*
    `nonsingle/1`, `append/3`, `reverse/2`, `reverse/3`, `delete/3`, `delete_non_ground/3`, `select/3`, `length/2`, `nth/3`, `add_after/4`, `add_before/4`, `dlist/3`, `list_concat/2`, `list_insert/2`, `insert_last/3`, `contains_ro/2`, `contains1/2`, `nocontainsx/2`, `last/2`, `list_lookup/3`, `list_lookup/4`, `intset_insert/3`, `intset_delete/3`, `intset_in/2`, `intset_sequence/3`, `intersection/3`, `union/3`, `difference/3`, `equal_lists/2`, `list_to_list_of_lists/2`, `powerset/2`, `cross_product/2`, `sequence_to_list/2`.
  - *Properties:*
    `list1/2`, `sublist/2`, `subordlist/2`.
  - *Regular Types:*
    `list_of_lists/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

44.2 Documentation on exports (lists)

nonsingle/1: PREDICATE

General properties: `nonsingle(A)`

- *Description:* nonsingle fails.
- *If the following properties should hold at call time:*
  term_basic:A=[a] (term_basic:= /2)
  then the following properties should hold globally:
  Calls of the form `nonsingle(A)` fail. (native_props:fails/1)

`nonsingle(A)`

- *Description:* nonsingle succeeds.
- *If the following properties should hold at call time:*
  term_basic:A=[a,b] (term_basic:= /2)

Usage: `nonsingle(X)`

- *Description:* `X` is not a singleton.

append/3: PREDICATE

General properties: `append(Xs,Ys,Zs)`

- *Description:* `Zs` is `Ys` appended to `Xs`.
- *The following properties should hold upon exit:*
  `Xs` is a list. (basic_props:list/1)

`append(Xs,Ys,Zs)`

- *If the following properties hold at call time:*
  `Xs` is a list. (basic_props:list/1)
  `Ys` is a list. (basic_props:list/1)
  then the following properties should hold upon exit:
  `Zs` is a list. (basic_props:list/1)

`append(Xs,Ys,Zs)`

- *If the following properties hold at call time:*
  `Zs` is a list. (basic_props:list/1)
  then the following properties should hold upon exit:
  `Xs` is a list. (basic_props:list/1)
  `Ys` is a list. (basic_props:list/1)

`append(Xs,Ys,Zs)`

- *The following properties should hold upon exit:*
  The sharing pattern is `[[X,Y,Z],[X,Z],[Y,Z]]`. (native_props:mshare/1)

`append(Xs,Ys,Zs)`

- *If the following properties hold at call time:*
  `Xs` is currently ground (it contains no variables). (term_typing:ground/1)
  `Ys` is currently ground (it contains no variables). (term_typing:ground/1)
  then the following properties should hold upon exit:
  `Zs` is currently ground (it contains no variables). (term_typing:ground/1)

`append(Xs,Ys,Zs)`

- *If the following properties hold at call time:*
  `Zs` is currently ground (it contains no variables). (term_typing:ground/1)
  then the following properties should hold upon exit:
  `Xs` is currently ground (it contains no variables). (term_typing:ground/1)
  `Ys` is currently ground (it contains no variables). (term_typing:ground/1)

`append(Xs,Ys,Zs)`

- *The following properties hold globally:*
  `append(Xs,Ys,Zs)` is side-effect `free`. (basic_props:sideff/2)

`append(Xs,Ys,Zs)`

- *If the following properties hold at call time:*
  `Xs` is a list. (basic_props:list/1)
  then the following properties hold globally:
  `append(Xs,Ys,Zs)` is evaluable at compile-time. (basic_props:eval/1)

`append(Xs,Ys,Zs)`

– *If the following properties hold at call time:*
`Zs` is a list. (basic_props:list/1)
then the following properties hold globally:
`append(Xs,Ys,Zs)` is evaluable at compile-time. (basic_props:eval/1)

`append(A,B,C)`
– *Description:* Simple call to append
– *If the following properties should hold at call time:*
term_basic:A=[1,2,3] (term_basic:= /2)
term_basic:B=[4,5] (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:C=[1,2,3,4,5] (term_basic:= /2)

`append(A,B,X)`
– *Description:* Simple append test
– *If the following properties should hold at call time:*
term_basic:L=[([1,2],[1,2,4,5,6]),([1,2,3],[1,2,3,4,5,6])] (term_basic:= /2)
term_basic:B=[4,5,6] (term_basic:= /2)
`A,X2` is an element of `L`. (basic_props:member/2)
then the following properties should hold upon exit:
The terms `X` and `X2` are strictly identical. (term_compare:== /2)

`append(A,B,X)`
– *Description:* Test of reverse call
– *If the following properties should hold at call time:*
term_basic:X=[1,2,3] (term_basic:= /2)
then the following properties should hold upon exit:
`A,B` is an element of `[([],[1,2,3]),([1],[2,3]),([1,2],[3]),([1,2,3],[])]`. (basic_props:member/2)

`append(A,B,X)`
– *Description:* Empty test.
– *If the following properties should hold at call time:*
term_basic:A=[] (term_basic:= /2)
term_basic:B=[] (term_basic:= /2)
then the following properties should hold upon exit:
The terms `X` and `[]` are strictly identical. (term_compare:== /2)

`append(_A,B,X)`
– *Description:* Test of a call that fails
– *If the following properties should hold at call time:*
term_basic:B=[2] (term_basic:= /2)
term_basic:X=[1,2,3] (term_basic:= /2)
then the following properties should hold globally:
Calls of the form `append(_A,B,X)` fail. (native_props:fails/1)

`append(X,Y,Z)`
– *Description:* Test of a reverse call.

– *If the following properties should hold at call time:*
term_basic:Y=[2] (term_basic:= /2)
term_basic:Z=[1,2] (term_basic:= /2)
then the following properties should hold upon exit:
The terms `X` and `[1]` are strictly identical. (term_compare:== /2)

Usage: `append(Xs,Ys,Zs)`
– *Call and exit should be compatible with:*
`Xs` is a list. (basic_props:list/1)
`Ys` is a list. (basic_props:list/1)
`Zs` is a list. (basic_props:list/1)

reverse/2: PREDICATE

General properties: `reverse(A,B)`
– *Description:* Reverse a list
– *If the following properties should hold at call time:*
term_basic:A=[1,2,3] (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:B=[3,2,1] (term_basic:= /2)
– *The following properties hold globally:*
`reverse(Arg1,Arg2)` is side-effect `free`. (basic_props:sideff/2)

`reverse(Xs,_Ys)`
– *If the following properties hold at call time:*
`Xs` is a list. (basic_props:list/1)
then the following properties hold globally:
`reverse(Xs,_Ys)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `reverse(Xs,Ys)`
– *Description:* Reverses the order of elements in `Xs`.
– *The following properties should hold at call time:*
`Xs` is a list. (basic_props:list/1)
`Ys` is any term. (basic_props:term/1)
– *The following properties should hold upon exit:*
`Xs` is a list. (basic_props:list/1)
`Ys` is a list. (basic_props:list/1)

reverse/3: PREDICATE

General properties: `reverse(A,B,C)`
– *Description:* reverse/3 test
– *Call and exit should be compatible with:*
`B` is a free variable. (term_typing:var/1)
– *If the following properties should hold at call time:*
term_basic:A=[1,2,3] (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:C=[3,2,1|B] (term_basic:= /2)

– *The following properties hold globally:*
`reverse(Arg1,Arg2,Arg3)` is side-effect `free`. (basic_props:sideff/2)

`reverse(Xs,Ys,Zs)`
– *If the following properties hold at call time:*
`Xs` is a list. (basic_props:list/1)
`Ys` is a list. (basic_props:list/1)
then the following properties hold globally:
`reverse(Xs,Ys,Zs)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `reverse(A,B,C)`
– *Description:* Reverse the order of elements in `A`, and append it with `B`.

delete/3: PREDICATE

General properties:
– *The following properties hold globally:*
`delete(Arg1,Arg2,Arg3)` is side-effect `free`. (basic_props:sideff/2)

`delete(L1,E,L2)`
– *If the following properties hold at call time:*
`L1` is currently ground (it contains no variables). (term_typing:ground/1)
`L2` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`delete(L1,E,L2)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `delete(L1,E,L2)`
– *Description:* `L2` is `L1` without the ocurrences of `E`.
– *The following properties should hold upon exit:*
`L1` is a list. (basic_props:list/1)
`L2` is a list. (basic_props:list/1)

delete_non_ground/3: PREDICATE

General properties:
– *The following properties hold globally:*
`delete_non_ground(Arg1,Arg2,Arg3)` is side-effect `true`. (basic_props:sideff/2)

`delete_non_ground(L1,E,L2)`
– *If the following properties hold at call time:*
`L1` is currently ground (it contains no variables). (term_typing:ground/1)
`L2` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`delete_non_ground(L1,E,L2)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `delete_non_ground(L1,E,L2)`
– *Description:* `L2` is `L1` without the ocurrences of `E`. `E` can be a nonground term so that all the elements in `L1` it unifies with will be deleted
– *The following properties should hold upon exit:*
`L1` is a list. (basic_props:list/1)
`L2` is a list. (basic_props:list/1)

select/3: PREDICATE

General properties:

– *The following properties hold globally:*
`select(Arg1,Arg2,Arg3)` is side-effect `free`. (basic_props:sideff/2)

`select(X,Xs,Ys)`

– *If the following properties hold at call time:*
`X` is currently ground (it contains no variables). (term_typing:ground/1)
`Xs` is currently ground (it contains no variables). (term_typing:ground/1)
then the following properties hold globally:
`select(X,Xs,Ys)` is evaluable at compile-time. (basic_props:eval/1)

Usage: `select(X,Xs,Ys)`

– *Description:* `Xs` and `Ys` have the same elements except for one occurrence of `X`.

length/2: PREDICATE

General properties: `length(A,B)`

– *The following properties hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)
– *The following properties hold globally:*
`length(Arg1,Arg2)` is side-effect `free`. (basic_props:sideff/2)

`length(L,N)`

– *If the following properties hold at call time:*
`L` is a list. (basic_props:list/1)
then the following properties hold globally:
`length(L,N)` is evaluable at compile-time. (basic_props:eval/1)

`length(L,N)`

– *If the following properties hold at call time:*
`N` is currently instantiated to an integer. (term_typing:integer/1)
then the following properties hold globally:
`length(L,N)` is evaluable at compile-time. (basic_props:eval/1)

Usage 1: `length(L,N)`

– *Description:* Computes the length of `L`.
– *The following properties should hold at call time:*
`L` is a list. (basic_props:list/1)
`N` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`L` is a list. (basic_props:list/1)
`N` is an integer. (basic_props:int/1)

Usage 2: `length(L,N)`

– *Description:* Outputs `L` of length `N`.
– *The following properties should hold at call time:*
`L` is a free variable. (term_typing:var/1)
`N` is an integer. (basic_props:int/1)

– *The following properties should hold upon exit:*
`L` is a list. (basic_props:list/1)
`N` is an integer. (basic_props:int/1)

Usage 3: `length(L,N)`
– *Description:* Checks that `L` is of length `N`.
– *The following properties should hold at call time:*
`L` is a list. (basic_props:list/1)
`N` is an integer. (basic_props:int/1)
– *The following properties should hold upon exit:*
`L` is a list. (basic_props:list/1)
`N` is an integer. (basic_props:int/1)

nth/3: PREDICATE

`nth(N,List,Elem)`
`N` is the position in `List` of `Elem`. `N` counts from one.

General properties:
– *The following properties hold globally:*
`nth(N,List,Elem)` is side-effect `free`. (basic_props:sideff/2)

`nth(N,L,E)`
– *If the following properties hold at call time:*
`N` is currently instantiated to an integer. (term_typing:integer/1)
then the following properties hold globally:
`nth(N,L,E)` is evaluable at compile-time. (basic_props:eval/1)

`nth(N,L,E)`
– *If the following properties hold at call time:*
`L` is a list. (basic_props:list/1)
then the following properties hold globally:
`nth(N,L,E)` is evaluable at compile-time. (basic_props:eval/1)

`nth(N,L,E)`
– *If the following properties hold at call time:*
`N` is an integer. (basic_props:int/1)
`L` is a list. (basic_props:list/1)
then the following properties hold globally:
All calls of the form `nth(N,L,E)` are deterministic. (native_props:is_det/1)

Usage 1:
– *Description:* Unifies `Elem` and the `N`th element of `List`.
– *Call and exit should be compatible with:*
`List` is a list. (basic_props:list/1)
`Elem` is any term. (basic_props:term/1)
– *The following properties should hold at call time:*
`N` is an integer. (basic_props:int/1)

– *The following properties should hold upon exit:*

`List` is a list. (basic_props:list/1)

`Elem` is any term. (basic_props:term/1)

Usage 2:

– *Description:* Finds the positions where `Elem` is in `List`. Positions are found in ascending order.

– *Call and exit should be compatible with:*

`List` is a list. (basic_props:list/1)

`Elem` is any term. (basic_props:term/1)

– *The following properties should hold at call time:*

`N` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`N` is an integer. (basic_props:int/1)

`List` is a list. (basic_props:list/1)

`Elem` is any term. (basic_props:term/1)

add_after/4: PREDICATE

Usage: `add_after(L0,E0,E,L)`

– *Description:* Adds element `E` after element `E0` (or at end) to list `L0` returning in `L` the new list (uses term comparison).

– *The following properties should hold at call time:*

`L0` is currently a term which is not a free variable. (term_typing:nonvar/1)

`E0` is currently a term which is not a free variable. (term_typing:nonvar/1)

`E` is currently a term which is not a free variable. (term_typing:nonvar/1)

`L` is a free variable. (term_typing:var/1)

add_before/4: PREDICATE

Usage: `add_before(L0,E0,E,L)`

– *Description:* Adds element E before element E0 (or at start) to list L0 returning in L the new list (uses term comparison).

– *The following properties should hold at call time:*

`L0` is currently a term which is not a free variable. (term_typing:nonvar/1)

`E0` is currently a term which is not a free variable. (term_typing:nonvar/1)

`E` is currently a term which is not a free variable. (term_typing:nonvar/1)

`L` is a free variable. (term_typing:var/1)

list1/2: PROPERTY

Meta-predicate with arguments: `list1(?,(pred 1))`.

Usage: `list1(X,Y)`

– *Description:* `X` is a list of `Y`s of at least one element.

dlist/3: PREDICATE

Usage: `dlist(List,DList,Tail)`

- *Description:* `List` is the result of removing `Tail` from the end of `DList` (makes a difference list from a list).

list_concat/2: PREDICATE

Usage: `list_concat(LL,L)`

- *Description:* `L` is the concatenation of all the lists in `LL`.
- *The following properties should hold at call time:*

  `LL` is a list of `lists`. (basic_props:list/2)
- *The following properties should hold upon exit:*

  `L` is a list. (basic_props:list/1)

list_insert/2: PREDICATE

Usage: `list_insert(List,Term)`

- *Description:* Adds `Term` to the end of `List` if there is no element in `List` identical to `Term`.
- *The following properties should hold at call time:*

  `Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

insert_last/3: PREDICATE

Usage: `insert_last(L0,E,L)`

- *Description:* Adds element `E` at end of list `L0` returning `L`.
- *The following properties should hold at call time:*

  `L0` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `E` is currently a term which is not a free variable. (term_typing:nonvar/1)

contains_ro/2: PREDICATE

Usage:

- *Description:* Impure membership (does not instantiate a variable in its first argument.

contains1/2: PREDICATE

Usage:

- *Description:* First membership.

nocontainsx/2: PREDICATE

Usage: `nocontainsx(L,X)`

- *Description:* `X` is not identical to any element of `L`.

last/2: PREDICATE

Usage: `last(L,X)`

– *Description:* `X` is the last element of list `L`.

list_lookup/3: PREDICATE

Usage: `list_lookup(List,Key,Value)`

– *Description:* Same as `list_lookup/4`, but use `-/2` as functor.

list_lookup/4: PREDICATE

Usage: `list_lookup(List,Functor,Key,Value)`

– *Description:* Look up `Functor`(`Key`,`Value`) pair in variable ended key-value pair list `L` or else add it at the end.

intset_insert/3: PREDICATE

Usage: `intset_insert(A,B,Set)`

– *Description:* Insert the element `B` in the ordered set of numbers `A`.

intset_delete/3: PREDICATE

Usage: `intset_delete(A,B,Set)`

– *Description:* Delete from the ordered set `A` the element `B`.

intset_in/2: PREDICATE

Usage: `intset_in(E,Set)`

– *Description:* Succeds iff `E` is element of `Set`

intset_sequence/3: PREDICATE

Usage: `intset_sequence(N,L1,L2)`

– *Description:* Generates an ordered set of numbers from 0 to `N`-1, and append it to `L1`.

intersection/3: PREDICATE

Usage: `intersection(List1,List2,List)`

– *Description:* `List` has the elements which are both in `List1` and `List2`.

– *The following properties should hold at call time:*

`List1` is currently a term which is not a free variable. (term_typing:nonvar/1)

`List2` is currently a term which is not a free variable. (term_typing:nonvar/1)

`List1` is a list. (basic_props:list/1)

`List2` is a list. (basic_props:list/1)

– *The following properties should hold upon exit:*

`List` is a list. (basic_props:list/1)

union/3: PREDICATE

Usage: `union(List1,List2,List)`

- *Description:* `List` has the elements which are in `List1` followed by the elements which are in `List2` but not in `List1`.
- *The following properties should hold at call time:*

  `List1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `List2` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `List` is a free variable. (term_typing:var/1)
  `List1` is a list. (basic_props:list/1)
  `List2` is a list. (basic_props:list/1)
- *The following properties should hold upon exit:*

  `List` is a list. (basic_props:list/1)

difference/3: PREDICATE

Usage: `difference(List1,List2,List)`

- *Description:* `List` has the elements which are in `List1` but not in `List2`.
- *The following properties should hold at call time:*

  `List1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `List2` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `List` is a free variable. (term_typing:var/1)
  `List1` is a list. (basic_props:list/1)
  `List2` is a list. (basic_props:list/1)
- *The following properties should hold upon exit:*

  `List` is a list. (basic_props:list/1)

sublist/2: PROPERTY

Usage: `sublist(List1,List2)`

- *Description:* `List2` contains all the elements of `List1`.
- *If the following properties should hold at call time:*

  `List2` is currently a term which is not a free variable. (term_typing:nonvar/1)

subordlist/2: PROPERTY

Usage: `subordlist(List1,List2)`

- *Description:* `List2` contains all the elements of `List1` in the same order.
- *If the following properties should hold at call time:*

  `List2` is currently a term which is not a free variable. (term_typing:nonvar/1)

equal_lists/2: PREDICATE

Usage: `equal_lists(List1,List2)`

- *Description:* `List1` has all the elements of `List2`, and vice versa.
- *The following properties should hold at call time:*

  `List1` is a list. (basic_props:list/1)
  `List2` is a list. (basic_props:list/1)

list_to_list_of_lists/2: PREDICATE

Usage 1: `list_to_list_of_lists(List,LList)`

- *The following properties should hold at call time:*
  `List` is a list. (basic_props:list/1)
- *The following properties should hold upon exit:*
  lists:list_of_lists(LList) (lists:list_of_lists/1)

Usage 2: `list_to_list_of_lists(List,LList)`

- *Description:* `LList` is the list of one element lists with elements of `List`.
- *The following properties should hold at call time:*
  lists:list_of_lists(LList) (lists:list_of_lists/1)
- *The following properties should hold upon exit:*
  `List` is a list. (basic_props:list/1)

powerset/2: PREDICATE

Usage: `powerset(List,LList)`

- *Description:* `LList` is the powerset of `List`, i.e., the list of all lists which have elements of `List`. If `List` is ordered, `LList` and all its elements are ordered.
- *The following properties should hold at call time:*
  `List` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `List` is a list. (basic_props:list/1)
- *The following properties should hold upon exit:*
  lists:list_of_lists(LList) (lists:list_of_lists/1)

cross_product/2: PREDICATE

Usage: `cross_product(LList,List)`

- *Description:* `List` is the cartesian product of the lists in `LList`, that is, the list of lists formed with one element of each list in `LList`, in the same order.
- *The following properties should hold at call time:*
  `LList` is currently a term which is not a free variable. (term_typing:nonvar/1)
  lists:list_of_lists(LList) (lists:list_of_lists/1)
- *The following properties should hold upon exit:*
  lists:list_of_lists(List) (lists:list_of_lists/1)

sequence_to_list/2: PREDICATE

Usage: `sequence_to_list(Sequence,List)`

- *Description:* `List` is the list of all elements in the (comma-separated) sequence `Sequence`. The use of this predicate is reversible.

list_of_lists/1: REGTYPE

A regular type, defined as follows:

```
list_of_lists([]).
list_of_lists([L|Xs]) :-
        list(L),
        list_of_lists(Xs).
```

45 Sorting lists

Author(s): Richard A. O'Keefe (original version), The CLIP Group (changes and modifications).

This module implements some sorting list predicates.

45.1 Usage and interface (sort)

- **Library usage:**
  `:- use_module(library(sort)).`
- **Exports:**
  - *Predicates:*
    `sort/2`, `keysort/2`.
  - *Regular Types:*
    `keylist/1`, `keypair/1`.

45.2 Documentation on exports (sort)

sort/2: PREDICATE

`sort(List1,List2)`

The elements of `List1` are sorted into the standard order (see Chapter 18 [Comparing terms], page 135) and any identical elements are merged, yielding `List2`. The time and space complexity of this operation is at worst `O(N lg N)` where `N` is the length of `List1`.

General properties: `sort(A,B)`

- *If the following properties should hold at call time:*
  term_basic:A=[1,2,6,5,2,1] (term_basic:= /2)
  then the following properties should hold upon exit:
  The terms `B` and `[1,2,5,6]` are strictly identical. (term_compare:== /2)

`sort(A,B)`

- *If the following properties hold at call time:*
  `A` is a list. (basic_props:list/1)
  then the following properties hold globally:
  `sort(A,B)` is evaluable at compile-time. (basic_props:eval/1)

`sort(A,B)`

- *The following properties hold globally:*
  `sort(A,B)` is side-effect `free`. (basic_props:sideff/2)

Usage:

- *Description:* `List2` is the sorted list corresponding to `List1`.
- *Call and exit should be compatible with:*
  `List2` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*
  `List1` is a list. (basic_props:list/1)

– *The following properties should hold upon exit:*
`List2` is a list. (basic_props:list/1)
– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

keysort/2: PREDICATE

`keysort(List1,List2)`

`List1` is sorted into order according to the value of the *keys* of its elements, yielding the list `List2`. No merging takes place. This predicate is *stable*, i.e., if an element `A` occurs before another element `B` *with the same key* in the input, then `A` will occur before `B` also in the output. The time and space complexity of this operation is at worst `O(N lg N)` where `N` is the length of `List1`.

Usage:

– *Description:* `List2` is the (key-)sorted list corresponding to `List1`.
– *Call and exit should be compatible with:*
`List2` is a list of pairs of the form `Key-Value`. (sort:keylist/1)
– *The following properties should hold at call time:*
`List1` is a list of pairs of the form `Key-Value`. (sort:keylist/1)
– *The following properties should hold upon exit:*
`List2` is a list of pairs of the form `Key-Value`. (sort:keylist/1)
– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

keylist/1: REGTYPE

Usage: `keylist(L)`

– *Description:* `L` is a list of pairs of the form `Key-Value`.

keypair/1: REGTYPE

Usage: `keypair(P)`

– *Description:* `P` is a pair of the form `"K-_"`, where `K` is considered the *key*.

45.3 Known bugs and planned improvements (sort)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

46 compiler (library)

46.1 Usage and interface (compiler)

- **Library usage:**
  `:- use_module(library(compiler)).`
- **Exports:**
  - *Predicates:*
    `make_po/1`, `make_wam/1`, `ensure_loaded/1`, `ensure_loaded/2`, `use_module/1`, `use_module/2`, `use_module/3`, `unload/1`, `set_debug_mode/1`, `set_nodebug_mode/1`, `set_debug_module/1`, `set_nodebug_module/1`, `set_debug_module_source/1`, `mode_of_module/2`, `module_of/2`.
- **Other modules used:**
  - *System library modules:*
    `system`, `compiler/c_itf_internal`, `compiler/exemaker`.

46.2 Documentation on exports (compiler)

make_po/1: PREDICATE

No further documentation available for this predicate.

make_wam/1: PREDICATE

No further documentation available for this predicate.

ensure_loaded/1: PREDICATE

No further documentation available for this predicate.

ensure_loaded/2: PREDICATE

No further documentation available for this predicate.

use_module/1: PREDICATE

No further documentation available for this predicate.

use_module/2: PREDICATE

No further documentation available for this predicate.

Meta-predicate with arguments: `use_module(?,addmodule(?))`.

use_module/3: PREDICATE
No further documentation available for this predicate.

unload/1: PREDICATE
No further documentation available for this predicate.

set_debug_mode/1: PREDICATE
No further documentation available for this predicate.

set_nodebug_mode/1: PREDICATE
No further documentation available for this predicate.

set_debug_module/1: PREDICATE
No further documentation available for this predicate.

set_nodebug_module/1: PREDICATE
No further documentation available for this predicate.

set_debug_module_source/1: PREDICATE
No further documentation available for this predicate.

mode_of_module/2: PREDICATE
No further documentation available for this predicate.

module_of/2: PREDICATE
No further documentation available for this predicate.

47 Enumeration of integers inside a range

Author(s): The CLIP Group.

This modules enumerates integers between two numbers, or checks that an integer lies within a range

47.1 Usage and interface (`between`)

- **Library usage:**
  `:- use_module(library(between)).`
- **Exports:**
  - *Predicates:*
    `between/3`.

47.2 Documentation on exports (`between`)

between/3: PREDICATE

Usage: `between(Min,Max,N)`

- *Description:* `N` is an integer which is greater than or equal to `Min` and smaller than or equal to `Max`. Both `Min` and `Max` can be either integer or real numbers.
- *The following properties should hold at call time:*

  `Min` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Max` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Min` is a number. (basic_props:num/1)

  `Max` is a number. (basic_props:num/1)
- *The following properties should hold upon exit:*

  `N` is an integer. (basic_props:int/1)

48 Operating system utilities

Author(s): Daniel Cabeza, Manuel Carro.

This module contains predicates for invoking services which are typically provided by the operating system. Note that the predicates which take names of files or directories as arguments in this module expect atoms, not path aliases. I.e., generally these predicates will not call `absolute_file_name/2` on names of files or directories taken as arguments.

48.1 Usage and interface (`system`)

- **Library usage:**
  `:- use_module(library(system)).`
- **Exports:**
  - *Predicates:*
    `pause/1`, `time/1`, `datime/1`, `datime/9`, `getenvstr/2`, `setenvstr/2`, `current_env/2`, `set_env/2`, `del_env/1`, `c_errno/1`, `copy_file/2`, `copy_file/3`, `dir_path/2`, `extract_paths/2`, `file_dir_name/3`, `get_pid/1`, `get_uid/1`, `get_gid/1`, `get_pwnam/1`, `get_grnam/1`, `get_tmp_dir/1`, `get_address/2`, `current_host/1`, `current_executable/1`, `umask/2`, `make_directory/2`, `make_directory/1`, `make_dirpath/2`, `make_dirpath/1`, `working_directory/2`, `cd/1`, `shell/0`, `shell/1`, `shell/2`, `system/1`, `system/2`, `popen/3`, `exec/4`, `exec/3`, `exec/8`, `wait/3`, `directory_files/2`, `mktemp/2`, `mktemp_in_tmp/2`, `file_exists/1`, `file_exists/2`, `file_property/2`, `file_properties/6`, `modif_time/2`, `modif_time0/2`, `fmode/2`, `chmod/2`, `chmod/3`, `set_exec_mode/2`, `delete_file/1`, `delete_directory/1`, `rename_file/2`, `using_windows/0`, `winpath/2`, `winpath/3`, `winpath_c/3`, `cyg2win/3`, `no_swapslash/3`, `replace_characters/4`, `system_error_report/1`.
  - *Regular Types:*
    `datime_struct/1`, `popen_mode/1`.
  - *Multifiles:*
    `define_flag/3`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

48.2 Documentation on exports (`system`)

pause/1: PREDICATE

`pause(Seconds)`

Make this thread sleep for some `Seconds`.

Usage:

- *The following properties should hold at call time:*
  `Seconds` is an integer. (basic_props:int/1)

time/1: PREDICATE

`time(Time)`

`Time` is unified with the number of seconds elapsed since January, 1, 1970 (UTC).

Usage:

- *Calls should, and exit will be compatible with:*
  `Time` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Time` is an integer. (basic_props:int/1)

datime/1: PREDICATE

`datime(Datime)`

`Datime` is unified with a term of the form `datime(Year,Month,Day,Hour,Minute,Second)` which contains the current date and time.

Usage:

- *Call and exit should be compatible with:*
  system:datime_struct(Datime) (system:datime_struct/1)
- *The following properties should hold upon exit:*
  system:datime_struct(Datime) (system:datime_struct/1)

datime/9: PREDICATE

`datime(Time,Year,Month,Day,Hour,Min,Sec,WeekDay,YearDay)`

`Time` is as in `time/1`. `WeekDay` is the number of days since Sunday, in the range 0 to 6. `YearDay` is the number of days since January 1, in the range 0 to 365.

Usage 1:

- *Description:* If `Time` is given, the rest of the arguments are unified with the date and time to which the `Time` argument refers.
- *Calls should, and exit will be compatible with:*
  `Year` is an integer. (basic_props:int/1)
  `Month` is an integer. (basic_props:int/1)
  `Day` is an integer. (basic_props:int/1)
  `Hour` is an integer. (basic_props:int/1)
  `Min` is an integer. (basic_props:int/1)
  `Sec` is an integer. (basic_props:int/1)
  `WeekDay` is an integer. (basic_props:int/1)
  `YearDay` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*
  `Time` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Year` is an integer. (basic_props:int/1)
  `Month` is an integer. (basic_props:int/1)
  `Day` is an integer. (basic_props:int/1)
  `Hour` is an integer. (basic_props:int/1)

`Min` is an integer. (basic_props:int/1)
`Sec` is an integer. (basic_props:int/1)
`WeekDay` is an integer. (basic_props:int/1)
`YearDay` is an integer. (basic_props:int/1)

Usage 2:

- *Description:* Bound `Time`, `WeekDay` and `YearDay` as determined by the input arguments.
- *Calls should, and exit will be compatible with:*
  `Time` is an integer. (basic_props:int/1)
  `WeekDay` is an integer. (basic_props:int/1)
  `YearDay` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*
  `Year` is an integer. (basic_props:int/1)
  `Month` is an integer. (basic_props:int/1)
  `Day` is an integer. (basic_props:int/1)
  `Hour` is an integer. (basic_props:int/1)
  `Min` is an integer. (basic_props:int/1)
  `Sec` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Time` is an integer. (basic_props:int/1)
  `WeekDay` is an integer. (basic_props:int/1)
  `YearDay` is an integer. (basic_props:int/1)

Usage 3:

- *Description:* Bound `Time` to current time and the rest of the arguments refer to current time.
- *Calls should, and exit will be compatible with:*
  `WeekDay` is an integer. (basic_props:int/1)
  `YearDay` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*
  `Time` is a free variable. (term_typing:var/1)
  `Year` is a free variable. (term_typing:var/1)
  `Month` is a free variable. (term_typing:var/1)
  `Day` is a free variable. (term_typing:var/1)
  `Hour` is a free variable. (term_typing:var/1)
  `Min` is a free variable. (term_typing:var/1)
  `Sec` is a free variable. (term_typing:var/1)
- *The following properties hold upon exit:*
  `Time` is an integer. (basic_props:int/1)
  `Year` is an integer. (basic_props:int/1)
  `Month` is an integer. (basic_props:int/1)
  `Day` is an integer. (basic_props:int/1)
  `Hour` is an integer. (basic_props:int/1)
  `Min` is an integer. (basic_props:int/1)
  `Sec` is an integer. (basic_props:int/1)
  `WeekDay` is an integer. (basic_props:int/1)
  `YearDay` is an integer. (basic_props:int/1)

datime_struct/1: REGTYPE

A regular type, defined as follows:

```
datime_struct(datime(Year,Month,Day,Hour,Min,Sec)) :-
        int(Year),
        int(Month),
        int(Day),
        int(Hour),
        int(Min),
        int(Sec).
```

getenvstr/2: PREDICATE

`getenvstr(Name,Value)`

The environment variable `Name` has `Value`. Fails if variable `Name` is not defined.

Usage:

- *Call and exit should be compatible with:*
  `Value` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*
  `Name` is an atom. (basic_props:atm/1)
- *The following properties should hold upon exit:*
  `Value` is a string (a list of character codes). (basic_props:string/1)

setenvstr/2: PREDICATE

`setenvstr(Name,Value)`

The environment variable `Name` is assigned `Value`.

Usage:

- *The following properties should hold at call time:*
  `Name` is an atom. (basic_props:atm/1)
  `Value` is a string (a list of character codes). (basic_props:string/1)

current_env/2: PREDICATE

`current_env(Name,Value)`

If `Name` is an atom, then unifies the environment variable `Name` with its value. Note that this predicate can be used to enumerate all the environment variables using backtracking.

Usage:

- *Call and exit should be compatible with:*
  `Name` is an atom. (basic_props:atm/1)
  `Value` is an atom. (basic_props:atm/1)
- *The following properties should hold upon exit:*
  `Name` is an atom. (basic_props:atm/1)
  `Value` is an atom. (basic_props:atm/1)

set_env/2: PREDICATE

`set_env(Name,Value)`

The environment variable `Name` is assigned `Value`.

Usage:

– *The following properties should hold at call time:*

`Name` is an atom. (basic_props:atm/1)

`Value` is an atom. (basic_props:atm/1)

del_env/1: PREDICATE

`del_env(Name)`

The environment variable `Name` is removed.

Usage:

– *The following properties should hold at call time:*

`Name` is an atom. (basic_props:atm/1)

c_errno/1: PREDICATE

Usage:

– *Calls should, and exit will be compatible with:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold upon exit:*

`Arg1` is an integer. (basic_props:int/1)

copy_file/2: PREDICATE

`copy_file(Source,Destination)`

Copies the file `Source` to `Destination`.

Usage:

– *The following properties should hold at call time:*

`Source` is an atom. (basic_props:atm/1)

`Destination` is an atom. (basic_props:atm/1)

copy_file/3: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an atom. (basic_props:atm/1)

`Arg2` is an atom. (basic_props:atm/1)

system:copy_options(Arg3) (system:copy_options/1)

dir_path/2: PREDICATE

No further documentation available for this predicate.

extract_paths/2: PREDICATE

`extract_paths(String,Paths)`

Interpret `String` as the value of a UNIX environment variable holding a list of paths and return in `Paths` the list of the paths. Paths in `String` are separated by colons, and an empty path is considered a shorthand for '.' (current path). The most typical environment variable with this format is PATH. For example, this is a typical use:

```
?- set_prolog_flag(write_strings, on).

yes
?- getenvstr('PATH', PATH), extract_paths(PATH, Paths).

PATH = ":/home/bardo/bin:/home/clip/bin:/opt/bin/:/bin",
Paths = [".","/home/bardo/bin","/home/clip/bin","/opt/bin/","/bin"] ?

yes
?-
```

Usage:

- *Call and exit should be compatible with:*
  `Paths` is a list of `string`s. (basic_props:list/2)
- *The following properties should hold at call time:*
  `String` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold upon exit:*
  `Paths` is a list of `string`s. (basic_props:list/2)

file_dir_name/3: PREDICATE

`file_dir_name(File,Dir,Name)`

Discomposes a given File in its directory and name

Usage:

- *Calls should, and exit will be compatible with:*
  `File` is an atom. (basic_props:atm/1)
  `Dir` is an atom. (basic_props:atm/1)
  `Name` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `File` is an atom. (basic_props:atm/1)
  `Dir` is an atom. (basic_props:atm/1)
  `Name` is an atom. (basic_props:atm/1)

get_pid/1: PREDICATE

`get_pid(Pid)`

Unifies `Pid` with the process identificator of the current process or thread.

Usage:

- *Calls should, and exit will be compatible with:*
  `Pid` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Pid` is an integer. (basic_props:int/1)

get_uid/1: PREDICATE

`get_uid(Uid)`

Unifies `Uid` with the user id of the current process.

Usage:

- *Calls should, and exit will be compatible with:*
  `Uid` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Uid` is an integer. (basic_props:int/1)

get_gid/1: PREDICATE

`get_gid(Uid)`

Unifies `Gid` with the group id of the current process.

Usage:

- *Calls should, and exit will be compatible with:*
  `Uid` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `Uid` is an integer. (basic_props:int/1)

get_pwnam/1: PREDICATE

`get_pwnam(User)`

Unifies `User` with the user of the current process, as specified in the /etc/passwd file.

Usage:

- *Calls should, and exit will be compatible with:*
  `User` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `User` is an atom. (basic_props:atm/1)

get_grnam/1: PREDICATE

`get_grnam(Group)`

Unifies `Group` with the group of the current process, as specified in the /etc/group file.

Usage:

- *Calls should, and exit will be compatible with:*
  `Group` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `Group` is an atom. (basic_props:atm/1)

get_tmp_dir/1: PREDICATE

Usage: `get_tmp_dir(TmpDir)`

- *Description:* Gets the directory name used to store temporary files. In Unix is /tmp, in Windows is determined by the *TMP* environment variable.

- *The following properties should hold at call time:*
  `TmpDir` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `TmpDir` is an atom. (basic_props:atm/1)

get_address/2: PREDICATE

No further documentation available for this predicate.

current_host/1: PREDICATE

`current_host(Hostname)`

`Hostname` is unified with the fully qualified name of the host.

Usage:

- *Calls should, and exit will be compatible with:*
  `Hostname` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `Hostname` is an atom. (basic_props:atm/1)

current_executable/1: PREDICATE

`current_executable(Path)`

Unifies `Path` with the path to the current executable.

Usage:

- *Calls should, and exit will be compatible with:*
  `Path` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `Path` is an atom. (basic_props:atm/1)

umask/2: PREDICATE

Usage 1: `umask(OldMask,NewMask)`

- *Description:* The process file creation mask was `OldMask`, and it is changed to `NewMask`.
- *The following properties should hold at call time:*
  `NewMask` is an integer. (basic_props:int/1)
- *The following properties hold upon exit:*
  `OldMask` is an integer. (basic_props:int/1)

Usage 2: `umask(OldMask,NewMask)`

- *Description:* Gets the process file creation mask without changing it.
- *The following properties should hold at call time:*
  `OldMask` is a free variable. (term_typing:var/1)
  `NewMask` is a free variable. (term_typing:var/1)
  The terms `OldMask` and `NewMask` are strictly identical. (term_compare:== /2)
- *The following properties hold upon exit:*
  `OldMask` is an integer. (basic_props:int/1)
  `NewMask` is an integer. (basic_props:int/1)

make_directory/2: PREDICATE

`make_directory(DirName,Mode)`

Creates the directory `DirName` with a given `Mode`. This is, as usual, operated against the current umask value.

Usage:

– *The following properties should hold at call time:*

`DirName` is an atom. (basic_props:atm/1)

`Mode` is an integer. (basic_props:int/1)

make_directory/1: PREDICATE

`make_directory(DirName)`

Equivalent to `make_directory(D,0o777)`.

Usage:

– *The following properties should hold at call time:*

`DirName` is an atom. (basic_props:atm/1)

make_dirpath/2: PREDICATE

`make_dirpath(Path,Mode)`

Creates the whole `Path` for a given directory with a given `Mode`. As an example, `make_dirpath('/tmp/var/mydir/otherdir')`.

Usage:

– *The following properties should hold at call time:*

`Path` is a source name. (streams_basic:sourcename/1)

`Mode` is an integer. (basic_props:int/1)

make_dirpath/1: PREDICATE

`make_dirpath(Path)`

Equivalent to `make_dirpath(D,0o777)`.

Usage:

– *The following properties should hold at call time:*

`Path` is an atom. (basic_props:atm/1)

working_directory/2: PREDICATE

`working_directory(OldDir,NewDir)`

Unifies current working directory with `OldDir`, and then changes the working directory to `NewDir`. Calling `working_directory(Dir,Dir)` simply unifies `Dir` with the current working directory without changing anything else.

Usage 1:

– *Description:* Changes current working directory.

– *Calls should, and exit will be compatible with:*

`OldDir` is an atom. (basic_props:atm/1)

– *The following properties should hold at call time:*
`NewDir` is an atom. (basic_props:atm/1)
– *The following properties hold upon exit:*
`OldDir` is an atom. (basic_props:atm/1)

Usage 2: `working_directory(OldDir,NewDir)`
– *Description:* Gets current working directory.
– *The following properties should hold at call time:*
`OldDir` is a free variable. (term_typing:var/1)
`NewDir` is a free variable. (term_typing:var/1)
The terms `OldDir` and `NewDir` are strictly identical. (term_compare:== /2)
– *The following properties hold upon exit:*
`OldDir` is an atom. (basic_props:atm/1)
`NewDir` is an atom. (basic_props:atm/1)

cd/1: PREDICATE

`cd(Path)`

Changes working directory to `Path`.

Usage:
– *The following properties should hold at call time:*
`Path` is an atom. (basic_props:atm/1)

shell/0: PREDICATE

Usage:
– *Description:* Execs the shell specified by the environment variable `SHELL`. When the shell process terminates, control is returned to Prolog.

shell/1: PREDICATE

`shell(Command)`

`Command` is executed in the shell specified by the environment variable `SHELL`. It succeeds if the exit code is zero and fails otherwise.

Usage:
– *The following properties should hold at call time:*
`Command` is an atom. (basic_props:atm/1)

shell/2: PREDICATE

`shell(Command,ReturnCode)`

Executes `Command` in the shell specified by the environment variable `SHELL` and stores the exit code in `ReturnCode`.

Usage:
– *Calls should, and exit will be compatible with:*
`ReturnCode` is an integer. (basic_props:int/1)

– *The following properties should hold at call time:*
  `Command` is an atom. (basic_props:atm/1)
– *The following properties hold upon exit:*
  `ReturnCode` is an integer. (basic_props:int/1)

system/1: PREDICATE

`system(Command)`

Executes `Command` using the shell `/bin/sh`.

Usage:

– *The following properties should hold at call time:*
  `Command` is an atom. (basic_props:atm/1)

system/2: PREDICATE

`system(Command,ReturnStatus)`

Executes `Command` in the `/bin/sh` shell and stores the return status in `ReturnStatus`. Note that the exit code is masked as the low order 8 bits of the return status:

`ReturnCode` is (`ReturnStatus` /\ 0xFF00) >> 8.

Usage:

– *Calls should, and exit will be compatible with:*
  `ReturnStatus` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
  `Command` is an atom. (basic_props:atm/1)
– *The following properties hold upon exit:*
  `ReturnStatus` is an integer. (basic_props:int/1)

popen/3: PREDICATE

`popen(Command,Mode,Stream)`

Open a pipe to process `Command` in a new shell with a given `Mode` and return a communication `Stream` (as in UNIX `popen(3)`). If `Mode` is `read` the output from the process is sent to `Stream`. If `Mode` is `write`, `Stream` is sent as input to the process. `Stream` may be read from or written into using the ordinary stream I/O predicates. `Stream` must be closed explicitly using `close/1`, i.e., it is not closed automatically when the process dies. Note that `popen/2` is defined in ***x as using `/bin/sh`, which usually does not exist in Windows systems. In this case, a `sh` shell which comes with Windows is used.

Usage:

– *The following properties should hold at call time:*
  `Command` is an atom. (basic_props:atm/1)
  `Mode` is 'read' or 'write'. (system:popen_mode/1)
  `Stream` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)

popen_mode/1: REGTYPE

Usage: `popen_mode(M)`

– *Description:* `M` is 'read' or 'write'.

exec/4: PREDICATE

`exec(Command,StdIn,StdOut,StdErr)`

Starts the process `Command` and returns the standart I/O streams of the process in `StdIn`, `StdOut`, and `StdErr`. If `Command` contains blank spaces, these are taken as separators between a program name (the first chunk of contiguous non-blank characters) and options for the program (the subsequent contiguous pieces of non-blank characters), as in `exec('ls -lRa ../sibling_dir', In, Out, Err)`.

Usage:

– *The following properties should hold at call time:*

`Command` is an atom. (basic_props:atm/1)

`StdIn` is a free variable. (term_typing:var/1)

`StdOut` is a free variable. (term_typing:var/1)

`StdErr` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`StdIn` is an open stream. (streams_basic:stream/1)

`StdOut` is an open stream. (streams_basic:stream/1)

`StdErr` is an open stream. (streams_basic:stream/1)

exec/3: PREDICATE

`exec(Command,StdIn,StdOut)`

Starts the process `Command` and returns the standart I/O streams of the process in `StdIn` and `StdOut`. `Standard error` is connected to whichever the parent process had it connected to. `Command` is treated and split in components as in `exec/4`.

Usage:

– *The following properties should hold at call time:*

`Command` is an atom. (basic_props:atm/1)

`StdIn` is a free variable. (term_typing:var/1)

`StdOut` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`StdIn` is an open stream. (streams_basic:stream/1)

`StdOut` is an open stream. (streams_basic:stream/1)

exec/8: PREDICATE

Usage: `exec(Command,Arguments,StdIn,StdOut,StdErr,Background,PID,ErrCode)`

– *Description:* `exec/8` gives a finer control on execution of process. `Command` is the command to be executed and `Arguments` is a list of atoms to be passed as arguments to the command. When called with free variables, `StdIn`, `StdOut`, and `StdErr` are instantiated to streams connected to the standard output, input, and error of the created process. `Background` controls whether the caller waits for `Command` to finish,

or if the process executing `Command` is completely detached (it can be waited for using `wait/3`). `ErrCode` is the error code returned by the lower-level `exec()` system call (this return code is system-dependent, but a non-zero value usually means that something has gone wrong). If `Command` does not start by a slash, `exec/8` uses the environment variable `PATH` to search for it. If `PATH` is not set, `/bin` and `/usr/bin` are searched.

– *The following properties should hold at call time:*

`Command` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Arguments` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Background` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`PID` is a free variable.	(term_typing:var/1)
`ErrCode` is a free variable.	(term_typing:var/1)
`Command` is an atom.	(basic_props:atm/1)
`Arguments` is a list of `atms`.	(basic_props:list/2)
`Background` is an atom.	(basic_props:atm/1)

– *The following properties should hold upon exit:*

`StdIn` is an open stream.	(streams_basic:stream/1)
`StdOut` is an open stream.	(streams_basic:stream/1)
`StdErr` is an open stream.	(streams_basic:stream/1)
`PID` is an integer.	(basic_props:int/1)
`ErrCode` is an integer.	(basic_props:int/1)

wait/3: PREDICATE

Usage: `wait(Pid,RetCode,Status)`

– *Description:* wait/3 waits for the process numbered `Pid`. If `PID` equals -1, it will wait for any children process. `RetCode` is usually the PID of the waited-for process, and -1 in case in case of error. `Status` is related to the exit value of the process in a system-dependent fashion.

– *The following properties should hold at call time:*

`Pid` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`RetCode` is a free variable.	(term_typing:var/1)
`Status` is a free variable.	(term_typing:var/1)
`Pid` is an integer.	(basic_props:int/1)
`RetCode` is a free variable.	(term_typing:var/1)
`Status` is a free variable.	(term_typing:var/1)

– *The following properties hold upon exit:*

`RetCode` is an integer.	(basic_props:int/1)
`Status` is an integer.	(basic_props:int/1)

directory_files/2: PREDICATE

`directory_files(Directory,FileList)`

`FileList` is the unordered list of entries (files, directories, etc.) in `Directory`.

Usage:

– *Calls should, and exit will be compatible with:*
`FileList` is a list of `atms`. (basic_props:list/2)
– *The following properties should hold at call time:*
`Directory` is an atom. (basic_props:atm/1)
– *The following properties hold upon exit:*
`FileList` is a list of `atms`. (basic_props:list/2)

mktemp/2: PREDICATE

`mktemp(Template,Filename)`

Returns a unique `Filename` based on `Template`: `Template` must be a valid file name with six trailing X, which are substituted to create a new file name. `Filename` is created in read/write mode but closed immediately after creation.

Usage:

– *Calls should, and exit will be compatible with:*
`Filename` is an atom. (basic_props:atm/1)
– *The following properties should hold at call time:*
`Template` is an atom. (basic_props:atm/1)
– *The following properties hold upon exit:*
`Filename` is an atom. (basic_props:atm/1)

mktemp_in_tmp/2: PREDICATE

No further documentation available for this predicate.

file_exists/1: PREDICATE

`file_exists(File)`

Succeeds if `File` (a file or directory) exists (and is accessible).

Usage:

– *The following properties should hold at call time:*
`File` is an atom. (basic_props:atm/1)

file_exists/2: PREDICATE

`file_exists(File,Mode)`

`File` (a file or directory) exists and it is accessible with `Mode`, as in the Unix call `access(2)`. Typically, `Mode` is 4 for read permission, 2 for write permission and 1 for execute permission.

Usage:

– *The following properties should hold at call time:*
`File` is an atom. (basic_props:atm/1)
`Mode` is an integer. (basic_props:int/1)
– *The following properties hold upon exit:*
`File` is an atom. (basic_props:atm/1)
`Mode` is an integer. (basic_props:int/1)

file_property/2: PREDICATE

`file_property(File,Property)`

`File` has the property `Property`. The possible properties are:

type(`Type`)
: `Type` is one of `regular`, `directory`, `symlink`, `fifo`, `socket` or `unknown`.

linkto(`Linkto`)
: If `File` is a symbolic link, `Linkto` is the file pointed to by the link (and the other properties come from that file, not from the link itself).

mod_time(`ModTime`)
: `ModTime` is the time of last modification (seconds since January, 1, 1970).

mode(`Protection`)
: `Protection` is the protection mode.

size(`Size`) `Size` is the size.

If `Property` is uninstantiated, the predicate will enumerate the properties on backtracking.

Usage:

– *Call and exit should be compatible with:*
  `Property` is a compound term. (basic_props:struct/1)
– *The following properties should hold at call time:*
  `File` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
  `Property` is a compound term. (basic_props:struct/1)

file_properties/6: PREDICATE

`file_properties(Path,Type,Linkto,Time,Protection,Size)`

The file `Path` has the following properties:

- File type `Type` (one of `regular`, `directory`, `symlink`, `fifo`, `socket` or `unknown`).
- If `Path` is a symbolic link, `Linkto` is the file pointed to. All other properties come from the file pointed, not the link. `Linkto` is ” if `Path` is not a symbolic link.
- Time of last modification `Time` (seconds since January, 1, 1970).
- Protection mode `Protection`.
- Size in bytes `Size`.

Usage:

– *Calls should, and exit will be compatible with:*
  `Type` is an atom. (basic_props:atm/1)
  `Linkto` is an atom. (basic_props:atm/1)
  `Time` is an integer. (basic_props:int/1)
  `Protection` is an integer. (basic_props:int/1)
  `Size` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
  `Path` is an atom. (basic_props:atm/1)

– *The following properties hold upon exit:*
`Type` is an atom. (basic_props:atm/1)
`Linkto` is an atom. (basic_props:atm/1)
`Time` is an integer. (basic_props:int/1)
`Protection` is an integer. (basic_props:int/1)
`Size` is an integer. (basic_props:int/1)

modif_time/2: PREDICATE

`modif_time(File,Time)`

The file `File` was last modified at `Time`, which is in seconds since January, 1, 1970. Fails if `File` does not exist.

Usage:

– *Call and exit should be compatible with:*
`Time` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`File` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
`Time` is an integer. (basic_props:int/1)

modif_time0/2: PREDICATE

`modif_time0(File,Time)`

If `File` exists, `Time` is its latest modification time, as in `modif_time/2`. Otherwise, if `File` does not exist, `Time` is zero.

Usage:

– *Call and exit should be compatible with:*
`Time` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`File` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
`Time` is an integer. (basic_props:int/1)

fmode/2: PREDICATE

`fmode(File,Mode)`

The file `File` has protection mode `Mode`.

Usage:

– *Call and exit should be compatible with:*
`Mode` is an integer. (basic_props:int/1)
– *The following properties should hold at call time:*
`File` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
`Mode` is an integer. (basic_props:int/1)

chmod/2: PREDICATE

`chmod(File,NewMode)`

Change the protection mode of file `File` to `NewMode`.

Usage:

– *The following properties should hold at call time:*

`File` is an atom. (basic_props:atm/1)

`NewMode` is an integer. (basic_props:int/1)

chmod/3: PREDICATE

`chmod(File,OldMode,NewMode)`

The file `File` has protection mode `OldMode` and it is changed to `NewMode`.

Usage 1:

– *Call and exit should be compatible with:*

`OldMode` is an integer. (basic_props:int/1)

– *The following properties should hold at call time:*

`File` is an atom. (basic_props:atm/1)

`NewMode` is an integer. (basic_props:int/1)

– *The following properties should hold upon exit:*

`OldMode` is an integer. (basic_props:int/1)

Usage 2: `chmod(File,OldMode,NewMode)`

– *Description:* If `OldMode` is identical to `NewMode` then it is equivalent to fmode(`File`,`OldMode`)

– *The following properties should hold at call time:*

`File` is an atom. (basic_props:atm/1)

`OldMode` is a free variable. (term_typing:var/1)

`NewMode` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`File` is an atom. (basic_props:atm/1)

`OldMode` is an atom. (basic_props:atm/1)

`NewMode` is an atom. (basic_props:atm/1)

set_exec_mode/2: PREDICATE

`set_exec_mode(SourceName,ExecName)`

Copies the permissions of `SourceName` to `ExecName` adding permissions to execute.

Usage:

– *The following properties should hold at call time:*

`SourceName` is an atom. (basic_props:atm/1)

`ExecName` is an atom. (basic_props:atm/1)

delete_file/1: PREDICATE

`delete_file(File)`

Delete the file `File`.

Usage:

– *The following properties should hold at call time:*

`File` is an atom. (basic_props:atm/1)

delete_directory/1: PREDICATE

`delete_directory(File)`

Delete the directory `Directory`.

Usage:

– *The following properties should hold at call time:*

`File` is an atom. (basic_props:atm/1)

rename_file/2: PREDICATE

`rename_file(File1,File2)`

Change the name of `File1` to `File2`.

Usage:

– *The following properties should hold at call time:*

`File1` is an atom. (basic_props:atm/1)

`File2` is an atom. (basic_props:atm/1)

using_windows/0: PREDICATE

Usage:

– *Description:* Success if the operating system is using windows instead of a posix operating system (which includes cygwin under windows). To do this, we look at the CIAOSCRIPT environment variable, so if it is defined we suppose we are inside a posix operating system (and not windows).

winpath/2: PREDICATE

Usage 1: `winpath(A,B)`

– *The following properties should hold at call time:*

`A` is an atom. (basic_props:atm/1)

`B` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`A` is an atom. (basic_props:atm/1)

`B` is an atom. (basic_props:atm/1)

Usage 2: `winpath(A,B)`

– *The following properties should hold at call time:*

`A` is a free variable. (term_typing:var/1)

`B` is an atom. (basic_props:atm/1)

– *The following properties should hold upon exit:*
  `A` is an atom. (basic_props:atm/1)
  `B` is an atom. (basic_props:atm/1)

Usage 3: `winpath(A,B)`
– *The following properties should hold at call time:*
  `A` is an atom. (basic_props:atm/1)
  `B` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
  `A` is an atom. (basic_props:atm/1)
  `B` is an atom. (basic_props:atm/1)

winpath/3: PREDICATE

`winpath(Option,Posix,WinPath)`

`Option` specifies if you want to get a relative or a full path. `Posix` represent a path as usual in unix, and `WinPath` is the Windows-Style representation of `Posix`.

Usage 1:
– *The following properties should hold at call time:*
  `Option` is a free variable. (term_typing:var/1)
  `Posix` is a free variable. (term_typing:var/1)
  `WinPath` is an atom. (basic_props:atm/1)
– *The following properties should hold upon exit:*
  system:winpath_option(Option) (system:winpath_option/1)
  `Posix` is an atom. (basic_props:atm/1)

Usage 2:
– *The following properties should hold at call time:*
  `Option` is a free variable. (term_typing:var/1)
  `Posix` is an atom. (basic_props:atm/1)
  `WinPath` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
  system:winpath_option(Option) (system:winpath_option/1)
  `WinPath` is an atom. (basic_props:atm/1)

winpath_c/3: PREDICATE

Same as winpath/3, but for strings.

cyg2win/3: PREDICATE

Usage: `cyg2win(CygWinPath,WindowsPath,SwapSlash)`
– *Description:* Converts a posix path to a Windows-style path. If `SwapSlash` is `swap`, slashes are converted in to backslash. If it is `noswap`, they are preserved.

– *The following properties should hold at call time:*
`CygWinPath` is a string (a list of character codes). (basic_props:string/1)
`WindowsPath` is a free variable. (term_typing:var/1)
`SwapSlash` is currently instantiated to an atom. (term_typing:atom/1)
– *The following properties should hold upon exit:*
`CygWinPath` is a string (a list of character codes). (basic_props:string/1)
`WindowsPath` is a string (a list of character codes). (basic_props:string/1)
`SwapSlash` is currently instantiated to an atom. (term_typing:atom/1)

no_swapslash/3: PREDICATE

No further documentation available for this predicate.

replace_characters/4: PREDICATE

`replace_characters(String,SearchChar,ReplaceChar,Output)`

Replaces all the occurrences of `SearchChar` by `ReplaceChar` and unifies the result with `Output`

system_error_report/1: PREDICATE

Usage: `system_error_report(Report)`

– *Description:* Report is the error message from the last system call, like `strerror` in POSIX.
– *The following properties should hold at call time:*
`Report` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Report` is an atom. (basic_props:atm/1)

48.3 Documentation on multifiles (`system`)

define_flag/3: PREDICATE

The predicate is *multifile*.

Usage: `define_flag(Flag,FlagValues,Default)`

– *The following properties hold upon exit:*
`Flag` is an atom. (basic_props:atm/1)
Define the valid flag values (basic_props:flag_values/1)

48.4 Known bugs and planned improvements (`system`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.
- In some situations, copy_file don't work when the second argument is a directory, example: copy_file('site/ciaopp_online.html' , ~distdir, yes),
- `shell/n` commands have a bug in Windows: if the environment variable SHELL is instantiated to some Windows shell implementation, then it is very possible that shell/`{1,2}` will not work, as it is always called with the -c flag to start the user command. For example, COMMAND.COM **might** need the flag /C – but there is no way to know a priori which command line option is necessary for every shell! It does not seems usual that Windows sets the SHELL environment variable: if it is not set, we set it up at startup time to point to the `sh.exe` provided with Ciao, which is able to start Windows aplications. Therefore, `?- shell('command.com').` just works.
- If `exec/4` does not find the command to be executed, there is no visible error message: it is sent to a error output which has already been assigned to a different stream, disconnected from the one the user sees.

49 Prolog system internal predicates

Author(s): Manuel Carro, Daniel Cabeza, Mats Carlsson.

This module implements some miscellaneous predicates which provide access to some internal statistics, special properties of the predicates, etc.

49.1 Usage and interface (prolog_sys)

- **Library usage:**
  `:- use_module(library(prolog_sys)).`
- **Exports:**
  - *Predicates:*
    `statistics/0`, `statistics/2`, `predicate_property/2`, `current_atom/1`, `garbage_collect/0`, `new_atom/1`.
  - *Regular Types:*
    `clockfreq_result/1`, `tick_result/1`, `symbol_result/1`, `gc_result/1`, `memory_result/1`, `time_result/1`, `symbol_option/1`, `garbage_collection_option/1`, `memory_option/1`, `clockfreq_option/1`, `tick_option/1`, `time_option/1`.

49.2 Documentation on exports (prolog_sys)

statistics/0: PREDICATE

Usage:

- *Description:* Prints statistics about the system.

statistics/2: PREDICATE

Usage 1: `statistics(Tick_option,Tick_result)`

- *Description:* Gather information about clock ticks (either run, user, system or wall tick) since last consult or since start of program. A tick is the smallest amount of time that a clock can measure.
- *The following properties should hold at call time:*
  Options to get information about execution ticks. (prolog_sys:tick_option/1)
  `Tick_result` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*
  Options to get information about execution ticks. (prolog_sys:tick_option/1)
  `Tick_result` is a two-element list of numbers. The first number is the number of ticks since the start of the execution; the second number is the number of ticks since the previous consult to tick. (prolog_sys:tick_result/1)

Usage 2: `statistics(Clockfreq_option,Clockfreq_result)`

- *Description:* Gather information about frequency of the clocks used to measure the ticks (either run-user, system or wall clock). Results are returned in hertz. This value also can be defined as the amount of ticks that a clock can measure in one second.

– *The following properties should hold at call time:*

Options to get information about the frequency of clocks used to get the ticks. (prolog_sys:clockfreq_option/1)

`Clockfreq_result` is any term. (basic_props:term/1)

– *The following properties should hold upon exit:*

Options to get information about the frequency of clocks used to get the ticks. (prolog_sys:clockfreq_option/1)

`Clockfreq_result` is a number. It gives the frequency in hertz used by the clock get the ticks. (prolog_sys:clockfreq_result/1)

Usage 3: `statistics(Time_option,Time_result)`

– *Description:* Gather information about time (either process time or wall time) since last consult or since start of program. Results are returned in milliseconds. Note that internally, time is calculated as:

```
Time_result = (Tick_result / Clockfreq_result) * 1000
```

– *The following properties should hold at call time:*

Options to get information about execution time. `Time_option` must be one of `runtime`, `usertime`, `systemtime` or `walltime`. (prolog_sys:time_option/1)

`Time_result` is any term. (basic_props:term/1)

– *The following properties should hold upon exit:*

Options to get information about execution time. `Time_option` must be one of `runtime`, `usertime`, `systemtime` or `walltime`. (prolog_sys:time_option/1)

`Time_result` is a two-element list of numbers. The first number is the time since the start of the execution; the second number is the time since the previous consult to time. (prolog_sys:time_result/1)

Usage 4: `statistics(Memory_option,Memory_result)`

– *Description:* Gather information about memory consumption.

– *The following properties should hold at call time:*

Options to get information about memory usage. (prolog_sys:memory_option/1)

`Memory_result` is any term. (basic_props:term/1)

– *The following properties should hold upon exit:*

Options to get information about memory usage. (prolog_sys:memory_option/1)

Result is a two-element list of integers. The first element is the space taken up by the option selected, measured in bytes; the second integer is zero for program space (which grows as necessary), and the amount of free space otherwise. (prolog_sys:memory_result/1)

Usage 5: `statistics(Garbage_collection_option,Gc_result)`

– *Description:* Gather information about garbage collection.

– *The following properties should hold at call time:*

Options to get information about garbage collection. (prolog_sys:garbage_collection_option/1)

`Gc_result` is any term. (basic_props:term/1)

– *The following properties should hold upon exit:*

Options to get information about garbage collection. (prolog_sys:garbage_collection_option/1)

`Gc_result` is a tree-element list of integers, related to garbage collection and memory management. When `stack_shifts` is selected, the first one is the number of shifts

(reallocations) of the local stack; the second is the number of shifts of the trail, and the third is the time spent in these shifts. When `garbage_collection` is selected, the numbers are, respectively, the number of garbage collections performed, the number of bytes freed, and the time spent in garbage collection. (prolog_sys:gc_result/1)

Usage 6: `statistics(Symbol_option,Symbol_result)`

- *Description:* Gather information about number of symbols and predicates.
- *The following properties should hold at call time:*

  Option to get information about the number of symbols in the program. (prolog_sys:symbol_option/1)

  `Symbol_result` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*

  Option to get information about the number of symbols in the program. (prolog_sys:symbol_option/1)

  `Symbol_result` is a two-element list of integers. The first one is the number of atom, functor, and predicate names in the symbol table. The second is the number of predicates known to be defined (although maybe without clauses). (prolog_sys:symbol_result/1)

Usage 7: `statistics(Option,Arg2)`

- *Description:* If `Option` is unbound, it is bound to the values on the other cases.
- *Call and exit should be compatible with:*

  `Arg2` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*

  `Arg2` is any term. (basic_props:term/1)

predicate_property/2: PREDICATE

General properties: `predicate_property(Head,Prop)`

- *Description:* Predicate property of true is compiled
- *If the following properties should hold at call time:*

  term_basic:Head=basiccontrol:true (term_basic:= /2)

  then the following properties should hold upon exit:

  term_basic:Prop=compiled (term_basic:= /2)

Usage: `predicate_property(Head,Property)`

- *Description:* The predicate with clause `Head` is `Property`.
- *The following properties should hold upon exit:*

  `Head` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Property` is an atom. (basic_props:atm/1)

current_atom/1: PREDICATE

Usage: `current_atom(Atom)`

- *Description:* Enumerates on backtracking all the existing atoms in the system.
- *The following properties hold upon exit:*

  `Atom` is an atom. (basic_props:atm/1)

garbage_collect/0: PREDICATE

Usage:

- *Description:* Forces garbage collection when called.

clockfreq_result/1: REGTYPE

Usage: `clockfreq_result(Result)`

- *Description:* `Result` is a number. It gives the frequency in hertz used by the clock get the ticks.

tick_result/1: REGTYPE

Usage: `tick_result(Result)`

- *Description:* `Result` is a two-element list of numbers. The first number is the number of ticks since the start of the execution; the second number is the number of ticks since the previous consult to tick.

new_atom/1: PREDICATE

Usage: `new_atom(Atom)`

- *Description:* Returns, on success, a new atom, not existing before in the system. The entry argument must be a variable. The idea behind this atom generation is to provide a fast source of identifiers for new objects, concurrent predicates, etc. on the fly.
- *The following properties should hold at call time:*

  `Atom` is a free variable. (term_typing:var/1)
- *The following properties hold upon exit:*

  `Atom` is an atom. (basic_props:atm/1)

symbol_result/1: REGTYPE

Usage: `symbol_result(Result)`

- *Description:* `Result` is a two-element list of integers. The first one is the number of atom, functor, and predicate names in the symbol table. The second is the number of predicates known to be defined (although maybe without clauses).

gc_result/1: REGTYPE

Usage: `gc_result(Result)`

- *Description:* `Result` is a tree-element list of integers, related to garbage collection and memory management. When `stack_shifts` is selected, the first one is the number of shifts (reallocations) of the local stack; the second is the number of shifts of the trail, and the third is the time spent in these shifts. When `garbage_collection` is selected, the numbers are, respectively, the number of garbage collections performed, the number of bytes freed, and the time spent in garbage collection.

memory_result/1: REGTYPE

Usage: `memory_result(Result)`

– *Description:* Result is a two-element list of integers. The first element is the space taken up by the option selected, measured in bytes; the second integer is zero for program space (which grows as necessary), and the amount of free space otherwise.

time_result/1: REGTYPE

Usage: `time_result(Result)`

– *Description:* `Result` is a two-element list of numbers. The first number is the time since the start of the execution; the second number is the time since the previous consult to time.

symbol_option/1: REGTYPE

Usage: `symbol_option(M)`

– *Description:* Option to get information about the number of symbols in the program.

garbage_collection_option/1: REGTYPE

Usage: `garbage_collection_option(M)`

– *Description:* Options to get information about garbage collection.

memory_option/1: REGTYPE

Usage: `memory_option(M)`

– *Description:* Options to get information about memory usage.

clockfreq_option/1: REGTYPE

Usage: `clockfreq_option(M)`

– *Description:* Options to get information about the frequency of clocks used to get the ticks.

tick_option/1: REGTYPE

Usage: `tick_option(M)`

– *Description:* Options to get information about execution ticks.

time_option/1: REGTYPE

Usage: `time_option(M)`

– *Description:* Options to get information about execution time. `M` must be one of `runtime`, `usertime`, `systemtime` or `walltime`.

49.3 Known bugs and planned improvements (`prolog_sys`)

- The space used by the process is not measured here: process data, code, and stack also take up memory. The memory reported for atoms is not what is actually used, but the space used up by the hash table (which is enlarged as needed).

50 DEC-10 Prolog file IO

This module implements the support for DEC-10 Prolog style file I/O.

50.1 Usage and interface (dec10_io)

- **Library usage:**
  `:- use_module(library(dec10_io)).`
- **Exports:**
  - *Predicates:*
    `see/1`, `seeing/1`, `seen/0`, `tell/1`, `telling/1`, `told/0`, `close_file/1`.

50.2 Documentation on exports (dec10_io)

see/1: PREDICATE

Usage: `see(File)`

- *The following properties should hold at call time:*
  `File` is currently instantiated to an atom. (term_typing:atom/1)

seeing/1: PREDICATE

Usage: `seeing(File)`

- *The following properties should hold upon exit:*
  `File` is currently instantiated to an atom. (term_typing:atom/1)

seen/0: PREDICATE

No further documentation available for this predicate.

tell/1: PREDICATE

Usage: `tell(File)`

- *The following properties should hold at call time:*
  `File` is currently instantiated to an atom. (term_typing:atom/1)

telling/1: PREDICATE

Usage: `telling(File)`

- *The following properties should hold upon exit:*
  `File` is currently instantiated to an atom. (term_typing:atom/1)

told/0: PREDICATE

No further documentation available for this predicate.

close_file/1: PREDICATE

No further documentation available for this predicate.

51 Quintus-like internal database

Author(s): The CLIP Group.

The predicates described in this section were introduced in early implementations of Prolog to provide efficient means of performing operations on large quantities of data. The introduction of indexed dynamic predicates have rendered these predicates obsolete, and the sole purpose of providing them is to support existing code. There is no reason whatsoever to use them in new code.

These predicates store arbitrary terms in the database without interfering with the clauses which make up the program. The terms which are stored in this way can subsequently be retrieved via the key on which they were stored. Many terms may be stored on the same key, and they can be individually accessed by pattern matching. Alternatively, access can be achieved via a special identifier which uniquely identifies each recorded term and which is returned when the term is stored.

51.1 Usage and interface (`old_database`)

- **Library usage:**
  `:- use_module(library(old_database)).`
- **Exports:**
  - *Predicates:*
    `recorda/3`, `recordz/3`, `recorded/3`, `current_key/2`.

51.2 Documentation on exports (`old_database`)

recorda/3: PREDICATE

`recorda(Key,Term,Ref)`

The term `Term` is recorded in the internal database as the first item for the key `Key`, where `Ref` is its implementation-defined identifier. The key must be given, and only its principal functor is significant. Any uninstantiated variables in the `Term` will be replaced by new private variables, along with copies of any subgoals blocked on these variables.

Usage: `recorda(Key,Term,Ref)`

- *The following properties should hold at call time:*
  `Key` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Ref` is a free variable. (term_typing:var/1)
- *The following properties should hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

recordz/3: PREDICATE

`recordz(Key,Term,Ref)`

Like `recorda/3`, except that the new term becomes the *last* item for the key `Key`.

Usage: `recordz(Key,Term,Ref)`

– *The following properties should hold at call time:*
`Key` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Ref` is a free variable. (term_typing:var/1)
– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

recorded/3: PREDICATE

`recorded(Key,Term,Ref)`

The internal database is searched for terms recorded under the key `Key`. These terms are successively unified with `Term` in the order they occur in the database. At the same time, `Ref` is unified with the implementation-defined identifier uniquely identifying the recorded item. If the key is instantiated to a compound term, only its principal functor is significant. If the key is uninstantiated, all terms in the database are successively unified with `Term` in the order they occur.

Usage: `recorded(Key,Term,Ref)`

– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

current_key/2: PREDICATE

`current_key(KeyName,KeyTerm)`

`KeyTerm` is the most general form of the key for a currently recorded term, and `KeyName` is the name of that key. This predicate can be used to enumerate in undefined order all keys for currently recorded terms through backtracking.

Usage: `current_key(Name,Key)`

– *The following properties should hold globally:*
This predicate is understood natively by CiaoPP. (basic_props:native/1)

52 ttyout (library)

52.1 Usage and interface (ttyout)

- **Library usage:**
  `:- use_module(library(ttyout)).`
- **Exports:**
  - *Predicates:*
    `ttyget/1`, `ttyget1/1`, `ttynl/0`, `ttyput/1`, `ttyskip/1`, `ttytab/1`, `ttyflush/0`, `ttydisplay/1`, `ttydisplayq/1`, `ttyskipeol/0`, `ttydisplay_string/1`.

52.2 Documentation on exports (ttyout)

ttyget/1: PREDICATE

Usage: `ttyget(X)`

- *The following properties should hold upon exit:*
  `X` is an integer. (basic_props:int/1)
- *The following properties should hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

ttyget1/1: PREDICATE

No further documentation available for this predicate.

ttynl/0: PREDICATE

- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

ttyput/1: PREDICATE

Usage: `ttyput(X)`

- *The following properties should hold at call time:*
  `X` is an integer. (basic_props:int/1)
- *The following properties should hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

ttyskip/1: PREDICATE

No further documentation available for this predicate.

ttytab/1: PREDICATE

No further documentation available for this predicate.

ttyflush/0: PREDICATE

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

ttydisplay/1: PREDICATE

No further documentation available for this predicate.

ttydisplayq/1: PREDICATE

No further documentation available for this predicate.

ttyskipeol/0: PREDICATE

No further documentation available for this predicate.

ttydisplay_string/1: PREDICATE

No further documentation available for this predicate.

53 Enabling operators at run-time

Author(s): Daniel Cabeza.

This library package allows the use of the statically defined operators of a module for the reading performed at run-time by the program that uses the module. Simply by using this package the operator definitions appearing in the module are enabled during the execution of the program.

53.1 Usage and interface (`runtime_ops_doc`)

- **Library usage:**
  `:- use_package(runtime_ops).`
  or
  `:- module(...,...,[runtime_ops]).`
- **Other modules used:**
  - *System library modules:*
    `operators`.

PART V - Assertions, Properties, Types, Modes, Comments (assertions)

Author(s): The CLIP Group.

Ciao allows *annotating* the program code with *assertions*. Such assertions include type and instantiation mode declarations, but also more general properties as well as comments in the style of the *literate programming*. These assertions document predicates (and modules and whole applications) and can be used by the Ciao preprocessor/compiler while debugging and optimizing the program or library, and by the Ciao documenter to build the program or library reference manual.

54 The Ciao assertion package

Author(s): Manuel Hermenegildo, Francisco Bueno, German Puebla.

The `assertions` package adds a number of new declaration definitions and new operator definitions which allow including program assertions in user programs. Such assertions can be used to describe predicates, properties, modules, applications, etc. These descriptions can contain formal specifications (such as sets of preconditions, post-conditions, or descriptions of computations) as well as machine-readable textual comments.

This module is part of the `assertions` library. It defines the basic code-related assertions, i.e., those intended to be used mainly by compilation-related tools, such as the static analyzer or the run-time test generator.

Giving specifications for predicates and other program elements is the main functionality documented here. The exact syntax of comments is described in the autodocumenter (`lpdoc` [Knu84,Her99]) manual, although some support for adding machine-readable comments in assertions is also mentioned here.

There are two kinds of assertions: predicate assertions and program point assertions. All predicate assertions are currently placed as directives in the source code, i.e., preceded by "`:-`". Program point assertions are placed as goals in clause bodies.

54.1 More info

The facilities provided by the library are documented in the description of its component modules. This documentation is intended to provide information only at a "reference manual" level. For a more tutorial introduction to the subject and some more examples please see [PBH00]. The assertion language implemented in this library is modeled after this design document, although, due to implementation issues, it may differ in some details. The purpose of this manual is to document precisely what the implementation of the library supports at any given point in time.

54.2 Some attention points

- **Formatting commands within text strings:** many of the predicates defined in these modules include arguments intended for providing textual information. This includes titles, descriptions, comments, etc. The type of this argument is a character string. In order for the automatic generation of documentation to work correctly, this character string should adhere to certain conventions. See the description of the `docstring/1` type/grammar for details.
- **Referring to variables:** In order for the automatic documentation system to work correctly, variable names (for example, when referring to arguments in the head patterns of *pred* declarations) must be surrounded by an `@var` command. For example, `@var{VariableName}` should be used for referring to the variable "VariableName", which will appear then formatted as follows: `VariableName`. See the description of the `docstring/1` type/grammar for details.

54.3 Usage and interface (assertions_doc)

- **Library usage:**
  The recommended procedure in order to make use of assertions in user programs is to include the `assertions` syntax library, using one of the following declarations, as appropriate:
  ```
  :- module(...,...,[assertions]).
  :- use_package([assertions]).
  ```
- **Exports:**
  - *Predicates:*
    `check/1`, `trust/1`, `true/1`, `false/1`.
- **New operators defined:**
  `=>/2` [975,xfx], `::/2` [978,xfx], `decl/1` [1150,fx], `decl/2` [1150,xfx], `pred/1` [1150,fx], `pred/2` [1150,xfx], `prop/1` [1150,fx], `prop/2` [1150,xfx], `modedef/1` [1150,fx], `calls/1` [1150,fx], `calls/2` [1150,xfx], `success/1` [1150,fx], `success/2` [1150,xfx], `test/1` [1150,fx], `test/2` [1150,xfx], `texec/1` [1150,fx], `texec/2` [1150,xfx], `comp/1` [1150,fx], `comp/2` [1150,xfx], `entry/1` [1150,fx], `exit/1` [1150,fx], `exit/2` [1150,xfx].
- **New declarations defined:**
  `pred/1`, `pred/2`, `texec/1`, `texec/2`, `calls/1`, `calls/2`, `success/1`, `success/2`, `test/1`, `test/2`, `comp/1`, `comp/2`, `prop/1`, `prop/2`, `entry/1`, `exit/1`, `exit/2`, `modedef/1`, `decl/1`, `decl/2`, `doc/2`, `comment/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/assertions_props`.

54.4 Documentation on new declarations (assertions_doc)

pred/1: DECLARATION

This assertion provides information on a predicate. The body of the assertion (its only argument) contains properties or comments in the formats defined by `assrt_body/1`.

More than one of these assertions may appear per predicate, in which case each one represents a possible " mode" of use (usage) of the predicate. The exact scope of the usage is defined by the properties given for calls in the body of each assertion (which should thus distinguish the different usages intended). All of them together cover all possible modes of usage.

For example, the following assertions describe (all the and the only) modes of usage of predicate `length/2` (see `lists`):

```
:- pred length(L,N) : list * var => list * integer
# "Computes the length of L.".
:- pred length(L,N) : var * integer => list * integer
# "Outputs L of length N.".
:- pred length(L,N) : list * integer => list * integer
# "Checks that L is of length N.".
```

Usage: :- `pred AssertionBody`.

- *The following properties should hold at call time:*
  `AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

pred/2: DECLARATION

This assertion is similar to a `pred/1` assertion but it is explicitely qualified. Non-qualified `pred/1` assertions are assumed the qualifier `check`.

Usage: :- `AssertionStatus pred AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

texec/1: DECLARATION

This assertion is similar to a `calls/1` assertion but it is used to provide input data and execution commands to the unit-test driver.

Usage: :- `texec AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is a call assertion body. (assertions_props:c_assrt_body/1)

texec/2: DECLARATION

This assertion is similar to a `texec/1` assertion but it is explicitely qualified with an assertion status. Non-qualified `texec/1` assertions are assumed to have `check` status.

Usage: :- `AssertionStatus texec AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is a call assertion body. (assertions_props:c_assrt_body/1)

calls/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it only provides information about the calls to a predicate. If one or several calls assertions are given they are understood to describe all possible calls to the predicate.

For example, the following assertion describes all possible calls to predicate `is/2` (see `arithmetic`):

```
:- calls is(term,arithexpression).
```

Usage: :- `calls AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is a call assertion body. (assertions_props:c_assrt_body/1)

calls/2: DECLARATION

This assertion is similar to a `calls/1` assertion but it is explicitely qualified with an assertion status. Non-qualified `calls/1` assertions are assumed to have `check` status.

Usage: :- `AssertionStatus calls AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is a call assertion body. (assertions_props:c_assrt_body/1)

success/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it only provides information about the answers to a predicate. The described answers might be conditioned to a particular way of calling the predicate.

For example, the following assertion specifies the answers of the `length/2` predicate *if* it is called as in the first mode of usage above (note that the previous pred assertion already conveys such information, however it also compelled the predicate calls, while the success assertion does not):

```
:- success length(L,N) : list * var => list * integer.
```

Usage: :- `success AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is a predicate assertion body. (assertions_props:s_assrt_body/1)

success/2: DECLARATION

success assertion This assertion is similar to a `success/1` assertion but it is explicitely qualified with an assertion status. The status of non-qualified `success/1` assertions is assumed to be `check`.

Usage: :- `AssertionStatus success AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is a predicate assertion body. (assertions_props:s_assrt_body/1)

test/1: DECLARATION

This assertion is similar to a success assertion but it specifies a concrete test case to be run in order verify (partially) that the predicate is working as expected. For example, the following test will verify that the length predicate works well for the particular list given:

```
:- test length(L,N) : ( L = [1,2,5,2] ) => ( N = 4 ).
```

Usage: :- `test AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is a predicate assertion body. (assertions_props:s_assrt_body/1)

test/2: DECLARATION

This assertion is similar to a `test/1` assertion but it is explicitely qualified with an assertion status. Non-qualified `test/1` assertions are assumed to have `check` status. In this context, check means that the test should be executed when the developer runs the test battery.

Usage: :- `AssertionStatus test AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is a predicate assertion body. (assertions_props:s_assrt_body/1)

comp/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it only provides information about the global execution properties of a predicate (note that such kind of information is also conveyed by pred assertions). The described properties might be conditioned to a particular way of calling the predicate.

For example, the following assertion specifies that the computation of `append/3` (see `lists`) will not fail *if* it is called as described (but does not compel the predicate to be called that way):

```
:- comp append(Xs,Ys,Zs) : var * var * var + not_fail.
```

Usage: :- `comp AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is a comp assertion body. (assertions_props:g_assrt_body/1)

comp/2: DECLARATION

This assertion is similar to a `comp/1` assertion but it is explicitely qualified. Non-qualified `comp/1` assertions are assumed the qualifier `check`.

Usage: :- `AssertionStatus comp AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is a comp assertion body. (assertions_props:g_assrt_body/1)

prop/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it flags that the predicate being documented is also a " property."

Properties are standard predicates, but which are *guaranteed to terminate for any possible instantiation state of their argument(s)*, do not perform side-effects which may interfere with the program behaviour, and do not further instantiate their arguments or add new constraints.

Provided the above holds, properties can thus be safely used as run-time checks. The program transformation used in `ciaopp` for run-time checking guarantees the third requirement. It also performs some basic checks on properties which in most cases are enough for the second requirement. However, it is the user's responsibility to guarantee termination of the properties defined. (See also Chapter 56 [Declaring regular types], page 355 for some considerations applicable to writing properties.)

The set of properties is thus a strict subset of the set of predicates. Note that properties can be used to describe characteristics of arguments in assertions and they can also be executed (called) as any other predicates.

Usage: :- `prop AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

prop/2: DECLARATION

This assertion is similar to a `prop/1` assertion but it is explicitely qualified. Non-qualified `prop/1` assertions are assumed the qualifier `check`.

Usage: :- `AssertionStatus prop AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

entry/1: DECLARATION

This assertion provides information about the *external* calls to a predicate. It is identical syntactically to a `calls/1` assertion. However, they describe only external calls, i.e., calls to the exported predicates of a module from outside the module, or calls to the predicates in a non-modular file from other files (or the user).

These assertions are *trusted* by the compiler. As a result, if their descriptions are erroneous they can introduce bugs in programs. Thus, `entry/1` assertions should be written with care.

An important use of these assertions is in providing information to the compiler which it may not be able to infer from the program. The main use is in providing information on the ways in which exported predicates of a module will be called from outside the module. This will greatly improve the precision of the analyzer, which otherwise has to assume that the arguments that exported predicates receive are any arbitrary term.

Usage: :- `entry AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is a call assertion body. (assertions_props:c_assrt_body/1)

exit/1: DECLARATION

This type of assertion provides information about the answers that an (exported) predicate provides for *external* calls. It is identical syntactically to a `success/1` assertion. However, it describes only external answers, i.e., answers to the exported predicates of a module from outside the module, or answers to the predicates in a non-modular file from other files (or the user). The described answers may be conditioned to a particular way of calling the predicate. E.g.:

```
:- exit length(L,N) : list * var => list * integer.
```

Usage: :- `exit AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is a predicate assertion body. (assertions_props:s_assrt_body/1)

exit/2: DECLARATION

exit assertion This assertion is similar to an `exit/1` assertion but it is explicitely qualified with an assertion status. Non-qualified `exit/1` assertions are assumed the qualifier `check`.

Usage: :- `AssertionStatus exit AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is a predicate assertion body. (assertions_props:s_assrt_body/1)

modedef/1: DECLARATION

This assertion is used to define modes. A mode defines in a compact way a set of call and success properties. Once defined, modes can be applied to predicate arguments in assertions. The meaning of this application is that the call and success properties defined by the mode hold for the argument to which the mode is applied. Thus, a mode is conceptually a "property macro".

The syntax of mode definitions is similar to that of pred declarations. For example, the following set of assertions:

```
:- modedef +A : nonvar(A) # "A is bound upon predicate entry.".

:- pred p(+A,B) : integer(A) =>  ground(B).
```

is equivalent to:

```
:- pred p(A,B) : (nonvar(A),integer(A)) =>  ground(B)
   # "A is bound upon predicate entry.".
```

Usage: :- `modedef AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

decl/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it is used for declarations instead than for predicates.

Usage: :- `decl AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

decl/2: DECLARATION

This assertion is similar to a `decl/1` assertion but it is explicitely qualified. Non-qualified `decl/1` assertions are assumed the qualifier `check`.

Usage: :- `AssertionStatus decl AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

doc/2: DECLARATION

Usage: :- `doc(Pred,Comment).`

- *Description:* Documentation . This assertion provides a text `Comment` for a given predicate `Pred`.
- *The following properties should hold at call time:*

  `Pred` is a head pattern. (assertions_props:head_pattern/1)

  `Comment` is a text comment with admissible documentation commands. The usual formatting commands that are applicable in comment strings are defined by `stringcommand/1`. See the `lpdoc` manual for documentation on comments. (assertions_props:docstring/1)

comment/2: DECLARATION

Usage: :- `comment(Pred,Comment).`

- *Description:* An alias for `doc/2` (deprecated, for compatibility with older versions).
- *The following properties should hold at call time:*

  `Pred` is a head pattern. (assertions_props:head_pattern/1)

  `Comment` is a text comment with admissible documentation commands. The usual formatting commands that are applicable in comment strings are defined by `stringcommand/1`. See the `lpdoc` manual for documentation on comments. (assertions_props:docstring/1)

54.5 Documentation on exports (`assertions_doc`)

check/1: PREDICATE

Usage: `check(PropertyConjunction)`

- *Description:* This assertion provides information on a clause program point (position in the body of a clause). Calls to a `check/1` assertion can appear in the body of a clause in any place where a literal can normally appear. The property defined by `PropertyConjunction` should hold in all the run-time stores corresponding to that program point. See also Chapter 60 [Run-time checking of assertions], page 377.
- *The following properties should hold at call time:*

  `PropertyConjunction` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument. (assertions_props:property_conjunction/1)

trust/1: PREDICATE

Usage: `trust(PropertyConjunction)`

- *Description:* This assertion also provides information on a clause program point. It is identical syntactically to a `check/1` assertion. However, the properties stated are not taken as something to be checked but are instead *trusted* by the compiler. While the compiler may in some cases detect an inconsistency between a `trust/1` assertion and the program, in all other cases the information given in the assertion will be taken to be true. As a result, if these assertions are erroneous they can introduce bugs in programs. Thus, `trust/1` assertions should be written with care.

An important use of these assertions is in providing information to the compiler which it may not be able to infer from the program (either because the information is not present or because the analyzer being used is not precise enough). In particular, providing information on external predicates which may not be accessible at the time of compiling the module can greatly improve the precision of the analyzer. This can be easily done with trust assertion.

– *The following properties should hold at call time:*

`PropertyConjunction` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument. (assertions_props:property_conjunction/1)

true/1: PREDICATE

Usage: `true(PropertyConjunction)`

– *Description:* This assertion is identical syntactically to a `check/1` assertion. However, the properties stated have been proved to hold by the analyzer. Thus, these assertions often represent the analyzer output.

– *The following properties should hold at call time:*

`PropertyConjunction` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument. (assertions_props:property_conjunction/1)

false/1: PREDICATE

Usage: `false(PropertyConjunction)`

– *Description:* This assertion is identical syntactically to a `check/1` assertion. However, the properties stated have been proved not to hold by the analyzer. Thus, these assertions often represent the analyzer output.

– *The following properties should hold at call time:*

`PropertyConjunction` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument. (assertions_props:property_conjunction/1)

55 Types and properties related to assertions

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This module is part of the `assertions` library. It provides the formal definition of the syntax of several forms of assertions and describes their meaning. It does so by defining types and properties related to the assertions themselves. The text describes, for example, the overall fields which are admissible in the bodies of assertions, where properties can be used inside these bodies, how to combine properties for a given predicate argument (e.g., conjunctions) , etc. and provides some examples.

55.1 Usage and interface (`assertions_props`)

- **Library usage:**
  `:- use_module(library(assertions_props)).`
- **Exports:**
  - *Properties:*
    `head_pattern/1`, `nabody/1`, `docstring/1`.
  - *Regular Types:*
    `assrt_body/1`, `complex_arg_property/1`, `property_conjunction/1`, `property_starterm/1`, `complex_goal_property/1`, `dictionary/1`, `c_assrt_body/1`, `s_assrt_body/1`, `g_assrt_body/1`, `assrt_status/1`, `assrt_type/1`, `predfunctor/1`, `propfunctor/1`.

55.2 Documentation on exports (`assertions_props`)

assrt_body/1: REGTYPE

This predicate defines the different types of syntax admissible in the bodies of `pred/1`, `decl/1`, etc. assertions. Such a body is of the form:

```
Pr [:: DP] [: CP] [=> AP] [+ GP] [# CO]
```

where (fields between [...] are optional):

- `Pr` is a head pattern (`head_pattern/1`) which describes the predicate or property and possibly gives some implicit call/answer information.
- `DP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which expresses properties which are compatible with the predicate, i.e., instantiations made by the predicate are *compatible* with the properties in the sense that applying the property at any point would not make it fail.
- `CP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *calls* to the predicate.
- `AP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *answers* to the predicate (if the predicate succeeds). These only apply if the (possibly empty) properties given for calls in the assertion hold.
- `GP` is a (possibly empty) complex goal property (`complex_goal_property/1`) which applies to the *whole execution* of a call to the predicate. These only apply if the (possibly empty) properties given for calls in the assertion hold.

- `CO` is a comment string (`docstring/1`). This comment only applies if the (possibly empty) properties given for calls in the assertion hold. The usual formatting commands that are applicable in comment strings can be used (see `stringcommand/1`).

  See the `lpdoc` manual for documentation on assertion comments.

Usage: `assrt_body(X)`

– *Description:* `X` is an assertion body.

head_pattern/1: PROPERTY

A head pattern can be a predicate name (functor/arity) (`predname/1`) or a term. Thus, both `p/3` and `p(A,B,C)` are valid head patterns. In the case in which the head pattern is a term, each argument of such a term can be:

- A variable. This is useful in order to be able to refer to the corresponding argument positions by name within properties and in comments. Thus, `p(Input,Parameter,Output)` is a valid head pattern.
- A variable, as above, but preceded by a " mode." This mode determines in a compact way certain call or answer properties. For example, the head pattern `p(Input,+Parameter,Output)` is valid, as long as `+/1` is declared as a mode.

  Acceptable modes are documented in `library(basicmodes)` and `library(isomodes)`. User defined modes are documented in `modedef/1`.
- Any term. In this case this term determines the instantiation state of the corresponding argument position of the predicate calls to which the assertion applies.
- A ground term preceded by a " mode." The ground term determines a property of the corresponding argument. The mode determines if it applies to the calls and/or the successes. The actual property referred to is that given by the term but with one more argument added at the beginning, which is a new variable which, in a rewriting of the head pattern, appears at the argument position occupied by the term. For example, the head pattern `p(Input,+list(int),Output)` is valid for mode `+/1` defined in `library(isomodes)`, and equivalent in this case to having the head pattern `p(Input,A,Output)` and stating that the property `list(A,int)` holds for the calls of the predicate.
- Any term preceded by a " mode." In this case, only one variable is admitted, it has to be the first argument of the mode, and it represents the argument position. I.e., it plays the role of the new variable mentioned above. Thus, no rewriting of the head pattern is performed in this case. For example, the head pattern `p(Input,+(Parameter,list(int)),Output)` is valid for mode `+/2` defined in `library(isomodes)`, and equivalent in this case to having the head pattern `p(Input,Parameter,Output)` and stating that the property `list(Parameter,int)` holds for the calls of the predicate.

Usage: `head_pattern(Pr)`

– *Description:* `Pr` is a head pattern.

complex_arg_property/1: REGTYPE

`complex_arg_property(Props)`

`Props` is a (possibly empty) complex argument property. Such properties can appear in two formats, which are defined by `property_conjunction/1` and `property_starterm/1`

respectively. The two formats can be mixed provided they are not in the same field of an assertion. I.e., the following is a valid assertion:

```
:- pred foo(X,Y) : nonvar * var => (ground(X),ground(Y)).
```

Usage: `complex_arg_property(Props)`

– *Description:* `Props` is a (possibly empty) complex argument property

property_conjunction/1: REGTYPE

This type defines the first, unabridged format in which properties can be expressed in the bodies of assertions. It is essentially a conjunction of properties which refer to variables. The following is an example of a complex property in this format:

- `(integer(X),list(Y,integer))`: `X` has the property `integer/1` and `Y` has the property `list/2`, with second argument `integer`.

Usage: `property_conjunction(Props)`

– *Description:* `Props` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument.

property_starterm/1: REGTYPE

This type defines a second, compact format in which properties can be expressed in the bodies of assertions. A `property_starterm/1` is a term whose main functor is `*/2` and, when it appears in an assertion, the number of terms joined by `*/2` is exactly the arity of the predicate it refers to. A similar series of properties as in `property_conjunction/1` appears, but the arity of each property is one less: the argument position to which they refer (first argument) is left out and determined by the position of the property in the `property_starterm/1`. The idea is that each element of the `*/2` term corresponds to a head argument position. Several properties can be assigned to each argument position by grouping them in curly brackets. The following is an example of a complex property in this format:

- `integer * list(integer)`: the first argument of the procedure (or function, or ...) has the property `integer/1` and the second one has the property `list/2`, with second argument `integer`.
- `{integer,var} * list(integer)`: the first argument of the procedure (or function, or ...) has the properties `integer/1` and `var/1` and the second one has the property `list/2`, with second argument `integer`.

Usage: `property_starterm(Props)`

– *Description:* `Props` is either a term or several terms separated by `*/2`. The main functor of each of those terms corresponds to that of the definition of a property, and the arity should be one less than in the definition of such property. All arguments of each such term are ground.

complex_goal_property/1: REGTYPE

`complex_goal_property(Props)`

`Props` is a (possibly empty) complex goal property. Such properties can be either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. Such properties apply to all executions of all goals of the predicate which comply with the assertion in which the `Props` appear.

The arguments of the terms in `Props` are implicitely augmented with a first argument which corresponds to a goal of the predicate of the assertion in which the `Props` appear. For example, the assertion

```
:- comp var(A) + not_further_inst(A).
```

has property `not_further_inst/1` as goal property, and establishes that in all executions of `var(A)` it should hold that `not_further_inst(var(A),A)`.

Usage: `complex_goal_property(Props)`

– *Description:* `Props` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. A first implicit argument in such terms identifies goals to which the properties apply.

nabody/1: PROPERTY

Usage: `nabody(ABody)`

– *Description:* `ABody` is a normalized assertion body.

dictionary/1: REGTYPE

Usage: `dictionary(D)`

– *Description:* `D` is a dictionary of variable names.

c_assrt_body/1: REGTYPE

This predicate defines the different types of syntax admissible in the bodies of `call/1`, `entry/1`, etc. assertions. The following are admissible:

```
Pr : CP [# CO]
```

where (fields between [...] are optional):

- `CP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *calls* to the predicate.
- `CO` is a comment string (`docstring/1`). This comment only applies if the (possibly empty) properties given for calls in the assertion hold. The usual formatting commands that are applicable in comment strings can be used (see `stringcommand/1`).

The format of the different parts of the assertion body are given by `n_assrt_body/5` and its auxiliary types.

Usage: `c_assrt_body(X)`

– *Description:* `X` is a call assertion body.

s_assrt_body/1: REGTYPE

This predicate defines the different types of syntax admissible in the bodies of `pred/1`, `func/1`, etc. assertions. The following are admissible:

```
Pr : CP => AP # CO
Pr : CP => AP
Pr => AP # CO
Pr => AP
```

where:

- `Pr` is a head pattern (`head_pattern/1`) which describes the predicate or property and possibly gives some implicit call/answer information.
- `CP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *calls* to the predicate.
- `AP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *answers* to the predicate (if the predicate succeeds). These only apply if the (possibly empty) properties given for calls in the assertion hold.
- `CO` is a comment string (`docstring/1`). This comment only applies if the (possibly empty) properties given for calls in the assertion hold. The usual formatting commands that are applicable in comment strings can be used (see `stringcommand/1`).

The format of the different parts of the assertion body are given by `n_assrt_body/5` and its auxiliary types.

Usage: `s_assrt_body(X)`

– *Description:* `X` is a predicate assertion body.

g_assrt_body/1: REGTYPE

This predicate defines the different types of syntax admissible in the bodies of `comp/1` assertions. The following are admissible:

```
Pr : CP + GP # CO
Pr : CP + GP
Pr + GP # CO
Pr + GP
```

where:

- `Pr` is a head pattern (`head_pattern/1`) which describes the predicate or property and possibly gives some implicit call/answer information.
- `CP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *calls* to the predicate.
- `GP` contains (possibly empty) complex goal property (`complex_goal_property/1`) which applies to the *whole execution* of a call to the predicate. These only apply if the (possibly empty) properties given for calls in the assertion hold.
- `CO` is a comment string (`docstring/1`). This comment only applies if the (possibly empty) properties given for calls in the assertion hold. The usual formatting commands that are applicable in comment strings can be used (see `stringcommand/1`).

The format of the different parts of the assertion body are given by `n_assrt_body/5` and its auxiliary types.

Usage: `g_assrt_body(X)`

– *Description:* `X` is a comp assertion body.

assrt_status/1: REGTYPE

The types of assertion status. They have the same meaning as the program-point assertions, and are as follows:

```
assrt_status(true).
assrt_status(false).
assrt_status(check).
assrt_status(checked).
```

```
assrt_status(trust).
```

Usage: `assrt_status(X)`

– *Description:* `X` is an acceptable status for an assertion.

assrt_type/1: REGTYPE

The admissible kinds of assertions:

```
assrt_type(pred).
assrt_type(prop).
assrt_type(decl).
assrt_type(func).
assrt_type(calls).
assrt_type(success).
assrt_type(comp).
assrt_type(entry).
assrt_type(exit).
assrt_type(test).
assrt_type(texec).
assrt_type(modedef).
```

Usage: `assrt_type(X)`

– *Description:* `X` is an admissible kind of assertion.

predfunctor/1: REGTYPE

Usage: `predfunctor(X)`

– *Description:* `X` is a type of assertion which defines a predicate.

propfunctor/1: REGTYPE

Usage: `propfunctor(X)`

– *Description:* `X` is a type of assertion which defines a *property*.

docstring/1: PROPERTY

Usage: `docstring(String)`

– *Description:* `String` is a text comment with admissible documentation commands. The usual formatting commands that are applicable in comment strings are defined by `stringcommand/1`. See the `lpdoc` manual for documentation on comments.

56 Declaring regular types

Author(s): Manuel Hermenegildo, Pedro López, Francisco Bueno.

This library package adds declarations and new operator definitions which provide simple syntactic sugar to write regular type definitions in source code. Regular types are just properties which have the additional characteristic of being regular types (`basic_props:regtype/1`), defined below.

For example, this library package allows writing:

```
:- regtype tree(X) # "X is a tree.".
```

instead of the more cumbersome:

```
:- prop tree(X) + regtype # "X is a tree.".
```

Regular types can be used as properties to describe predicates and play an essential role in program debugging (see the Ciao Prolog preprocessor (`ciaopp`) manual).

In this chapter we explain some general considerations worth taking into account when writing properties in general, not just regular types.

56.1 Defining properties

Given the classes of assertions in the Ciao assertion language, there are two fundamental classes of properties. Properties used in assertions which refer to execution states (i.e., `calls/1`, `success/1`, and the like) are called *properties of execution states*. Properties used in assertions related to computations (i.e., `comp/1`) are called *properties of computations*. Different considerations apply when writing a property of the former or of the later kind.

Consider a definition of the predicate `string_concat/3` which concatenates two character strings (represented as lists of ASCII codes):

```
string_concat([],L,L).
string_concat([X|Xs],L,[X|NL]):- string_concat(Xs,L,NL).
```

Assume that we would like to state in an assertion that each argument "is a list of integers." However, we must decide which one of the following two possibilities we mean exactly: "the argument is *instantiated* to a list of integers" (let us call this property `instantiated_to_intlist/1`), or "if any part of the argument is instantiated, this instantiation must be compatible with the argument being a list of integers" (we will call this property `compatible_with_intlist/1`). For example, `instantiated_to_intlist/1` should be true for the terms `[]` and `[1,2]`, but should not for `X`, `[a,2]`, and `[X,2]`. In turn, `compatible_with_intlist/1` should be true for `[]`, `X`, `[1,2]`, and `[X,2]`, but should not be for `[X|1]`, `[a,2]`, and `1`. We refer to properties such as `instantiated_to_intlist/1` above as *instantiation properties* and to those such as `compatible_with_intlist/1` as *compatibility properties* (corresponding to the traditional notions of "instantiation types" and "compatibility types").

It turns out that both of these notions are quite useful in practice. In the example above, we probably would like to use `compatible_with_intlist/1` to state that on success of `string_concat/3` all three argument must be compatible with lists of integers in an assertion like:

```
:- success string_concat(A,B,C) => ( compatible_with_intlist(A),
                                     compatible_with_intlist(B),
                                     compatible_with_intlist(C) ).
```

With this assertion, no error will be flagged for a call to `string_concat/3` such as `string_concat([20],L,R)`, which on success produces the resulting atom `string_concat([20],L,[20|L])`, but a call `string_concat([],a,R)` would indeed flag an error.

On the other hand, and assuming that we are running on a Prolog system, we would probably like to use `instantiated_to_intlist/1` for `sumlist/2` as follows:

```
:- calls sumlist(L,N) : instantiated_to_intlist(L).

sumlist([],0).
sumlist([X|R],S) :- sumlist(R,PS), S is PS+X.
```

to describe the type of calls for which the program has been designed, i.e., those in which the first argument of `sumlist/2` is indeed a list of integers.

The property `instantiated_to_intlist/1` might be written as in the following (Prolog) definition:

```
:- prop instantiated_to_intlist/1.

instantiated_to_intlist(X) :-
       nonvar(X), instantiated_to_intlist_aux(X).

instantiated_to_intlist_aux([]).
instantiated_to_intlist_aux([X|T]) :-
       integer(X), instantiated_to_intlist(T).
```

(Recall that the Prolog builtin `integer/1` itself implements an instantiation check, failing if called with a variable as the argument.)

The property `compatible_with_intlist/1` might in turn be written as follows (also in Prolog):

```
:- prop compatible_with_intlist/1.

compatible_with_intlist(X) :- var(X).
compatible_with_intlist(X) :-
       nonvar(X), compatible_with_intlist_aux(X).

compatible_with_intlist_aux([]).
compatible_with_intlist_aux([X|T]) :-
       int_compat(X), compatible_with_intlist(T).

int_compat(X) :- var(X).
int_compat(X) :- nonvar(X), integer(X).
```

Note that these predicates meet the criteria for being properties and thus the `prop/1` declaration is correct.

Ensuring that a property meets the criteria for "not affecting the computation" can sometimes make its coding somewhat tedious. In some ways, one would like to be able to write simply:

```
intlist([]).
intlist([X|R]) :- int(X), intlist(R).
```

(Incidentally, note that the above definition, provided that it suits the requirements for being a property and that `int/1` is a regular type, meets the criteria for being a regular type. Thus, it could be declared `:- regtype intlist/1`.)

But note that (independently of the definition of `int/1`) the definition above is not the correct instantiation check, since it would succeed for a call such as `intlist(X)`. In fact, it is not strictly correct as a compatibility property either, because, while it would fail or succeed as expected, it would perform instantiations (e.g., if called with `intlist(X)` it would bind `X` to `[]`). In practice, it is convenient to provide some run-time support to aid in this task.

The run-time support of the Ciao system (see Chapter 60 [Run-time checking of assertions], page 377) ensures that the execution of properties is performed in such a way that properties written as above can be used directly as instantiation checks. Thus, writing:

```
:- calls sumlist(L,N) : intlist(L).
```

has the desired effect. Also, the same properties can often be used as compatibility checks by writing them in the assertions as `compat(Property)` (`basic_props:compat/1`). Thus, writing:

```
:- success string_concat(A,B,C) => ( compat(intlist(A)),
                                     compat(intlist(B)),
                                     compat(intlist(C)) ).
```

also has the desired effect.

As a general rule, the properties that can be used directly for checking for compatibility should be *downwards closed*, i.e., once they hold they will keep on holding in every state accessible in forwards execution. There are certain predicates which are inherently *instantiation* checks and should not be used as *compatibility* properties nor appear in the definition of a property that is to be used with `compat`. Examples of such predicates (for Prolog) are `==`, `ground`, `nonvar`, `integer`, `atom`, `>`, etc. as they require a certain instantiation degree of their arguments in order to succeed.

In contrast with properties of execution states, *properties of computations* refer to the entire execution of the call(s) that the assertion relates to. One such property is, for example, `not_fail/1` (note that although it has been used as in `:- comp append(Xs,Ys,Zs) + not_fail`, it is in fact read as `not_fail(append(Xs,Ys,Zs))`; see `assertions_props:complex_goal_property/1`). For this property, which should be interpreted as "execution of the predicate either succeeds at least once or loops," we can use the following predicate `not_fail/1` for run-time checking:

```
not_fail(Goal):-
      if( call(Goal),
          true,            %% then
          warning(Goal) ). %% else
```

where the `warning/1` (library) predicate simply prints a warning message.

In this simple case, implementation of the predicate is not very difficult using the (non-standard) `if/3` builtin predicate present in many Prolog systems.

However, it is not so easy to code predicates which check other properties of the computation and we may in general need to program a meta-interpreter for this purpose.

56.2 Usage and interface (`regtypes_doc`)

- **Library usage:**
  `:- use_package(regtypes).`
  or
  `:- module(...,...,[regtypes]).`
- **New operators defined:**
  `regtype/1` [1150,fx], `regtype/2` [1150,xfx].
- **New declarations defined:**
  `regtype/1`, `regtype/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/assertions_props`.

56.3 Documentation on new declarations (regtypes_doc)

regtype/1: DECLARATION

This assertion is similar to a prop assertion but it flags that the property being documented is also a " regular type." Regular types are properties whose definitions are *regular programs* (see lelow). This allows for example checking whether it is in the class of types supported by the regular type checking and inference modules.

A regular program is defined by a set of clauses, each of the form:

```
p(x, v_1, ..., v_n)  :- body_1, ..., body_k.
```

where:

1. `x` is a term whose variables (which are called *term variables*) are unique, i.e., it is not allowed to introduce equality constraints between the variables of `x`.

   For example, `p(f(X, Y)) :- ...` is valid, but `p(f(X, X)) :- ...` is not.
2. in all clauses defining `p/n+1` the terms `x` do not unify except maybe for one single clause in which `x` is a variable.
3. `n >= 0` and `p/n` is a *parametric type functor* (whereas the predicate defined by the clauses is `p/n+1`).
4. `v_1`, ..., `v_n` are unique variables, which are called *parametric variables*.
5. Each `body_i` is of the form:
   1. `t(z)` where `z` is one of the *term variables* and `t` is a *regular type expression*;
   2. `q(y, t_1, ..., t_m)` where `m >= 0`, `q/m` is a *parametric type functor*, not in the set of functors `=/2`, `^/2`, `./3`.

      `t_1, ..., t_m` are *regular type expressions*, and `y` is a *term variable*.
6. Each term variable occurs at most once in the clause's body (and should be as the first argument of a literal).

A *regular type expression* is either a parametric variable or a parametric type functor applied to some of the parametric variables.

A parametric type functor is a regular type, defined by a regular program, or a basic type. Basic types are defined in Chapter 15 [Basic data types and properties], page 105.

The set of regular types is thus a well defined subset of the set of properties. Note that types can be used to describe characteristics of arguments in assertions and they can also be executed (called) as any other predicates.

Usage: :- `regtype AssertionBody`.

– *The following properties should hold at call time:*

`AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

regtype/2: DECLARATION

This assertion is similar to a `regtype/1` assertion but it is explicitely qualified. Non-qualified `regtype/1` assertions are assumed the qualifier `check`. Note that checking regular type definitions should be done with the `ciaopp` preprocessor.

Usage: :- `AssertionStatus regtype AssertionBody`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (assertions_props:assrt_status/1)

`AssertionBody` is an assertion body. (assertions_props:assrt_body/1)

57 Properties which are native to analyzers

Author(s): Francisco Bueno, Manuel Hermenegildo, Pedro López, Edison Mera.

This library contains a set of properties which are natively understood by the different program analyzers of `ciaopp`. They are used by `ciaopp` on output and they can also be used as properties in assertions.

57.1 Usage and interface (`native_props`)

- **Library usage:**
  `:- use_module(library(assertions(native_props)))`
  or also as a package `:- use_package(nativeprops)`.
  Note the different names of the library and the package.
- **Exports:**
  - *Properties:*
    `clique/1`,
    `clique_1/1`, `constraint/1`, `covered/1`, `covered/2`, `exception/1`, `exception/2`, `fails/1`, `finite_solutions/1`, `have_choicepoints/1`, `indep/1`, `indep/2`, `is_det/1`, `linear/1`, `mshare/1`, `mut_exclusive/1`, `no_choicepoints/1`, `no_exception/1`, `no_exception/2`, `no_signal/1`, `no_signal/2`, `non_det/1`, `nonground/1`, `not_covered/1`, `not_fails/1`, `not_mut_exclusive/1`, `num_solutions/2`, `solutions/2`, `possibly_fails/1`, `possibly_nondet/1`, `relations/2`, `sideff_hard/1`, `sideff_pure/1`, `sideff_soft/1`, `signal/1`, `signal/2`, `signals/2`, `size/2`, `size/3`, `size_lb/2`, `size_o/2`, `size_ub/2`, `size_metric/3`, `size_metric/4`, `steps/2`, `steps_lb/2`, `steps_o/2`, `steps_ub/2`, `tau/1`, `terminates/1`, `test_type/2`, `throws/2`, `user_output/2`, `intervals/2`.
- **Other modules used:**
  - *System library modules:*
    `terms_check`, `terms_vars`, `sort`, `lists`, `streams`, `file_utils`, `system`.

57.2 Documentation on exports (`native_props`)

clique/1: PROPERTY

`clique(X)`

`X` is a set of variables of interest, much the same as a sharing group but `X` represents all the sharing groups in the powerset of those variables. Similar to a sharing group, a clique is often translated to `ground/1`, `indep/1`, and `indep/2` properties.

Usage: `clique(X)`

- *Description:* The clique pattern is `X`.
- *The following properties should hold globally:*
  This predicate is understood natively by CiaoPP as `clique(X)`. (basic_props:native/2)

clique_1/1: PROPERTY

`clique_1(X)`

`X` is a set of variables of interest, much the same as a sharing group but `X` represents all the sharing groups in the powerset of those variables but disregarding the singletons. Similar to a sharing group, a clique_1 is often translated to `ground/1`, `indep/1`, and `indep/2` properties.

Usage: `clique_1(X)`

- *Description:* The 1-clique pattern is `X`.
- *The following properties should hold globally:*

  This predicate is understood natively by CiaoPP as `clique_1(X)`. (basic_props:native/2)

constraint/1: PROPERTY

`constraint(C)`

`C` contains a list of linear (in)equalities that relate variables and `int` values. For example, `[A < B + 4]` is a constraint while `[A < BC + 4]` or `[A = 3.4, B >= C]` are not.

Usage: `constraint(C)`

- *Description:* `C` is a list of linear equations
- *The following properties hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

covered/1: PROPERTY

`covered(X)`

For any call of the form `X` there is at least one clause whose test succeeds (i.e., all the calls of the form `X` are covered) [DLGH97].

Usage: `covered(X)`

- *Description:* All the calls of the form `X` are covered.

covered/2: PROPERTY

`covered(X,Y)`

All variables occuring in `X` occur also in `Y`.

Usage: `covered(X,Y)`

- *Description:* `X` is covered by `Y`.
- *The following properties hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

exception/1: PROPERTY

Meta-predicate with arguments: `exception(goal)`.

Usage: `exception(Goal)`

- *Description:* Calls of the form `Goal` throw an exception.

exception/2: PROPERTY

Meta-predicate with arguments: `exception(goal,?)`.

Usage: `exception(Goal,E)`

- *Description:* Calls of the form `Goal` throw an exception that unifies with `E`.

fails/1: PROPERTY

`fails(X)`

Calls of the form `X` fail.

Meta-predicate with arguments: `fails(goal)`.

Usage: `fails(X)`

- *Description:* Calls of the form `X` fail.
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

finite_solutions/1: PROPERTY

`finite_solutions(X)`

Calls of the form `X` produce a finite number of solutions [DLGH97].

Meta-predicate with arguments: `finite_solutions(goal)`.

Usage: `finite_solutions(X)`

- *Description:* All the calls of the form `X` have a finite number of solutions.

have_choicepoints/1: PROPERTY

Meta-predicate with arguments: `have_choicepoints(goal)`.

Usage: `have_choicepoints(X)`

- *Description:* A call to `X` creates choicepoints.

indep/1: PROPERTY

Usage: `indep(X)`

- *Description:* The variables in pairs in `X` are pairwise independent.
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP as `indep(X)`. (basic_props:native/2)

indep/2: PROPERTY

Usage: `indep(X,Y)`

- *Description:* `X` and `Y` do not have variables in common.
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP as `indep([[X,Y]])`. (basic_props:native/2)

is_det/1: PROPERTY

`is_det(X)`

All calls of the form `X` are deterministic, i.e., produce at most one solution, or do not terminate. In other words, if `X` succeeds, it can only succeed once. It can still leave choice points after its execution, but when backtracking into these, it can only fail or go into an infinite loop.

Meta-predicate with arguments: `is_det(goal)`.

Usage: `is_det(X)`

- *Description:* All calls of the form `X` are deterministic.

linear/1: PROPERTY

`linear(X)`

`X` is bound to a term which is linear, i.e., if it contains any variables, such variables appear only once in the term. For example, `[1,2,3]` and `f(A,B)` are linear terms, while `f(A,A)` is not.

Usage: `linear(X)`

- *Description:* `X` is instantiated to a linear term.
- *The following properties hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

mshare/1: PROPERTY

`mshare(X)`

`X` contains all *sharing sets* [JL88,MH89] which specify the possible variable occurrences in the terms to which the variables involved in the clause may be bound. Sharing sets are a compact way of representing groundness of variables and dependencies between variables. This representation is however generally difficult to read for humans. For this reason, this information is often translated to `ground/1`, `indep/1` and `indep/2` properties, which are easier to read.

Usage: `mshare(X)`

- *Description:* The sharing pattern is `X`.
- *The following properties should hold globally:*

  This predicate is understood natively by CiaoPP as `sharing(X)`. (basic_props:native/2)

mut_exclusive/1: PROPERTY

`mut_exclusive(X)`

For any call of the form `X` at most one clause succeeds, i.e., clauses are pairwise exclusive.

Meta-predicate with arguments: `mut_exclusive(goal)`.

Usage: `mut_exclusive(X)`

- *Description:* For any call of the form `X` at most one clause succeeds.

no_choicepoints/1: PROPERTY

Meta-predicate with arguments: `no_choicepoints(goal)`.

Usage: `no_choicepoints(X)`

– *Description:* A call to `X` does not create choicepoints.

no_exception/1: PROPERTY

Meta-predicate with arguments: `no_exception(goal)`.

Usage: `no_exception(Goal)`

– *Description:* Calls of the form `Goal` do not throw any exception.

no_exception/2: PROPERTY

Meta-predicate with arguments: `no_exception(goal,?)`.

Usage: `no_exception(Goal,E)`

– *Description:* Calls of the form `Goal` do not throw exception `E`.

no_signal/1: PROPERTY

Meta-predicate with arguments: `no_signal(goal)`.

Usage: `no_signal(Goal)`

– *Description:* Calls of the form `Goal` do not send any signal.

no_signal/2: PROPERTY

Meta-predicate with arguments: `no_signal(goal,?)`.

Usage: `no_signal(Goal,E)`

– *Description:* Calls of the form `Goal` do not send the signal `E`.

non_det/1: PROPERTY

`non_det(X)`

All calls of the form `X` are non-deterministic, i.e., produce several solutions.

Meta-predicate with arguments: `non_det(goal)`.

Usage: `non_det(X)`

– *Description:* All calls of the form `X` are non-deterministic.

nonground/1: PROPERTY

Usage: `nonground(X)`

– *Description:* `X` is not ground.

– *The following properties should hold globally:*

This predicate is understood natively by CiaoPP as `not_ground(X)`. (basic_props:native/2)

not_covered/1: PROPERTY

`not_covered(X)`

There is some call of the form `X` for which there is no clause whose test succeeds [DLGH97].

Usage: `not_covered(X)`

- *Description:* Not all of the calls of the form `X` are covered.

not_fails/1: PROPERTY

`not_fails(X)`

Calls of the form `X` produce at least one solution, or do not terminate [DLGH97].

Meta-predicate with arguments: `not_fails(goal)`.

Usage: `not_fails(X)`

- *Description:* All the calls of the form `X` do not fail.
- *The following properties hold globally:*

  This predicate is understood natively by CiaoPP. (basic_props:native/1)

not_mut_exclusive/1: PROPERTY

`not_mut_exclusive(X)`

For calls of the form `X` more than one clause may succeed. I.e., clauses are not disjoint for some call.

Meta-predicate with arguments: `not_mut_exclusive(goal)`.

Usage: `not_mut_exclusive(X)`

- *Description:* For some calls of the form `X` more than one clause may succeed.

num_solutions/2: PROPERTY

Usage 1: `num_solutions(X,N)`

- *Description:* All the calls of the form `X` have `N` solutions.
- *If the following properties should hold at call time:*

  `X` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `N` is an integer. (basic_props:int/1)

Usage 2: `num_solutions(Goal,Check)`

- *Description:* For a call to `Goal`, `Check(X)` succeeds, where `X` is the number of solutions.
- *If the following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Check` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

solutions/2: PROPERTY

Usage: `solutions(Goal,Sols)`

- *Description:* Goal `Goal` produces the solutions listed in `Sols`.
- *If the following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Sols` is a list. (basic_props:list/1)

possibly_fails/1: PROPERTY

`possibly_fails(X)`

Non-failure is not ensured for any call of the form `X` [DLGH97]. In other words, nothing can be ensured about non-failure nor termination of such calls.

Meta-predicate with arguments: `possibly_fails(goal)`.

Usage: `possibly_fails(X)`

- *Description:* Non-failure is not ensured for calls of the form `X`.

possibly_nondet/1: PROPERTY

`possibly_nondet(X)`

Non-determinism is not ensured for all calls of the form `X`. In other words, nothing can be ensured about determinacy nor termination of such calls.

Usage: `possibly_nondet(X)`

- *Description:* Non-determinism is not ensured for calls of the form `X`.

relations/2: PROPERTY

`relations(X,N)`

The goal `X` produces `N` solutions. In other words, `N` is the cardinality of the solution set of `X`.

Meta-predicate with arguments: `relations(goal,?)`.

Usage: `relations(X,N)`

- *Description:* Goal `X` produces `N` solutions.

sideff_hard/1: PROPERTY

Meta-predicate with arguments: `sideff_hard(goal)`.

Usage: `sideff_hard(X)`

- *Description:* `X` has *hard side-effects*, i.e., those that might affect program execution (e.g., assert/retract).

sideff_pure/1: PROPERTY

Meta-predicate with arguments: `sideff_pure(goal)`.

Usage: `sideff_pure(X)`

- *Description:* `X` is pure, i.e., has no side-effects.

sideff_soft/1: PROPERTY

Meta-predicate with arguments: `sideff_soft(goal)`.

Usage: `sideff_soft(X)`

– *Description:* `X` has *soft side-effects*, i.e., those not affecting program execution (e.g., input/output).

signal/1: PROPERTY

Meta-predicate with arguments: `signal(goal)`.

Usage: `signal(Goal)`

– *Description:* Calls of the form `Goal` throw a signal.

signal/2: PROPERTY

Meta-predicate with arguments: `signal(goal,?)`.

Usage: `signal(Goal,E)`

– *Description:* A call to `Goal` sends a signal that unifies with `E`.

signals/2: PROPERTY

Meta-predicate with arguments: `signals(goal,?)`.

Usage: `signals(Goal,Es)`

– *Description:* Calls of the form `Goal` can generate only the signals that unify with the terms listed in `Es`.

size/2: PROPERTY

Usage: `size(X,Y)`

– *Description:* `Y` is the size of argument `X`, for any approximation.

size/3: PROPERTY

Usage: `size(A,X,Y)`

– *Description:* `Y` is the size of argument `X`, for the approximation `A`.

size_lb/2: PROPERTY

`size_lb(X,Y)`

The minimum size of the terms to which the argument `Y` is bound is given by the expression `Y`. Various measures can be used to determine the size of an argument, e.g., list-length, term-size, term-depth, integer-value, etc. [DL93,LGHD96].

Usage: `size_lb(X,Y)`

– *Description:* `Y` is a lower bound on the size of argument `X`.

size_o/2: PROPERTY

Usage: `size_o(X,Y)`

– *Description:* The size of argument `X` is in the order of `Y`.

size_ub/2: PROPERTY

`size_ub(X,Y)`

The maximum size of the terms to which the argument `Y` is bound is given by the expression `Y`. Various measures can be used to determine the size of an argument, e.g., list-length, term-size, term-depth, integer-value, etc. [DL93,LGHD96].

Usage: `size_ub(X,Y)`

– *Description:* `Y` is a upper bound on the size of argument `X`.

size_metric/3: PROPERTY

Meta-predicate with arguments: `size_metric(goal,?,?)`.

Usage: `size_metric(Head,Var,Metric)`

– *Description:* `Metric` is the metric of the variable `Var`, for any approximation.

size_metric/4: PROPERTY

Meta-predicate with arguments: `size_metric(goal,?,?,?)`.

Usage: `size_metric(Head,Approx,Var,Metric)`

– *Description:* `Metric` is the metric of the variable `Var`, for the approximation `Approx`. Currently, `Metric` can be: `int/1`, `size/1`, `length/1`, `depth/2`, and `void/1`.

steps/2: PROPERTY

`steps(X,Y)`

The time (in resolution steps) spent by any call of the form `X` is given by the expression `Y`

Meta-predicate with arguments: `steps(goal,?)`.

Usage: `steps(X,Y)`

– *Description:* `Y` is the cost (number of resolution steps) of any call of the form `X`.

steps_lb/2: PROPERTY

`steps_lb(X,Y)`

The minimum computation time (in resolution steps) spent by any call of the form `X` is given by the expression `Y` [DLGHL97,LGHD96]

Meta-predicate with arguments: `steps_lb(goal,?)`.

Usage: `steps_lb(X,Y)`

– *Description:* `Y` is a lower bound on the cost of any call of the form `X`.

steps_o/2: PROPERTY

Meta-predicate with arguments: `steps_o(goal,?)`.

Usage: `steps_o(X,Y)`

– *Description:* `Y` is the complexity order of the cost of any call of the form `X`.

steps_ub/2: PROPERTY

`steps_ub(X,Y)`

The maximum computation time (in resolution steps) spent by any call of the form `X` is given by the expression `Y` [DL93,LGHD96].

Meta-predicate with arguments: `steps_ub(goal,?)`.

Usage: `steps_ub(X,Y)`

– *Description:* `Y` is a upper bound on the cost of any call of the form `X`.

tau/1: PROPERTY

`tau(Types)`

`Types` contains a list with the type associations for each variable, in the form `V/[T1,..,TN]`.Note that tau is used in object-oriented programs only

Usage: `tau(TypeInfo)`

– *Description:* `Types` is a list of associations between variables and list of types

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

terminates/1: PROPERTY

`terminates(X)`

Calls of the form `X` always terminate [DLGH97].

Meta-predicate with arguments: `terminates(goal)`.

Usage: `terminates(X)`

– *Description:* All calls of the form `X` terminate.

test_type/2: PROPERTY

Meta-predicate with arguments: `test_type(goal,?)`.

Usage: `test_type(X,T)`

– *Description:* Indicates the type of test that a predicate performs. Required by the nonfailure analyisis.

throws/2: PROPERTY

Meta-predicate with arguments: `throws(goal,?)`.

Usage: `throws(Goal,Es)`

– *Description:* Calls of the form `Goal` can throw only the exceptions that unify with the terms listed in `Es`.

user_output/2: PROPERTY

Meta-predicate with arguments: `user_output(goal,?)`.

Usage: `user_output(Goal,S)`

– *Description:* Calls of the form `Goal` write `S` to standard output.

intervals/2: PROPERTY

Usage: `intervals(X,Y)`

– *Description:* Data size `X` belongs to some interval in the list of intervals `Y`. The list of intervals `Y` represents union of its elements

instance/2: PROPERTY

Usage: `instance(Term1,Term2)`

– *Description:* `Term1` is an instance of `Term2`.

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP. (basic_props:native/1)

57.3 Known bugs and planned improvements (`native_props`)

- A missing property is succeeds (not_fails = succeeds or not_terminates. – EMM
- run-time check for throws/2 unimplemented yet.
- run-time check for signals/2 unimplemented yet.

58 ISO-Prolog modes

Author(s): Daniel Cabeza, Manuel Hermenegildo.

This file defines the " modes" used in the documentation of the ISO-Prolog standard. See also Chapter 59 [Classical Prolog modes], page 373 for an alternative set of modes.

58.1 Usage and interface (`isomodes_doc`)

- **Library usage:**
  `:- use_package([assertions,isomodes]).`
- **New operators defined:**
  `?/1` [200,fy], `@/1` [200,fy].
- **New modes defined:**
  `+/1`, `@/1`, `-/1`, `?/1`, `*/1`, `+/2`, `@/2`, `-/2`, `?/2`, `*/2`.

58.2 Documentation on new modes (`isomodes_doc`)

`+/1`: MODE

Usage: `+A`

– *The following properties are added at call time:*
`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`@/1`: MODE

Usage: `@A`

– *The following properties are added globally:*
`A` is not further instantiated. (basic_props:not_further_inst/2)

`-/1`: MODE

Usage: `-A`

– *The following properties are added at call time:*
`A` is a free variable. (term_typing:var/1)

`?/1`: MODE

Unspecified argument.

`*/1`: MODE

Unspecified argument.

+/2: MODE

Usage: `A+X`

- *The following properties are added at call time:*
  undefined:call(X,A) (undefined property)

@/2: MODE

Usage: `@(A,X)`

- *The following properties are added at call time:*
  undefined:call(X,A) (undefined property)
- *The following properties are added upon exit:*
  undefined:call(X,A) (undefined property)
- *The following properties are added globally:*
  `A` is not further instantiated. (basic_props:not_further_inst/2)

-/2: MODE

Usage: `A-X`

- *The following properties are added at call time:*
  `A` is a free variable. (term_typing:var/1)
- *The following properties are added upon exit:*
  undefined:call(X,A) (undefined property)

?/2: MODE

Usage: `A?X`

- *Call and exit are compatible with:*
  undefined:call(X,A) (undefined property)
- *The following properties are added upon exit:*
  undefined:call(X,A) (undefined property)

***/2:** MODE

Usage: `A*X`

- *Call and exit are compatible with:*
  undefined:call(X,A) (undefined property)

59 Classical Prolog modes

Author(s): Manuel Hermenegildo.

This file defines a number of very simple " modes" which are frequently useful in programs. These correspond to the modes used in classical Prolog texts with some simple addtions. Note that some of these modes use the same symbol as one of the ISO-modes (see Chapter 58 [ISO-Prolog modes], page 371) but with subtly different meaning.

59.1 Usage and interface (basicmodes_doc)

- **Library usage:**
  :- use_package([assertions,basicmodes]).
- **New operators defined:**
  `?/1` [500,fx], `@/1` [500,fx].
- **New modes defined:**
  `+/1`, `-/1`, `?/1`, `@/1`, `in/1`, `out/1`, `go/1`, `+/2`, `-/2`, `?/2`, `@/2`, `in/2`, `out/2`, `go/2`.
- **Other modules used:**
  - *System library modules:*
    `metaprops/meta_props`.

59.2 Documentation on new modes (basicmodes_doc)

+/1: MODE

Input value in argument.

Usage: `+A`

- *The following properties are added at call time:*
  `A` is currently a term which is not a free variable. (term_typing:nonvar/1)

-/1: MODE

No input value in argument.

Usage: `-A`

- *The following properties are added at call time:*
  `A` is a free variable. (term_typing:var/1)

?/1: MODE

Unspecified argument.

@/1: MODE

No output value in argument.

Usage: `@A`

- *The following properties are added globally:*
  `A` is not further instantiated. (basic_props:not_further_inst/2)

in/1: MODE

Input argument.

Usage: `in(A)`

- *The following properties are added at call time:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)
- *The following properties are added upon exit:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)

out/1: MODE

Output argument.

Usage: `out(A)`

- *The following properties are added at call time:*
  `A` is a free variable. (term_typing:var/1)
- *The following properties are added upon exit:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)

go/1: MODE

Ground output (input/output argument).

Usage: `go(A)`

- *The following properties are added upon exit:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)

+/2: MODE

Usage: `A+X`

- *Call and exit are compatible with:*
  `A` has property `X`. (meta_props:call/2)
- *The following properties are added at call time:*
  `A` is currently a term which is not a free variable. (term_typing:nonvar/1)

-/2: MODE

Usage: `A-X`

- *Call and exit are compatible with:*
  `A` has property `X`. (meta_props:call/2)
- *The following properties are added at call time:*
  `A` is a free variable. (term_typing:var/1)

?/2: MODE

Usage: `A?X`

- *Call and exit are compatible with:*
  `A` has property `X`. (meta_props:call/2)

@/2: MODE

Usage: `@(A,X)`

- *Call and exit are compatible with:*
  `A` has property `X`. (meta_props:call/2)
- *The following properties are added globally:*
  `A` is not further instantiated. (basic_props:not_further_inst/2)

in/2: MODE

Usage: `in(A,X)`

- *Call and exit are compatible with:*
  `A` has property `X`. (meta_props:call/2)
- *The following properties are added at call time:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)
- *The following properties are added upon exit:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)

out/2: MODE

Usage: `out(A,X)`

- *Call and exit are compatible with:*
  `A` has property `X`. (meta_props:call/2)
- *The following properties are added at call time:*
  `A` is a free variable. (term_typing:var/1)
- *The following properties are added upon exit:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)

go/2: MODE

Usage: `go(A,X)`

- *Call and exit are compatible with:*
  `A` has property `X`. (meta_props:call/2)
- *The following properties are added upon exit:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)

60 Run-time checking of assertions

Author(s): Edison Mera.

This package provides a complete implementation of run-time checks of predicate assertions. The program is instrumented to check such assertions at run time, and in case a property does not hold, the error is reported. Note that there is also an older package called rtchecks, by David Trallero. The advantage of this one is that it can be used independently of CiaoPP and also has updated functionality.

There are two main applications of run-time checks:

- To improve debugging of certain predicates, specifying some expected behavior that is checked at run-time with the assertions.
- To avoid manual implementation of run-time checks that should be done in some predicates, leaving the code clean and understandable.

The run-time checks can be configured using prolog flags. Below we itemize the valid prolog flags with its values and a brief explanation of the meaning:

- `rtchecks_level`
  - `exports`: Only use rtchecks for external calls of the exported predicates.
  - `inner` : Use also rtchecks for internal calls. Default.
- `rtchecks_trust`
  - `no` : Disable rtchecks for trust assertions.
  - `yes` : Enable rtchecks for trust assertions. Default.
- `rtchecks_entry`
  - `no` : Disable rtchecks for entry assertions.
  - `yes` : Enable rtchecks for entry assertions. Default.
- `rtchecks_exit`
  - `no` : Disable rtchecks for exit assertions.
  - `yes` : Enable rtchecks for exit assertions. Default.
- `rtchecks_test`
  - `no` : Disable rtchecks for test assertions. Default.
  - `yes` : Enable rtchecks for test assertions. Used for debugging purposes, but is better to use the unittest library.
- `rtchecks_inline`
  - `no` : Instrument rtchecks using call to library predicates present in `rtchecks_rt.pl`, `nativeprops.pl` and `basic_props.pl`. In this way, space is saved, but sacrifying performance due to usage of meta calls and external methods in the libraries. Default.
  - `yes` : Expand library predicates inline as far as possible. In this way, the code is faster, because its avoids metacalls and usage of external methods, but the final executable could be bigger.
- `rtchecks_asrloc` Controls the usage of locators for the assertions in the error messages. The locator says the file and lines that contains the assertion that had failed. Valid values are:
  - `no` : Disabled.
  - `yes` : Enabled. Default.
- `rtchecks_predloc` Controls the usage of locators for the predicate that caused the run-time check error. The locator says the first clause of the predicate that the violated assertion refers to.
  - `no` : Disabled.

  - `yes` : Enabled, Default.
- `rtchecks_callloc`
  - `no` : Do not show the stack of predicates that caused the failure
  - `predicate`: Show the stack of predicates that caused the failure. Instrument it in the predicate. Default.
  - `literal` : Show the stack of predicates that caused the failure. Instrument it in the literal. This mode provides more information, because reports also the literal in the body of the predicate.
- `rtchecks_namefmt`
  - `long` : Show the name of predicates, properties and the values of the variables
  - `short` : Only show the name of the predicate in a reduced format. Default.

60.1 Usage and interface (`rtchecks_doc`)

- **Library usage:**

  ```
  :- use_package(rtchecks).
  ```

  or

  ```
  :- module(...,...,[rtchecks]).
  ```

61 Unit Testing Library

Author(s): Edison Mera.

This library provides an extension of the Ciao assertion language which allows writing *unit tests*. The central idea is to use the assertion language to provide specifications of test cases for a given predicate. The package also provides some special properties that are convenient when specifying unit tests and the required run-time libraries.

In general, a *test assertion* is written as follows:

```
:- test predicate(A1, A2, ..., An)
   :  <Precondition>
   => <Postcondition>
   +  <Global properties>
   #  <Comment>.
```

Where the fields of the test assertion have the usual meaning in Ciao assertions, i.e., they contain conjunctions of properties which must hold at certain points in the execution. Here we give a somewhat more operational ("test oriented"), reading to these fields: `predicate/n` is the predicate to be tested. `Precondition` is a goal that is called before the predicate being tested, and can be used to generate values of the input parameters. `Postcondition` is a goal that should succeed after `predicate/n` has been called. The idea appears to be simple, but note that due to the non-determinism of logic programs, the test engine needs to test all the solutions that can be tested up to given limits (for example, a maximum number of solutions, or a given time-out). `Properties` specifies some global properties that the predicate should meet, for example, `not_fails` means that the program does not fail, `exception(error(a,b))` means that the program should throw the exception `error(a,b)`, and so on. But there are some specific properties that only applies to testing specified in the module unittest_props.pl, for example `times(N)` specifies that the given test should be executed N times, `try_sols(N)` specifies that the first N solutions of the predicate `predicate/n` are tested. `Comment` is a string that document the test.

A convenient way to run these tests is by selecting options in the CiaoDbg menu within the development environment:

1. `Run tests in current module`: execute only the tests specified in the current module.
2. `Run tests in all related modules`: execute the tests specified in the module and in all the modules being used by this.
3. `Show untested predicates`: show the *exported* predicates that do not have any test assertion.

61.1 Additional notes

1. The test assertions allow performing *unit* testing, i.e., in Ciao, performing tests *at the predicate level*.
2. The tests currently can only be applied to exported predicates.
3. If you need to write tests for predicates that are spread over several modules, but work together, then it is best to create a separate module, and reexport to the predicates required to build the test. This allows performing *integration testing*, using the same syntax of the unit tests.
4. The Ciao system includes a good (and growing) number of unit tests. To run all the tests among the other standard tests within the CiaoDE run the following (at the top level of the source tree):

   ```
   ./ciaosetup runtests
   ```

61.2 Usage and interface (unittest_doc)

- **Library usage:**
  `:- use_module(library(unittest)).`

PART VI - Ciao library miscellanea

Author(s): The CLIP Group.

This part documents several Ciao libraries which provide different useful additional functionalities. Such functionalities include performing operating system calls, gathering statistics from the Ciao engine, file and file name manipulation, error and exception handling, fast reading and writing of terms (marshalling and unmarshalling), file locking, program reporting messages, pretty-printing programs and assertions, a browser of the system libraries, additional expansion utilities, concurrent aggregates, graph visualization, etc.

62 Analytic benchmarks

Author(s): Manuel Carro (adapted to Ciao Prolog).

This module provides a set of analytic benchmarks which try to isolate and measure the speed of certain very common operations in a Prolog system. The benchmarks come from a variety of sources, mostly within former ECRC (please look at the comments in the source code) and were posted by Jean-Claude Syre on 24th June 1986 to the Prolog Digest. Further packaging was done by Thoma Sjoland and SICS. They were adapted to Ciao Prolog by Manuel Carro, by:

- Changing the syntax to Ciao Prolog, when needed, including extensive use of higher-order programming for the benchmarking loops.
- Adapting the size of the benchmarks and the number of repetitions to fit modern computers and Prolog compilation.
- Changing the format of the output and recording performance data in the incore database.
- Changing benchmarking loops to be failure-driven.
- Adding a void initial dry run to heat up the caches.

The comments corresponding to the **original** programs follow. They have been largely unchanged, except to reflect changes in the program interface necessary to perform the modularization and to adapt them to Ciao Prolog. Of course the number of repeated calls was changed. The original comments are still in the source files.

62.1 Testing Calls

This is the one you always dreamed to test! Like all benchmarks, it uses a loop calling the actual benchmark program. The benchmark program consists of a sequence of 200 predicates having no arguments, no choice points, NOTHING. 200 is chosen to have sufficient accuracy in measuring the execution time.

The results show the effect of pure calls, and the Klips performance can be called the peak performance of the prolog system. Note that the peak performance has very little significance to classify the overall performance of a Prolog system.

62.2 Testing non-deterministic behavior

This program contains a series of 3 different benchmark predicates.

The predicate `choice_point/1` tests calls invoking the creation of a choice point, i.e. a branch point where the execution will possibly come back to in case of backtracking. It does NOT backtrack. Two versions are proposed, one with and the other without arguments.

We then present two predicates to evaluate the mechanism of backtracking during execution. Both predicates create one choice_point and then backtrack 20 times on every loop iteration step. `baktrak1/1` exhibits a kind of backtracking called *deep*, while `baktrak2/1` deals with *shallow* backtracking. Both are worth being tried, whatever your particular Prolog System is.

62.3 Testing environment handling

The creation and deletion of environments are an important feature in prolog machines. The following program attempts to evaluate that. A usual condition to have environments is that the clause is made of several goals. Thus there will be calls in the clause creating environments, and some work to set the parameters of each call. Three arguments per goal were chosen because this number comes close to the average number of arguments of a predicate and to the average number of permanent variables in an environment. The arguments were arranged in different orders for every goal, because we did not want to measure the merits of register transfer

optimisations. Note that these transfers exist, so the results cannot be compared with those given by the program which creates choice points (generally slower).

Another version, `envir0ar/1`, with 0 argument in each call, can also be usefully tried

62.4 Testing indexing mechanisms

We give only one test for indexing, i.e. the selection of a clause due to the type of an argument. This program does not test the merits of indexing on an argument other than the first one. It does not test for multiple indexing either. It does not show the inefficiency which occurs if 2 choice points per clause are created. This may happen e.g. in Warren's indexing scheme.

Each of these tests would require an extra benchmark program. The program given below tests the main point in indexing. Right now we think it is not worth adding all this complexity to the benchmarks, in order to measure all the details in indexing. Therefore we give only this single test.

62.5 Testing unification

We have 6 programs to evaluate the process of unification in the Prolog system:

- Test of list construction via unification.
- Test of list matching unification.
- Test of structure construction via unification This program is equivalent to construct_list, except that it uses the standard structure representation instead of the simplified list notation.
- Test of structure matching via unification. This predicate matches a list of 100 elements in structure notation.
- Test to match a nested structure. This predicate tests the (compiled) unification of a complex structure.
- Test of general unification of 2 complex structures. This predicate tests general unification. We call it general unification, because it cannot be analysed at compile time. Therefore this kind of unification cannot be compiled and, even in a compiled system, it must be handled at run time, exactly as by an interpreter. This is done by a general procedure for unification. The name of the benchmark therefore does not reflect that the unification is general, i.e. including all Prolog types (e.g. it does not contain variables), but it reflects the use of the procedure for general unification as opposed to specific, compiled unification.

Manuel Carro: note that in this case the term "Logical Inference" is a bit contrived, since by design some of these (head) unifications are very more compled, naturally being slower and giving slow KLIPS results.

62.6 Testing dereferencing

Program to benchmark the dereferencing speed. It constructs a list containing 500 variables which are then bound together. Since different systems use different strategies for binding variables on the global stack, the whole is made for two lists and the long variable chain is created only in one of them.

Manuel Carro: different results in this benchmark are not likely to affect larger, general programs. It is a well-known fact that n programs tend not to generate long dereferencing chains. Empirical measurements show that dereference chains of length greater than three are extremely rare. So a suboptimal / optimal behavior in this test is not likely to affect greatly the overall speed of a system.

62.7 Testing the cut

It seems almost impossible to isolate the cut operator in a simple test program. However, the cut-testing program in this benchmark set contains a lot of cut at exec time. It may be regarded as a partial test of cut, and may be worthwhile for some software implementations of Prolog. `cuttest/1` calls the cutit11 predicate, which performs 100 calls to a predicate cutt1 where a cut operator appears in the second clause. Having indexing makes the evaluation of the cut more accurate, so please indicate in our result whether or not your Prolog system uses indexing, to clarify the comparison with others.

62.8 Assorted small programs

Here we deal with prolog programs that do something, while being still small but representative of some well-known Prolog computations. This set should be augmented by other programs, some of them might come from your ideas.

Some of the following programs were taken from the Berkeley paper by Peter Van Roy "A Prolog Compiler for the PLM". Other programs were kindly donated by the following ECRC members: Helmut Simonis, Mehmet Dincbas, Micha Meier and Pascal Van Hentenryck.

The programs have been statically analysed and they represent fairly standard programs as far as the statistical averages are concerned. That is the arity of most clauses is 2 or 3 and there are usually 2 or 3 clauses per predicate. The programs range from fairly trivial programs like fibonacci series to problems such as Hamiltonian graph traversal.

Also, some more programs have been added since the last release and some corrections have been made. Most of the writes were removed in order to reduce i/o activity.

The programs added were symbolic differentiation (from Warren's paper) and a quick sort algorithm using difference lists. The last addition is a bit of a rogue: its a naive reverse, where one can enter the list length. The list gets constructed and then gets reversed.

We are grateful to Saumya Debray from Stony Brook and others for comments, suggestions, feedback and useful inputs.

These benchmarks were run on a VAX 785 with 8 Meg of memory, under 4.2 BSD Unix. The interpreter was C-Prolog version 1.5.

This entire file (without mail/net headers) contains 584 lines.

Name	Call by	# of Inferences (one iteration)	KLips (C-Prolog)
fib	fibonacci(1).	4932	2.0
map	map(200).	68	1.3
mham	mham(1).	493824	1.7
mutest	mutest(1).	1366	2.3
quicksort	qs(10).	601	1.9
queens	qu(10).	684	1.7
query	query(1).	2294	0.9
sym_diff	differen(150).	71	1.5

```
diff_lists| diff(50).         |         608       |   2.1
----------+-------------------+-------------------+-----------
nrev  10  | nrev.             |          66       |   2.0
----------+-------------------+-------------------+-----------
nrev  30  | nrev.             |         496       |   2.5
----------+-------------------+-------------------+-----------
nrev  50  | nrev.             |        1326       |   2.5
----------+-------------------+-------------------+-----------
nrev 100  | nrev.             |        5151       |   2.5
----------+-------------------+-------------------+-----------
nrev 150  | nrev.             |       11476       |   2.5
----------+-------------------+-------------------+-----------
nrev 200  | nrev.             |       20301       |   2.5
----------+-------------------+-------------------+-----------
```

62.9 Usage and interface (ecrc)

- **Library usage:**
  `:- use_module(library(ecrc)).`
- **Exports:**
  - *Predicates:*
    `main/1`, `just_benchmarks/0`, `generate_human_file/0`, `generate_machine_file/0`, `send_info_to_developers/0`, `arithm_average/2`, `geom_average/2`.
  - *Regular Types:*
    `benchmark_usage/1`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `format`, `lists`, `system`, `dec10_io`, `terms`, `hiordlib`, `getopts`, `prolog_sys`, `benchmarks/benchmark_utilities`, `benchmarks/boresea`, `benchmarks/choice`, `benchmarks/envir`, `benchmarks/index`, `benchmarks/unif`, `benchmarks/deref`, `benchmarks/cut`, `benchmarks/small_programs`, `benchmarks/results`.

62.10 Documentation on exports (ecrc)

main/1: PREDICATE

Usage: `main(Flags)`

- *Description:* Main entry point. Execute all benchmarks and report on the performance obtained. This makes it easy to run the set of benchmarks as an executable. Its behavior regarding printing gathered data can be controlled with the list of flags passed as argument. Data is **always** asserted and available to other programs through the `dump_benchmark_data/0` and `access_benchmark_data/8` predicates.
- *The following properties should hold at call time:*
  `Flags` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Flags` is a list of `benchmark_usage`s. (basic_props:list/2)

benchmark_usage/1: REGTYPE

Usage: `benchmark_usage(Flag)`

– *Description:* Options which determine what this module should do with the execution results when called through the `main/1` entry point (i.e., if compiled to an executable). It is defined as

```
benchmark_usage('--estimation').
benchmark_usage('--no-machine').
benchmark_usage('--no-human').
benchmark_usage('--send-info').
benchmark_usage('--base-file-name').
```

with the following meaning:

- `'--no-human'`: do **not** dump human-readable data.
- `'--no-machine'`: do **not** dump data as a series of facts (which is a machine-readable format) which can be saved to a file and later read back in Prolog.
- `'--send-info'`: send a mail to the Ciao developers with the information gathered plus a terse description of the machine (O.S., architecture, CPU type and speed). The existence of a suitable user command to send mail is expected. No message is sent otherwise. No sensible (personal, etc.) information is gathered or sent.
- `--base-file-name` *file-name*: use *file-name* as a base to generate file with the reports this module generates. The machine-oriented file will have the `.pl` extension and the human-oriented file will have the `.txt` extension.

The options aboce can be used when calling `main/1` predicate or as command-line options for an executable built from this file. Note that the default options **print** available data both in human-readable and machine-readable formats.

– *Call and exit should be compatible with:*

`Flag` is an atom. (basic_props:atm/1)

just_benchmarks/0: PREDICATE

Usage:

– *Description:* Run the set of benchmarks in this program and save the speed information gathered. They can be later accessed using the predicates `generate_machine_file/0` or `generate_human_file/0`.

generate_human_file/0: PREDICATE

Usage:

– *Description:* Print to standard output a human-readable report of the information gathered by running `just_benchmarks/0`.

generate_machine_file/0: PREDICATE

Usage:

– *Description:* Print to standard output a machine-readable report of the information gathered by running `just_benchmarks/0`.

send_info_to_developers/0: PREDICATE

Usage:

– *Description:* Send a message to the Ciao developers with a report of the information gathered by running `just_benchmarks/0`.

arithm_average/2: PREDICATE

No further documentation available for this predicate.

geom_average/2: PREDICATE

No further documentation available for this predicate.

62.11 Known bugs and planned improvements (`ecrc`)

- The actual logical inferences each benchmark does has to be checked.

63 Parse and return command-line options

Author(s): Manuel Carro.

63.1 Usage and interface (getopts)

- **Library usage:**
  `:- use_module(library(getopts)).`
- **Exports:**
  - *Predicates:*
    `getopts/4`, `cl_option/2`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

63.2 Documentation on exports (getopts)

getopts/4: PREDICATE

Usage: `getopts(Arguments,Opts,Matched,Rest)`

– *Description:* Ciao Prolog parses the command-line arguments of its executables and passes them as a list of atoms to the `main/1` predicate. Thus, a shell invocation such as

```
./my_program -file input.txt -file input2.txt --output_file out.txt
-create-dir --decode --unsorte
```

makes `main/1` receive an argument such as

```
['-file', 'input.txt', '-file', 'input2.txt', '--output_file',
'out.txt', '-create-dir', '--decode', '--unsorte']
```

`getopts/4` can be used to parse such an command-line option list. passed in the `Arguments` parameter. `Opts` is a list of expected options, each option being an *option spec*, i.e., a term of the form `atom/arity`. For every `atom` a command-line option of the form `'--atom'` or `'-atom'` is expected, with `arity` arguments following it. An `arity` of zero can be omitted. For each matched option spec, the list `Matched` will contain a term of the form `atom(Arg1, Arg2, ..., Argn)`, where `n = arity`. The list `Rest` will contain the unmatched element in `Arguments`.

`Rest` will respect the relative order of the elements in `Arguments`. The matching elements in `Matched` appear in the same order as the options in `Opts`, and for every option in `Opts`, its matches appear in the order as they came in `Arguments`.

Assuming `Arguments` is `['-file', 'input.txt', '-file', 'input2.txt', '--output_file', 'out.txt', '-create-dir', '--decode', '--unsorte']`, some possible uses of `getopts/4` follow.

- Check that a simple option has been selected:

```
?- getopts(Args, ['create-dir'], M, R).
Args = ...
M = ['create-dir'],
R = ['-file','input.txt','-file','input2.txt','--output_file',
     'out.txt','--decode','--unsorte']
```

- Which argument was given to an option expecting an additional value?

```
1 ?- getopts(Args, [output_file/1], M, R).
Args = ...
M = [output_file('out.txt')],
R = ['-file','input.txt','-file','input2.txt','-create-dir',
     '--decode','--unsorte']

1 ?- getopts(Args, [output_file/1], [output_file(F)], R).
Args = ..
F = 'out.txt',
R = ['-file','input.txt','-file','input2.txt','-create-dir',
     '--decode','--unsorte']
```

- Extract options (and associated values) which can appear several times.

```
1 ?- getopts(Args, [file/1], M, R).
Args = ...
M = [file('input.txt'),file('input2.txt')],
R = ['--output_file','out.txt','-create-dir','--decode',
     '--unsorte']
```

- Was decoding selected?

```
1 ?- getopts(Args, [decode], [_], R).
Args = ...
R = ['-file','input.txt','-file','input2.txt','--output_file',
     'out.txt', '-create-dir','--unsorte']
```

- Was encoding selected?

```
1 ?- getopts(Args, [encoding], [_], R).
no
```

- Was decoding **not** selected?

```
1 ?- getopts(Args, [decode], [], R).
no
```

- Are all the options passed to the program legal options? If this is not the case, which option(s) is/are not legal?

```
1 ?- getopts(Args, [file/1, output_file/1, 'create-dir',
                    encode, decode, unsorted], _, R).
Args = ...
R = ['--unsorte'] ?
```

The complexity of `getopts/1` is currently *O(La x Lo)*, where *La* is the length of the argument list and *Lo* is the length of the option list.

– *Call and exit should be compatible with:*

`Arguments` is a list of `atoms`. (basic_props:list/2)

`Opts` is a list of `specs`. (basic_props:list/2)

`Matched` is a list of `terms`. (basic_props:list/2)

`Rest` is a list of `terms`. (basic_props:list/2)

– *The following properties should hold at call time:*

`Arguments` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Opts` is currently a term which is not a free variable. (term_typing:nonvar/1)

cl_option/2: PREDICATE

Usage: `cl_option(Arguments,Option)`

- *Description:* Check that `Option` is an option in `Arguments`.
- *Call and exit should be compatible with:*

  `Arguments` is a list of `atoms`. (basic_props:list/2)

  `Option` is `AtomName/Arity` (getopts:spec/1)
- *The following properties should hold at call time:*

  `Arguments` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Option` is currently a term which is not a free variable. (term_typing:nonvar/1)

63.3 Documentation on internals (getopts)

spec/1: REGTYPE

Usage: `spec(Spec)`

- *Description:* `Spec` is `AtomName/Arity`

64 llists (library)

64.1 Usage and interface (llists)

- **Library usage:**
  `:- use_module(library(llists)).`
- **Exports:**
  - *Predicates:*
    `append/2`, `flatten/2`, `collect_singletons/2`, `transpose/2`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

64.2 Documentation on exports (llists)

append/2: PREDICATE

Usage:

- *Description:* Concatenates a list of lists into a list.
- *Call and exit should be compatible with:*
  `Arg1` is a list of `lists`. (basic_props:list/2)
  `Arg2` is a list. (basic_props:list/1)

flatten/2: PREDICATE

Usage:

- *Description:* Flattens out nested lists into a list.
- *Call and exit should be compatible with:*
  `Arg2` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*
  `Arg1` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*
  `Arg2` is a list. (basic_props:list/1)

collect_singletons/2: PREDICATE

Usage:

- *Description:* Collects in a list the singletons lists appearing in a list of lists.
- *Call and exit should be compatible with:*
  `Arg2` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*
  `Arg1` is a list of `lists`. (basic_props:list/2)
- *The following properties should hold upon exit:*
  `Arg2` is a list. (basic_props:list/1)

transpose/2: PREDICATE

Usage:

- *Description:* Transposes a list of lists, that is, viewing it as a matrix changes rows by columns.
- *Call and exit should be compatible with:*

  `Arg2` is a list of `lists`. (basic_props:list/2)
- *The following properties should hold at call time:*

  `Arg1` is a list of `lists`. (basic_props:list/2)
- *The following properties should hold upon exit:*

  `Arg2` is a list of `lists`. (basic_props:list/2)

65 Structured stream handling

65.1 Usage and interface (streams)

- **Library usage:**
  `:- use_module(library(streams)).`
- **Exports:**
  - *Predicates:*
    `open_null_stream/1`, `open_input/2`, `close_input/1`, `open_output/2`, `close_output/1`.

65.2 Documentation on exports (streams)

open_null_stream/1: PREDICATE

Usage: `open_null_stream(S)`

- *The following properties should hold upon exit:*
  `S` is an open stream. (streams_basic:stream/1)

open_input/2: PREDICATE

Usage: `open_input(FileName,InputStreams)`

- *The following properties should hold at call time:*
  `FileName` is a source name. (streams_basic:sourcename/1)
- *The following properties should hold upon exit:*
  streams:input_handler(InputStreams) (streams:input_handler/1)

close_input/1: PREDICATE

Usage: `close_input(InputStreams)`

- *The following properties should hold at call time:*
  streams:input_handler(InputStreams) (streams:input_handler/1)
- *The following properties should hold upon exit:*
  streams:input_handler(InputStreams) (streams:input_handler/1)

open_output/2: PREDICATE

Usage: `open_output(FileName,OutputStreams)`

- *The following properties should hold at call time:*
  `FileName` is a source name. (streams_basic:sourcename/1)
- *The following properties should hold upon exit:*
  streams:output_handler(OutputStreams) (streams:output_handler/1)

close_output/1: PREDICATE

Usage: `close_output(OutputStreams)`

- *The following properties should hold at call time:*
  streams:output_handler(OutputStreams) (streams:output_handler/1)
- *The following properties should hold upon exit:*
  streams:output_handler(OutputStreams) (streams:output_handler/1)

66 Dictionaries

Author(s): The CLIP Group.

This module provides predicates for implementing dictionaries. Such dictionaries are currently implemented as ordered binary trees of key-value pairs.

66.1 Usage and interface (dict)

- **Library usage:**
  `:- use_module(library(dict)).`
- **Exports:**
  - *Predicates:*
    `dictionary/5`, `dic_node/2`, `dic_lookup/3`, `dic_lookup/4`, `dic_get/3`, `dic_replace/4`.
  - *Regular Types:*
    `dictionary/1`, `old_or_new/1`, `non_empty_dictionary/1`.

66.2 Documentation on exports (dict)

dictionary/1: REGTYPE

Usage: `dictionary(D)`

- *Description:* `D` is a dictionary.

dictionary/5: PREDICATE

Usage: `dictionary(D,K,V,L,R)`

- *Description:* The dictionary node `D` has key `K`, value `V`, left child `L`, and right child `R`.
- *The following properties should hold upon exit:*
  `D` is a non-empty dictionary. (dict:non_empty_dictionary/1)

dic_node/2: PREDICATE

Usage: `dic_node(D,N)`

- *Description:* `N` is a sub-dictionary of `D`.
- *The following properties should hold at call time:*
  `D` is a non-empty dictionary. (dict:non_empty_dictionary/1)
- *The following properties should hold upon exit:*
  `N` is a dictionary. (dict:dictionary/1)

dic_lookup/3: PREDICATE

Usage: `dic_lookup(D,K,V)`

- *Description:* `D` contains value `V` at key `K`. If it was not already in `D` it is added.
- *The following properties should hold upon exit:*
  `D` is a non-empty dictionary. (dict:non_empty_dictionary/1)

dic_lookup/4: PREDICATE

Usage: `dic_lookup(D,K,V,O)`

- *Description:* Same as `dic_lookup(D,K,V)`. `O` indicates if it was already in `D` (`old`) or not (`new`).
- *The following properties should hold upon exit:*

  `D` is a non-empty dictionary. (dict:non_empty_dictionary/1)

  dict:old_or_new(O) (dict:old_or_new/1)

dic_get/3: PREDICATE

Usage: `dic_get(D,K,V)`

- *Description:* `D` contains value `V` at key `K`. Fails if it is not already in `D`.
- *The following properties should hold at call time:*

  `D` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `D` is a dictionary. (dict:dictionary/1)
- *The following properties should hold upon exit:*

  `D` is a non-empty dictionary. (dict:non_empty_dictionary/1)

dic_replace/4: PREDICATE

Usage: `dic_replace(D,K,V,D1)`

- *Description:* `D` and `D1` are identical except for the element at key `K`, which in `D1` contains value `V`, whatever has (or whether it is) in `D`.
- *The following properties should hold at call time:*

  `D` is a dictionary. (dict:dictionary/1)

  `D1` is a dictionary. (dict:dictionary/1)
- *The following properties should hold upon exit:*

  `D` is a dictionary. (dict:dictionary/1)

  `D1` is a dictionary. (dict:dictionary/1)

old_or_new/1: REGTYPE

A regular type, defined as follows:

```
old_or_new(old).
old_or_new(new).
```

non_empty_dictionary/1: REGTYPE

Usage: `non_empty_dictionary(D)`

- *Description:* `D` is a non-empty dictionary.

66.3 Known bugs and planned improvements (`dict`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

67 String processing

Author(s): Daniel Cabeza.

This module provides predicates for doing input/output with strings (character code lists) and for including in grammars defining strings.

67.1 Usage and interface (strings)

- **Library usage:**
  `:- use_module(library(strings)).`
- **Exports:**
  - *Predicates:*
    `get_line/2`, `get_line/1`, `write_string/2`, `write_string/1`, `whitespace/2`, `whitespace0/2`, `string/3`.
  - *Regular Types:*
    `line/1`.

67.2 Documentation on exports (strings)

get_line/2: PREDICATE

`get_line(Stream,Line)`

Reads from `Stream` a line of text and unifies `Line` with it. The end of the line can have UNIX [10] or MS-DOS [13 10] termination, which is not included in `Line`. At EOF, the term end_of_file is returned.

Usage: `get_line(S,L)`

- *The following properties should hold at call time:*
  `S` is an open stream. (streams_basic:stream/1)
- *The following properties should hold upon exit:*
  strings:line(L) (strings:line/1)

get_line/1: PREDICATE

`get_line(Line)`

Behaves like `current_input(S), get_line(S,Line)`.

Usage: `get_line(L)`

- *The following properties should hold upon exit:*
  strings:line(L) (strings:line/1)

line/1: REGTYPE

A regular type, defined as follows:

```
line(L) :-
        string(L).
line(end_of_file).
```

write_string/2: PREDICATE

`write_string(Stream,String)`

Writes `String` onto `Stream`.

Usage: `write_string(Stream,String)`

- *The following properties should hold at call time:*

  `Stream` is an open stream. (streams_basic:stream/1)

  `String` is a string (a list of character codes). (basic_props:string/1)

write_string/1: PREDICATE

`write_string(String)`

Behaves like `current_input(S), write_string(S, String)`.

Usage: `write_string(String)`

- *The following properties should hold at call time:*

  `String` is a string (a list of character codes). (basic_props:string/1)

whitespace/2: PREDICATE

`whitespace(String,Rest)`

In a grammar rule, as `whitespace/0`, represents whitespace (a positive number of space (32), tab (9), newline (10) or return (13) characters). Thus, `Rest` is a proper suffix of `String` with one or more whitespace characters removed. An example of use would be:

```
attrs([]) --> ""
attrs([N|Ns]) -->
    whitespace,
    attr(N),
    attrs(Ns).
```

Usage: `whitespace(S1,S2)`

- *The following properties should hold at call time:*

  `S1` is a string (a list of character codes). (basic_props:string/1)

- *The following properties should hold upon exit:*

  `S2` is a string (a list of character codes). (basic_props:string/1)

whitespace0/2: PREDICATE

`whitespace0(String,Rest)`

In a grammar rule, as `whitespace0/0`, represents possible whitespace (any number of space (32), tab (9), newline (10) or return (13) characters). Thus, `Rest` is `String` or a proper suffix of `String` with one or more whitespace characters removed. An example of use would be:

```
assignment(N,V) -->
    variable_name(N), whitespace0, "=", whitespace0, value(V).
```

Usage: `whitespace0(S1,S2)`

- *The following properties should hold at call time:*

  `S1` is a string (a list of character codes). (basic_props:string/1)

- *The following properties should hold upon exit:*

  `S2` is a string (a list of character codes). (basic_props:string/1)

string/3: PREDICATE

`string(String,Head,Tail)`

In a grammar rule, as `string/1`, represents literally `String`. An example of use would be:

```
double(A) -->
        string(A),
        string(A).
```

Usage 1:

– *Call and exit should be compatible with:*

`String` is a string (a list of character codes). (basic_props:string/1)

`Head` is a string (a list of character codes). (basic_props:string/1)

`Tail` is a string (a list of character codes). (basic_props:string/1)

– *The following properties should hold upon exit:*

`String` is a string (a list of character codes). (basic_props:string/1)

`Head` is a string (a list of character codes). (basic_props:string/1)

`Tail` is a string (a list of character codes). (basic_props:string/1)

Usage 2: `string(A,B,C)`

– *The following properties should hold at call time:*

`C` is a list. (basic_props:list/1)

– *The following properties should hold upon exit:*

`A` is a list. (basic_props:list/1)

`B` is a list. (basic_props:list/1)

68 Printing status and error messages

Author(s): The CLIP Group.

This is a very simple library for printing status and error messages to the console.

68.1 Usage and interface (messages)

- **Library usage:**
  `:- use_module(library(messages)).`
- **Exports:**
  - *Predicates:*
    `error_message/1`, `error_message/2`, `error_message/3`, `warning_message/1`, `warning_message/2`, `warning_message/3`, `note_message/1`, `note_message/2`, `note_message/3`, `simple_message/1`, `simple_message/2`, `optional_message/2`, `optional_message/3`, `debug_message/1`, `debug_message/2`, `debug_goal/2`, `debug_goal/3`, `show_message/2`, `show_message/3`, `show_message/4`.
  - *Regular Types:*
    `message_t/1`.
  - *Multifiles:*
    `issue_debug_messages/1`.
- **Other modules used:**
  - *System library modules:*
    `format`, `lists`, `write`, `filenames`, `compiler/c_itf_internal`.

68.2 Documentation on exports (messages)

error_message/1: PREDICATE

Usage: `error_message(Text)`

- *Description:* Same as `message(error,Text)`.
- *The following properties should hold at call time:*
  `Text` is a string (a list of character codes). (basic_props:string/1)

error_message/2: PREDICATE

Meta-predicate with arguments: `error_message(?,addmodule(?))`.

Usage: `error_message(Text,ArgList)`

- *Description:* Same as `message(error,Text,ArgList)`.
- *The following properties should hold at call time:*
  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)
  `ArgList` is a list. (basic_props:list/1)

error_message/3: PREDICATE

Meta-predicate with arguments: `error_message(?,?,addmodule(?))`.

Usage: `error_message(Lc,Text,ArgList)`

- *Description:* Same as `message(error,Lc,Text,ArgList)`.
- *The following properties should hold at call time:*

  Identifies a source line range in a file.

```
location_t(loc(File,L1,L2)) :-
        atm(File),
        int(L1),
        int(L2).
```

(c_itf_internal:location_t/1)

`Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

`ArgList` is a list. (basic_props:list/1)

warning_message/1: PREDICATE

Usage: `warning_message(Text)`

- *Description:* Same as `message(warning,Text)`.
- *The following properties should hold at call time:*

  `Text` is a string (a list of character codes). (basic_props:string/1)

warning_message/2: PREDICATE

Meta-predicate with arguments: `warning_message(?,addmodule(?))`.

Usage: `warning_message(Text,ArgList)`

- *Description:* Same as `message(warning,Text,ArgList)`.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

  `ArgList` is a list. (basic_props:list/1)

warning_message/3: PREDICATE

Meta-predicate with arguments: `warning_message(?,?,addmodule(?))`.

Usage: `warning_message(Lc,Text,ArgList)`

- *Description:* Same as `message(warning,Lc,Text,ArgList)`.
- *The following properties should hold at call time:*

  Identifies a source line range in a file.

```
location_t(loc(File,L1,L2)) :-
        atm(File),
        int(L1),
        int(L2).
```

(c_itf_internal:location_t/1)

`Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

`ArgList` is a list. (basic_props:list/1)

note_message/1: PREDICATE

Usage: `note_message(Text)`

– *Description:* Same as `message(note,Text)`.

– *The following properties should hold at call time:*

`Text` is a string (a list of character codes). (basic_props:string/1)

note_message/2: PREDICATE

Meta-predicate with arguments: `note_message(?,addmodule(?))`.

Usage: `note_message(Text,ArgList)`

– *Description:* Same as `message(note,Text,ArgList)`.

– *The following properties should hold at call time:*

`Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

`ArgList` is a list. (basic_props:list/1)

note_message/3: PREDICATE

Meta-predicate with arguments: `note_message(?,?,addmodule(?))`.

Usage: `note_message(Lc,Text,ArgList)`

– *Description:* Same as `message(note,Lc,Text,ArgList)`.

– *The following properties should hold at call time:*

Identifies a source line range in a file.

```
location_t(loc(File,L1,L2)) :-
        atm(File),
        int(L1),
        int(L2).
```

(c_itf_internal:location_t/1)

`Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

`ArgList` is a list. (basic_props:list/1)

simple_message/1: PREDICATE

Usage: `simple_message(Text)`

– *Description:* The text provided in `Text` is printed.

– *The following properties should hold at call time:*

`Text` is a string (a list of character codes). (basic_props:string/1)

simple_message/2: PREDICATE

Usage: `simple_message(Text,ArgList)`

– *Description:* The text provided in `Text` is printed as a message, using the arguments in `ArgList`.

– *The following properties should hold at call time:*

`Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

`ArgList` is a list. (basic_props:list/1)

optional_message/2: PREDICATE

Usage: `optional_message(Text,Opts)`

- *Description:* The text provided in `Text` is printed as a message, but only if the atom `-v` is a member of `Opts`. These predicates are meant to be used for optional messages, which are only to be printed when *verbose* output is requested explicitly.
- *The following properties should hold at call time:*

  `Text` is a string (a list of character codes). (basic_props:string/1)

  `Opts` is a list of `atm`s. (basic_props:list/2)

optional_message/3: PREDICATE

Usage: `optional_message(Text,ArgList,Opts)`

- *Description:* The text provided in `Text` is printed as a message, using the arguments in `ArgList`, but only if the atom `-v` is a member of `Opts`. These predicates are meant to be used for optional messages, which are only to be printed when *verbose* output is requested explicitly.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

  `ArgList` is a list. (basic_props:list/1)

  `Opts` is a list of `atm`s. (basic_props:list/2)

debug_message/1: PREDICATE

Usage: `debug_message(Text)`

- *Description:* The text provided in `Text` is printed as a debugging message. These messages are turned `on` by defining a fact of `issue_debug_messages/1` with the module name as argument.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

debug_message/2: PREDICATE

Meta-predicate with arguments: `debug_message(?,addmodule(?))`.

Usage: `debug_message(Text,ArgList)`

- *Description:* The text provided in `Text` is printed as a debugging message, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`. These messages are turned `on` by defining a fact of `issue_debug_messages/1` which the module name as argument.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

  `ArgList` is a list. (basic_props:list/1)

debug_goal/2: PREDICATE

Usage: `debug_goal(Goal,Text)`

– *Description:* `Goal` is called. The text provided in `Text` is then printed as a debugging message. The whole process (including running `Goal`) is turned `on` by defining a fact of `issue_debug_messages/1` with the module name as argument.

debug_goal/3: PREDICATE

Meta-predicate with arguments: `debug_goal(goal,?,addmodule(?))`.

Usage: `debug_goal(Goal,Text,ArgList)`

– *Description:* `Goal` is called. The text provided in `Text` is then printed as a debugging message, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`. Note that the variables in `ArgList` can be computed by `Goal`. The whole process (including running `Goal`) is turned `on` by defining a fact of `issue_debug_messages/1` with the module name as argument.

show_message/2: PREDICATE

Usage: `show_message(Type,Text)`

– *Description:* The text provided in `Text` is printed as a message of type `Type`.

– *The following properties should hold at call time:*

The types of messaes supported by the message predicate (messages:message_t/1)

`Text` is a string (a list of character codes). (basic_props:string/1)

show_message/3: PREDICATE

Meta-predicate with arguments: `show_message(?,?,addmodule(?))`.

Usage: `show_message(Type,Text,ArgList)`

– *Description:* The text provided in `Text` is printed as a message of type `Type`, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`.

– *The following properties should hold at call time:*

The types of messaes supported by the message predicate (messages:message_t/1)

`Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

`ArgList` is a list. (basic_props:list/1)

show_message/4: PREDICATE

Meta-predicate with arguments: `show_message(?,?,?,addmodule(?))`.

Usage: `show_message(Type,Lc,Text,ArgList)`

– *Description:* The text provided in `Text` is printed as a message of type `Type`, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`, and reporting error location `Lc` (file and line numbers).

– *The following properties should hold at call time:*

The types of messaes supported by the message predicate (messages:message_t/1)

Identifies a source line range in a file.

```
location_t(loc(File,L1,L2)) :-
        atm(File),
        int(L1),
        int(L2).
```

(c_itf_internal:location_t/1)

`Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

`ArgList` is a list. (basic_props:list/1)

message_t/1: REGTYPE

Usage:

– *Description:* The types of messaes supported by the message predicate

location_t/1: (UNDOC_REEXPORT)

Imported from `c_itf_internal` (see the corresponding documentation for details).

68.3 Documentation on multifiles (messages)

issue_debug_messages/1: PREDICATE

The predicate is *multifile*.

The predicate is of type *data*.

Usage: `issue_debug_messages(Module)`

– *Description:* Printing of debugging messages is enabled for module `Module`.

– *The following properties hold upon exit:*

`Module` is an atom. (basic_props:atm/1)

68.4 Known bugs and planned improvements (messages)

- Debug message switching should really be done with an expansion, for performance.

69 Accessing and redirecting the stream aliases

Author(s): Manuel Carro.

This library allows the redefinition of the files to which the special streams `user_input`, `user_output`, and `user_error` point to. On startup they point to the standard input, standard output, and standard error, in Unix style (Windows users may find that standard error stream does not work properly). Changing the file pointed to is useful for, e.g., redirecting the place to which the Prolog's standard error stream goes from within Prolog (e.g., to start a log file).

69.1 Usage and interface (`io_alias_redirection`)

- **Library usage:**
  `:- use_module(library(io_alias_redirection)).`
- **Exports:**
  - *Predicates:*
    `set_stream/3`, `get_stream/2`.

69.2 Documentation on exports (`io_alias_redirection`)

set_stream/3: PREDICATE

Usage: `set_stream(StreamAlias,NewStream,OldStream)`

- *Description:* Associate `StreamAlias` with an open stream `newStream`. Returns in `OldStream` the stream previously associated with the alias. The mode of `NewStream` must match the intended use of `StreamAlias`.
- *The following properties should hold at call time:*

  `StreamAlias` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `NewStream` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `StreamAlias` is the alias of an open stream, i.e., an atom which represents a stream at Prolog level. (streams_basic:stream_alias/1)

  `NewStream` is an open stream. (streams_basic:stream/1)

  `OldStream` is an open stream. (streams_basic:stream/1)

get_stream/2: PREDICATE

Usage: `get_stream(StreamAlias,Stream)`

- *Description:* Return in `Stream` the stream associated with `StreamAlias`.
- *The following properties should hold at call time:*

  `StreamAlias` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `StreamAlias` is the alias of an open stream, i.e., an atom which represents a stream at Prolog level. (streams_basic:stream_alias/1)

  `Stream` is an open stream. (streams_basic:stream/1)

70 Atom to term conversion

Author(s): Francisco Bueno, Daniel Cabeza, Manuel Hermenegildo.
This module implements predicates for atom or string to term conversion.

70.1 Usage and interface (atom2term)

- **Library usage:**
  `:- use_module(library(atom2term)).`
- **Exports:**
  - *Predicates:*
    `atom2term/2`, `string2term/2`, `parse_term/3`, `parse_term/4`.

70.2 Documentation on exports (atom2term)

atom2term/2: PREDICATE

General properties: `atom2term(A,T)`

- *If the following properties should hold at call time:*
  term_basic:A=a (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:T=a (term_basic:= /2)

`atom2term(A,T)`

- *If the following properties should hold at call time:*
  term_basic:A=1 (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:T=1 (term_basic:= /2)

`atom2term(A,T)`

- *If the following properties should hold at call time:*
  term_basic:A=A (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:T=A (term_basic:= /2)

`atom2term(A,T)`

- *If the following properties should hold at call time:*
  term_basic:A=f(a) (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:T=f(a) (term_basic:= /2)

`atom2term(A,T)`

- *If the following properties should hold at call time:*
  term_basic:A=f/2 (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:T=f/2 (term_basic:= /2)

Usage: `atom2term(Atom,Term)`

- *Description:* Convert an atom into a term. `Atom` is an atom, but must have term syntax. `Term` is a term resulting from parsing `Atom` char by char. The term is assumed to be ground.
- *The following properties should hold at call time:*

  `Atom` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Term` is a free variable. (term_typing:var/1)

string2term/2: PREDICATE

General properties: `string2term(A,T)`

- *If the following properties should hold at call time:*

  term_basic:A=[97] (term_basic:= /2)

  then the following properties should hold upon exit:

  term_basic:T=a (term_basic:= /2)

`string2term(A,T)`

- *If the following properties should hold at call time:*

  term_basic:A=[49] (term_basic:= /2)

  then the following properties should hold upon exit:

  term_basic:T=1 (term_basic:= /2)

`string2term(A,T)`

- *If the following properties should hold at call time:*

  term_basic:A=[65] (term_basic:= /2)

  then the following properties should hold upon exit:

  term_basic:T=A (term_basic:= /2)

`string2term(A,T)`

- *If the following properties should hold at call time:*

  term_basic:A=[102,40,97,41] (term_basic:= /2)

  then the following properties should hold upon exit:

  term_basic:T=f(a) (term_basic:= /2)

`string2term(A,T)`

- *If the following properties should hold at call time:*

  term_basic:A=[102,47,50] (term_basic:= /2)

  then the following properties should hold upon exit:

  term_basic:T=f/2 (term_basic:= /2)

Usage: `string2term(String,Term)`

- *Description:* Same as `atom2term/2` but first argument is a string (containing a term).
- *The following properties should hold at call time:*

  `String` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Term` is a free variable. (term_typing:var/1)

parse_term/3: PREDICATE

General properties: `parse_term(A,T,R)`

– *If the following properties should hold at call time:*
term_basic:A=[102,40,97,41] (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:T=f(a) (term_basic:= /2)
term_basic:R=[] (term_basic:= /2)

`parse_term(A,T,R)`

– *If the following properties should hold at call time:*
term_basic:A=[102,40,97,41,32,102,111,111,32] (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:T=f(a) (term_basic:= /2)
term_basic:R=[32,102,111,111,32] (term_basic:= /2)

Usage: `parse_term(String,Term,Rest)`

– *Description:* `String` is parsed into `Term` up to `Rest` (which is the non-parsed rest of the list). The term is assumed to be ground.
– *The following properties should hold at call time:*
`String` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Term` is a free variable. (term_typing:var/1)

parse_term/4: PREDICATE

General properties: `parse_term(A,T,R,V)`

– *If the following properties should hold at call time:*
term_basic:A=[102,40,88,41] (term_basic:= /2)
term_basic:V=nonvars (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:T=f(X) (term_basic:= /2)
term_basic:R=[] (term_basic:= /2)

`parse_term(A,T,R,V)`

– *If the following properties should hold at call time:*
term_basic:A=[102,40,88,41] (term_basic:= /2)
term_basic:V=vars (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:T=f([88]) (term_basic:= /2)
term_basic:R=[] (term_basic:= /2)

`parse_term(A,T,R,V)`

– *If the following properties should hold at call time:*
term_basic:A=[102,40,88,41,32,102,111,111,32] (term_basic:= /2)
term_basic:V=vars (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:T=f([88]) (term_basic:= /2)
term_basic:R=[32,102,111,111,32] (term_basic:= /2)

Usage: `parse_term(String,Term,Rest,Vars)`

- *Description:* `String` is parsed into `Term` up to `Rest` (which is the non-parsed rest of the list). The term is assumed to be ground. If `Vars` is `vars` then upper case identifiers in the term are turned into variables.
- *The following properties should hold at call time:*

  `String` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Term` is a free variable. (term_typing:var/1)

  `Vars` is currently a term which is not a free variable. (term_typing:nonvar/1)

70.3 Known bugs and planned improvements (`atom2term`)

- This is just a quick hack written mainly for parsing daVinci's messages. There should be a call to the standard reader to do this!

71 ctrlcclean (library)

71.1 Usage and interface (ctrlcclean)

- **Library usage:**
  `:- use_module(library(ctrlcclean)).`
- **Exports:**
  - *Predicates:*
    `ctrlc_clean/1`, `delete_on_ctrlc/2`, `ctrlcclean/0`.
- **Other modules used:**
  - *System library modules:*
    `system`.

71.2 Documentation on exports (ctrlcclean)

ctrlc_clean/1: PREDICATE

No further documentation available for this predicate.

Meta-predicate with arguments: `ctrlc_clean(goal)`.

delete_on_ctrlc/2: PREDICATE

No further documentation available for this predicate.

ctrlcclean/0: PREDICATE

No further documentation available for this predicate.

72 errhandle (library)

72.1 Usage and interface (errhandle)

- **Library usage:**
  `:- use_module(library(errhandle)).`
- **Exports:**
  - *Predicates:*
    `error_protect/1`, `handle_error/2`.
- **Other modules used:**
  - *System library modules:*
    `system`.

72.2 Documentation on exports (errhandle)

error_protect/1: PREDICATE

No further documentation available for this predicate.

Meta-predicate with arguments: `error_protect(goal)`.

handle_error/2: PREDICATE

No further documentation available for this predicate.

73 Fast reading and writing of terms

Author(s): Daniel Cabeza, Oscar Portela Arjona.

This library provides predicates to support reading / writing of terms on a format designed to be handled on read faster than standard representation.

73.1 Usage and interface (fastrw)

- **Library usage:**
  `:- use_module(library(fastrw)).`
- **Exports:**
  - *Predicates:*
    `fast_read/1`, `fast_write/1`, `fast_read/2`, `fast_write/2`, `fast_write_to_string/3`.

73.2 Documentation on exports (fastrw)

fast_read/1: PREDICATE

`fast_read(Term)`

The next term is read from current standard input and is unified with `Term`. The syntax of the term must agree with fast_read / fast_write format. If the end of the input has been reached, `Term` is unified with the term 'end_of_file'. Further calls to `fast_read/1` will then cause an error.

fast_write/1: PREDICATE

`fast_write(Term)`

Output `Term` in a way that `fast_read/1` and `fast_read/2` will be able to read it back.

fast_read/2: PREDICATE

`fast_read(Stream,Term)`

The next term is read from `Stream` and unified with `Term`. The syntax of the term must agree with fast_read / fast_write format. If the end of the input has been reached, `Term` is unified with the term 'end_of_file'. Further calls to `fast_read/2` will then cause an error.

Usage:

- *Call and exit should be compatible with:*
  `Term` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties should hold upon exit:*
  `Term` is any term. (basic_props:term/1)

fast_write/2: PREDICATE

`fast_write(Stream,Term)`

Output `Term` to `Stream` in a way that `fast_read/1` and `fast_read/2` will be able to read it back.

Usage:

- *The following properties should hold at call time:*

  `Stream` is an open stream. (streams_basic:stream/1)

  `Term` is any term. (basic_props:term/1)

- *The following properties should hold upon exit:*

  `Term` is any term. (basic_props:term/1)

- *The following properties should hold globally:*

  `Term` is not further instantiated. (basic_props:not_further_inst/2)

fast_write_to_string/3: PREDICATE

No further documentation available for this predicate.

73.3 Known bugs and planned improvements (`fastrw`)

- Both `fast_read/2` and `fast_write/2` simply set the current output/input and call `fast_read/1` and `fast_write/1`. Therefore, in the event an error hapens during its execution, the current input / output streams may be left pointing to the `Stream`

74 File name manipulation

Author(s): Daniel Cabeza, Angel Fernandez Pineda.
This library provides some small utilities to handle file name syntax.

74.1 Usage and interface (filenames)

- **Library usage:**
  `:- use_module(library(filenames)).`
- **Exports:**
  - *Predicates:*
    `no_path_file_name/2`, `file_directory_base_name/3`, `file_name_extension/3`, `basename/2`, `extension/2`.
  - *Regular Types:*
    `atom_or_str/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`, `lists`.

74.2 Documentation on exports (filenames)

no_path_file_name/2: PREDICATE

This predicate will extract the last item (usually the file name) from a given path.

The first argument must be instantiated to a string or atom. Whenever the first argument is an atom, the second argument will be an atom. Whenever the first argument is a string, the second argument will be a string.

This predicate will fail under any of the following conditions:

- First argument is not an atom, nor a string.
- Second argument is not the last given path item (given path is the first argument).

Those are the most usual usages of no_path_file_name/2:

```
?- no_path_file_name("/home/nexusV/somefile.txt",K).

K = "somefile.txt" ?

yes
?- no_path_file_name('/home/nexusV/somefile.txt',K).

K = 'somefile.txt' ?

yes
?-
```

Usage: `no_path_file_name(Path,FileName)`

- *Description:* `FileName` is the file corresponding to the given `Path`.

– *Call and exit should be compatible with:*
`Path` is an atom or a string (filenames:atom_or_str/1)
`FileName` is an atom or a string (filenames:atom_or_str/1)

file_directory_base_name/3: PREDICATE

Usage: `file_directory_base_name(Path,Directory,BaseName)`

– *Description:* Given a file path `Path`, `Directory` is the directory part and `BaseName` is the filename part. `Directory` does not end in '/' unless it is just '/'. `Directory` is '.' if `Path` does not contain '/'.
– *Call and exit should be compatible with:*
`Path` is an atom or a string (filenames:atom_or_str/1)
`Directory` is an atom or a string (filenames:atom_or_str/1)
`BaseName` is an atom or a string (filenames:atom_or_str/1)

file_name_extension/3: PREDICATE

This predicate may be used in two ways:

- To create a file name from its components: name and extension. For instance:

```
?- file_name_extension(File,mywork,'.txt').

File = 'mywork.txt' ?

yes
?-
```

- To split a file name into its name and extension. For Instance:

```
?- file_name_extension('mywork.txt',A,B).

A = mywork,
B = '.txt' ?

yes
?-
```

Any other usage of file_name_extension/3 will cause the predicate to fail. Notice that valid arguments are accepted both as atoms or strings.

General properties: `file_name_extension(File,Name,Ext)`

– *Description:* This is a bug, this test must succeeds.
– *If the following properties do not hold at call time:*
term_basic:File=/home/user/emacs.d/dummy (term_basic:= /2)
then the following properties do not hold upon exit:
term_basic:Name=/home/user/emacs.d/dummy (term_basic:= /2)
term_basic:Ext= (term_basic:= /2)
then the following properties do not hold globally:
All calls of the form `file_name_extension(File,Name,Ext)` are deterministic. (native_props:is_det/1)
All the calls of the form `file_name_extension(File,Name,Ext)` do not fail. (native_props:not_fails/1)

Usage: `file_name_extension(FileName,BaseName,Extension)`

- *Description:* Splits a `FileName` into its `BaseName` and `Extension`.
- *Call and exit should be compatible with:*

  `FileName` is an atom or a string (filenames:atom_or_str/1)
  `BaseName` is an atom or a string (filenames:atom_or_str/1)
  `Extension` is an atom or a string (filenames:atom_or_str/1)

basename/2: PREDICATE

`basename(FileName,BaseName)`

`BaseName` is `FileName` without extension. Equivalent to `file_name_extension(FileName,BaseName,_)`. Useful to extract the base name of a file using functional syntax.

Usage:

- *Call and exit should be compatible with:*

  `FileName` is an atom or a string (filenames:atom_or_str/1)
  `BaseName` is an atom or a string (filenames:atom_or_str/1)

atom_or_str/1: REGTYPE

Usage: `atom_or_str(X)`

- *Description:* `X` is an atom or a string

extension/2: PREDICATE

`extension(FileName,Extension)`

`Extension` is the extension (suffix) of `FileName`. Equivalent to `file_name_extension(FileName,_,Extension)`. Useful to extract the extension of a file using functional syntax.

Usage:

- *Call and exit should be compatible with:*

  `FileName` is an atom or a string (filenames:atom_or_str/1)
  `Extension` is an atom or a string (filenames:atom_or_str/1)

75 Symbolic filenames

Author(s): Francisco Bueno.

This module provides a predicate for file opening which can use any term as an alias for the filename (i.e., symbolic filenames) instead of the usual constants which are file system path names of the actual files.

The correspondence between an alias and the actual file path is done dynamically, without having to recompile the program. It is possible to define the correspondence via facts for `file_alias/2` in a file declared with `multifile:alias_file/1` in the program: those facts will be dynamically loaded when running the program. Alternatively, the correspondence can be defined via shell environment variables, by defining the value of a variable by the (symbolic) name of the file to be the path of the actual file.

75.1 Usage and interface (symfnames)

- **Library usage:**
  `:- use_module(library(symfnames)).`
- **Exports:**
  - *Predicates:*
    `open/3`.
  - *Multifiles:*
    `alias_file/1`, `file_alias/2`.
- **Other modules used:**
  - *System library modules:*
    `read`, `system`.

75.2 Documentation on exports (symfnames)

open/3: PREDICATE

`open(File,Mode,Stream)`

Open `File` with mode `Mode` and return in `Stream` the stream associated with the file. It is like `streams_basic:open/3`, but `File` is considered a symbolic name: either defined by `user:file_alias/2` or as an environment variable. Predicate `user:file_alias/2` is inspected before the environment variables.

Usage:

- *Calls should, and exit will be compatible with:*
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties should hold at call time:*
  `File` is any term. (basic_props:term/1)
  `Mode` is an opening mode ('read', 'write' or 'append'). (streams_basic:io_mode/1)
- *The following properties hold upon exit:*
  `Stream` is an open stream. (streams_basic:stream/1)

75.3 Documentation on multifiles (symfnames)

alias_file/1: PREDICATE

`alias_file(File)`

Declares `File` to be a file defining symbolic names via `file_alias/2`. Anything else in `File` is simply ignored.

The predicate is *multifile*.

file_alias/2: PREDICATE

`file_alias(Alias,File)`

Declares `Alias` as a symbolic name for `File`, the real name of an actual file (or directory).

The predicate is *multifile*.

The predicate is of type *data*.

75.4 Other information (symfnames)

The example discussed here is included in the distribution files. There is a main application file which uses module `mm`. This module reads a line from a file; the main predicate in the main file then prints this line. The important thing is that the file read is named by a symbolic name `"file"`. The main application file declares another file where the symbolic names are assigned actual file names:

```
:- use_module(mm).

:- multifile alias_file/1.
alias_file(myfiles).

main :- p(X), display(X), nl.
```

Now, the file `myfiles.pl` can be used to change the file you want to read from without having to recompile the application. The current assignment is:

```
%:- use_package([]).
file_alias(file,'mm.pl').
```

so the execution of the application will show the first line of `mm.pl`. However, you can change to:

```
file_alias(file,'main.pl').
```

and then execution of the same executable will show the first line of `main.pl`.

76 File I/O utilities

Author(s): The CLIP Group.
This module implements the file I/O utilities.

76.1 Usage and interface (file_utils)

- **Library usage:**
  `:- use_module(library(file_utils)).`
- **Exports:**
  - *Predicates:*
    `file_terms/2`, `copy_stdout/1`, `file_to_string/2`, `file_to_string/3`, `string_to_file/2`, `stream_to_string/2`, `stream_to_string/3`, `output_to_file/2`.
- **Other modules used:**
  - *System library modules:*
    `read`, `streams`, `strings`.

76.2 Documentation on exports (file_utils)

file_terms/2: PREDICATE

Usage 1: `file_terms(File,Terms)`
- *Description:* Unifies `Terms` with the list of all terms in `File`.
- *The following properties should hold at call time:*
  `File` is a source name. (streams_basic:sourcename/1)
  `Terms` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `Terms` is a list. (basic_props:list/1)

Usage 2: `file_terms(File,Terms)`
- *Description:* Writes the terms in list `Terms` (including the ending '.') onto file `File`.
- *The following properties should hold at call time:*
  `File` is a source name. (streams_basic:sourcename/1)
  `Terms` is a list. (basic_props:list/1)

copy_stdout/1: PREDICATE

Usage: `copy_stdout(File)`
- *Description:* Copies file `File` to standard output.
- *The following properties should hold at call time:*
  `File` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `File` is a source name. (streams_basic:sourcename/1)

file_to_string/2: PREDICATE

Usage: `file_to_string(FileName,String)`

- *Description:* Reads all the characters from the file `FileName` and returns them in `String`.
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `String` is a free variable. (term_typing:var/1)

  `FileName` is a source name. (streams_basic:sourcename/1)
- *The following properties should hold upon exit:*

  `String` is a string (a list of character codes). (basic_props:string/1)

file_to_string/3: PREDICATE

Usage: `file_to_string(FileName,String,Tail)`

- *Description:* Reads all the characters from the file `FileName` and returns them in `String`. `Tail` is the end of `String`.
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `String` is a free variable. (term_typing:var/1)

  `FileName` is a source name. (streams_basic:sourcename/1)
- *The following properties should hold upon exit:*

  `String` is a string (a list of character codes). (basic_props:string/1)

string_to_file/2: PREDICATE

Usage: `string_to_file(String,FileName)`

- *Description:* Reads all the characters from the string `String` and writes them to file `FileName`.
- *The following properties should hold at call time:*

  `String` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `String` is a string (a list of character codes). (basic_props:string/1)

  `FileName` is a source name. (streams_basic:sourcename/1)

stream_to_string/2: PREDICATE

Usage: `stream_to_string(Stream,String)`

- *Description:* Reads all the characters from `Stream`, returns them in `String`, and closes `Stream`.
- *The following properties should hold at call time:*

  `Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `String` is a free variable. (term_typing:var/1)

  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties should hold upon exit:*

  `String` is a string (a list of character codes). (basic_props:string/1)

stream_to_string/3: PREDICATE

Usage: `stream_to_string(Stream,String,Tail)`

- *Description:* Reads all the characters from `Stream`, returns them in `String`, and closes `Stream`. `Tail` is the end of `String`
- *The following properties should hold at call time:*

  `Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `String` is a free variable. (term_typing:var/1)

  `Stream` is an open stream. (streams_basic:stream/1)

output_to_file/2: PREDICATE

No further documentation available for this predicate.

Meta-predicate with arguments: `output_to_file(goal,?)`.

77 File locks

Author(s): José Manuel Gómez Pérez, Daniel Cabeza, Manuel Carro.

This module implements file locks: the ability to lock a fiel so that other processes cannot access it until the file is unlocked. **It is, however, not working.** The predicates do nothing. Proper implementation is planned for a near future.

77.1 Usage and interface (`file_locks`)

- **Library usage:**
  `:- use_module(library(file_locks)).`
- **Exports:**
  - *Predicates:*
    `lock_file/3`, `unlock_file/2`.

77.2 Documentation on exports (`file_locks`)

lock_file/3: PREDICATE

Usage: `lock_file(File,LockType,Result)`

- *Description:* Tries to lock `File` with `LockType` and returns the result (either `true` or `false`) in `Result`.
- *Call and exit should be compatible with:*

`File` is an atom.	(basic_props:atm/1)
`LockType` is an atom.	(basic_props:atm/1)
`Result` is an atom.	(basic_props:atm/1)

unlock_file/2: PREDICATE

Usage: `unlock_file(File,Result)`

- *Description:* Tries to unlock `File` the result (either `true` or `false`) in `Result`.
- *Call and exit should be compatible with:*

`File` is an atom.	(basic_props:atm/1)
`Result` is an atom.	(basic_props:atm/1)

77.3 Known bugs and planned improvements (`file_locks`)

- No doing anything helpful.

78 Lists and conjunctions and disjunctions

78.1 Usage and interface (formulae)

- **Library usage:**
  `:- use_module(library(formulae)).`
- **Exports:**
  - *Predicates:*
    `list_to_conj/3`, `list_to_conj/2`, `conj_to_list/2`, `list_to_disj/2`, `disj_to_list/2`, `conj_to_llist/2`, `llist_to_conj/2`, `disj_to_llist/2`, `llist_to_disj/2`, `body2list/2`, `asbody_to_conj/2`, `list_to_disj2/2`.
  - *Properties:*
    `assert_body_type/1`.
  - *Regular Types:*
    `conj_disj_type/1`, `t_conj/1`, `t_disj/1`.
- **Other modules used:**
  - *System library modules:*
    `messages`.

78.2 Documentation on exports (formulae)

list_to_conj/3: PREDICATE

`list_to_conj(List,Conj,End)`

`Conj` is the conjunction made up of the elements of `List` plus a final element `End`.

list_to_conj/2: PREDICATE

Usage 1: `list_to_conj(A,B)`

- *Description:* `Conj` is the conjunction made up of the elements of `List`. (`[]` is `true`). It runs in both ways.

```
?- list_to_conj( A , a ).

A = [a] ? ;

no
?- list_to_conj( A , (a,V) ).

A = [a,V] ? ;

no
?- list_to_conj( A , (a,V,b) ).

A = [a,V,b] ? ;
```

```
no
?- list_to_conj( [A] , B ).

B = A ? ;

no
?- list_to_conj( [a,A] , B ).

B = (a,A) ? ;

no
?- list_to_conj( [a,A,b] , B ).

B = (a,A,b) ? ;

no
?- list_to_conj( [] , B ).

B = true ? ;

no
```

– *The following properties should hold at call time:*
  `A` is a list. (basic_props:list/1)
  `B` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
  Conjuntions. (formulae:t_conj/1)

Usage 2: `list_to_conj(A,B)`
– *The following properties should hold at call time:*
  `A` is a free variable. (term_typing:var/1)
  Conjuntions. (formulae:t_conj/1)
– *The following properties should hold upon exit:*
  `A` is a list. (basic_props:list/1)

conj_to_list/2: PREDICATE

`conj_to_list(Conj,List)`

`List` is the list made up of the elements of conjunction `Conj` (`true` is `[]`).

list_to_disj/2: PREDICATE

Usage: `list_to_disj(A,B)`
– *Description:* `Disj` is the disjunction made up of the elements of `List`. (`[]` is `true`). It runs in both ways. Examples:

```
?- list_to_disj( [a] , A ).

A = a ? ;

no
```

```
?- list_to_disj( [a,b] , A ).

A = (a;b) ? ;

no
?- list_to_disj( [a,B,b] , A ).

A = (a;B;b) ? ;

no
?- list_to_disj( [a,b,B] , A ).

A = (a;b;B) ? ;

no
?- list_to_disj( A , (a) ).

A = [a] ? ;

no
?- list_to_disj( A , (a;b) ).

A = [a,b] ? ;

no
?- list_to_disj( A , (a;B;b) ).

A = [a,B,b] ? ;

no
?-
```

– *The following properties should hold at call time:*
  `A` is a list. (basic_props:list/1)
  `B` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
  Conjuntions. (formulae:t_disj/1)

disj_to_list/2: PREDICATE

`disj_to_list(Disj,List)`

`List` is the list made up of the elements of disjunction `Disj` (`true` is `[]`).

conj_to_llist/2: PREDICATE

Turns a conjunctive (normal form) formula into a list (of lists of ...). As a side-effect, inner conjunctions get flattened. No special care for `true`.

llist_to_conj/2: PREDICATE

Inverse of `conj_to_llist/2`. No provisions for anything else than a non-empty list on input (i.e., they will go 'as are' in the output.

disj_to_llist/2: PREDICATE

Turns a disjunctive (normal form) formula into a list (of lists of ...). As a side-effect, inner disjunctions get flattened. No special care for `true`.

llist_to_disj/2: PREDICATE

Inverse of `disj_to_llist/2`. No provisions for anything else than a non-empty list on input (i.e., they will go 'as are' in the output.

body2list/2: PREDICATE

No further documentation available for this predicate.

asbody_to_conj/2: PREDICATE

Usage 1: `asbody_to_conj(A,B)`

- *Description:* Transforms assertion body `A` into a conjuntion (`B`). It runs in both ways
- *The following properties should hold at call time:*

  formulae:assert_body_type(A) (formulae:assert_body_type/1)

  `B` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  The usual prolog way of writting conjuntions and disjuntions in a body using ',' and ';' (formulae:conj_disj_type/1)

Usage 2: `asbody_to_conj(A,B)`

- *The following properties should hold at call time:*

  `A` is a free variable. (term_typing:var/1)

  The usual prolog way of writting conjuntions and disjuntions in a body using ',' and ';' (formulae:conj_disj_type/1)
- *The following properties should hold upon exit:*

  formulae:assert_body_type(A) (formulae:assert_body_type/1)

assert_body_type/1: PROPERTY

A property, defined as follows:

```
assert_body_type(X) :-
        list(X,assert_body_type__).
```

conj_disj_type/1: REGTYPE

Usage:

- *Description:* The usual prolog way of writting conjuntions and disjuntions in a body using ',' and ';'

t_conj/1: REGTYPE

Usage:

- *Description:* Conjuntions.

t_disj/1: REGTYPE

Usage:

– *Description:* Conjuntions.

list_to_disj2/2: PREDICATE

No further documentation available for this predicate.

79 Term manipulation utilities

Author(s): The CLIP Group.
This module implements some utils to do term manipulation.

79.1 Usage and interface (terms)

- **Library usage:**
  `:- use_module(library(terms)).`
- **Exports:**
  - *Predicates:*
    `term_size/2`, `copy_args/3`, `arg/2`, `atom_concat/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

79.2 Documentation on exports (terms)

term_size/2: PREDICATE

General properties: `term_size(A,B)`

- *If the following properties should hold at call time:*
  term_basic:A=p(a,b,c(d,e)) (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:B=6 (term_basic:= /2)

`term_size(A,B)`

- *If the following properties should hold at call time:*
  term_basic:A=p(a,b,c(d,_91234)) (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:B=6 (term_basic:= /2)

`term_size(A,B)`

- *If the following properties should hold at call time:*
  term_basic:A=[1,2,3] (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:B=7 (term_basic:= /2)

Usage: `term_size(Term,N)`

- *Description:* Determines the size of a term.
- *The following properties should hold at call time:*
  `Term` is any term. (basic_props:term/1)
  `N` is a non-negative integer. (basic_props:nnegint/1)

copy_args/3: PREDICATE

General properties: `copy_args(N,Term,Copy)`

– *If the following properties hold at call time:*
`N` is currently ground (it contains no variables). (term_typing:ground/1)
`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)
then the following properties hold globally:
`copy_args(N,Term,Copy)` is evaluable at compile-time. (basic_props:eval/1)

`copy_args(N,Term,Copy)`

– *The following properties hold globally:*
`copy_args(N,Term,Copy)` is side-effect `free`. (basic_props:sideff/2)

Usage: `copy_args(N,Term,Copy)`

– *Description:* `Term` and `Copy` have the same first `N` arguments.
– *The following properties should hold at call time:*
`N` is a non-negative integer. (basic_props:nnegint/1)

arg/2: PREDICATE

Usage: `arg(Term,Arg)`

– *Description:* `Arg` is an argument of `Term`. Gives each of the arguments on backtracking.

atom_concat/2: PREDICATE

`atom_concat(Atms,Atm)`

`Atm` is the atom resulting from concatenating all atoms in the list `Atms` in the order in which they appear. If `Atm` is an atom at call then `Atms` can contain free variables.

General properties: `atom_concat(A,B)`

– *If the following properties should hold at call time:*
term_basic:A=[/home/edison/svn/dist/CiaoDE/bin,/,X,-,1.11,] (term_basic:= /2)
term_basic:B=/home/edison/svn/dist/CiaoDE/bin/fileinfo-1.11 (term_basic:= /2)
then the following properties should hold upon exit:
The terms `X` and `fileinfo` are strictly identical. (term_compare:== /2)

`atom_concat(A,B)`

– *If the following properties should hold at call time:*
term_basic:A=[a,b,c] (term_basic:= /2)
then the following properties should hold upon exit:
The terms `B` and `abc` are strictly identical. (term_compare:== /2)

`atom_concat(X,Y)`

– *Description:* atom_concat that generates several solutions.
– *If the following properties should hold at call time:*
term_basic:X=[a,B|C] (term_basic:= /2)
term_basic:Y=abcde (term_basic:= /2)
then the following properties should hold upon exit:
`B,C` is an element of `[(,[b,c,d,e]),(,[b,c,de]),(,[b,cd,e]),(,[b,cde]),(,[bc,d,e]),(,[bc,de]),(,[bcd,e]`
(basic_props:member/2)

`atom_concat(X,Y)`

- *Description:* atom_concat that generates several solutions.
- *If the following properties should hold at call time:*

  term_basic:X=[a,B|C] (term_basic:= /2)

  term_basic:Y=abcde (term_basic:= /2)

  then the following properties should hold globally:

  Goal `atom_concat(X,Y)` produces the solutions listed in `[atom_concat([a,,b,c,d,e],abcde),atom_concat([a,,b,c,de],abcde),atom_concat([a,,b,cd,e],abcde),atom_concat([a,,b,cde],abcde),atom_concat([a,,bc,d,e],abcde),atom_concat([a,,bc,de],abcde),atom_concat([a,,bcd,e],abcde),atom_concat([a,,bcde],abcde),atom_concat([a,b,c,d,e],abcde),atom_concat([a,b,c,de],abcde),atom_concat([a,b,cd,e],abcde),atom_concat([a,b,cde],abcde),atom_concat([a,bc,d,e],abcde),atom_concat([a,bc,de],abcde),atom_concat([a,bcd,e],abcde),atom_concat([a,bcde],abcde)]`. (native_props:solutions/2)

`atom_concat(X,Y)`

- *If the following properties should hold at call time:*

  term_basic:X=[A,b,C] (term_basic:= /2)

  term_basic:Y=abc (term_basic:= /2)

  then the following properties should hold upon exit:

  The terms `A` and `a` are strictly identical. (term_compare:== /2)

  The terms `C` and `c` are strictly identical. (term_compare:== /2)

`atom_concat(X,Y)`

- *If the following properties should hold at call time:*

  term_basic:X=[A,b,] (term_basic:= /2)

  term_basic:Y=ab (term_basic:= /2)

  then the following properties should hold upon exit:

  term_basic:A=a (term_basic:= /2)

Usage 1: `atom_concat(Atms,Atm)`

- *The following properties should hold at call time:*

  `Atms` is a list of `atm`s. (basic_props:list/2)
- *The following properties should hold upon exit:*

  `Atm` is an atom. (basic_props:atm/1)

Usage 2: `atom_concat(Atms,Atm)`

- *Call and exit should be compatible with:*

  `Atms` is a list of `atm`s. (basic_props:list/2)
- *The following properties should hold at call time:*

  `Atm` is an atom. (basic_props:atm/1)
- *The following properties should hold upon exit:*

  `Atms` is a list of `atm`s. (basic_props:list/2)

80 Term checking utilities

Author(s): The CLIP Group.
This module implements the term checking utilities.

80.1 Usage and interface (terms_check)

- **Library usage:**
  `:- use_module(library(terms_check)).`
- **Exports:**
  - *Predicates:*
    `ask/2`, `variant/2`, `most_general_instance/3`, `most_specific_generalization/3`.
  - *Properties:*
    `instance/2`.

80.2 Documentation on exports (terms_check)

ask/2: PREDICATE

`ask(Term1,Term2)`

`Term1` and `Term2` unify without producing bindings for the variables of `Term1`. I.e., `instance(Term1,Term2)` holds.

instance/2: PROPERTY

Usage: `instance(Term1,Term2)`

- *Description:* `Term1` is an instance of `Term2`.
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

variant/2: PREDICATE

`variant(Term1,Term2)`

`Term1` and `Term2` are identical up to renaming.

most_general_instance/3: PREDICATE

`most_general_instance(Term1,Term2,Term)`

`Term` satisfies `instance(Term,Term1)` and `instance(Term,Term2)` and there is no term more general than `Term` (modulo variants) that satisfies it.

most_specific_generalization/3: PREDICATE

`most_specific_generalization(Term1,Term2,Term)`

`Term` satisfies `instance(Term1,Term)` and `instance(Term2,Term)` and there is no term less general than `Term` (modulo variants) that satisfies it.

80.3 Other information (terms_check)

Currently, ask/2 and instance/2 are exactly the same. However, ask/2 is more general, since it is also applicable to constraint domains (although not yet implemented): for the particular case of Herbrand terms, it is just instance/2 (which is the only ask check currently implemented).

80.4 Known bugs and planned improvements (terms_check)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

81 Sets of variables in terms

Author(s): The CLIP Group.

This module implements predicates to handle sets of variables in terms.

81.1 Usage and interface (terms_vars)

- **Library usage:**
  `:- use_module(library(terms_vars)).`
- **Exports:**
  - *Predicates:*
    `varset/2`, `varsbag/3`, `varset_in_args/2`.
- **Other modules used:**
  - *System library modules:*
    `idlists`, `sort`.

81.2 Documentation on exports (terms_vars)

varset/2: PREDICATE

`varset(Term,Xs)`

`Xs` is the sorted list of all the variables in `Term`.

varsbag/3: PREDICATE

`varsbag(Term,Vs,Xs)`

`Vs` is the list of all the variables in `Term` ordered as they appear in `Term` right-to-left depth-first (including duplicates) plus `Xs`.

varset_in_args/2: PREDICATE

Usage: `varset_in_args(T,LL)`

- *Description:* Each list of `LL` contains the variables of an argument of `T`, for each argument, and in left to right order.
- *The following properties should hold at call time:*
  `T` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties should hold upon exit:*
  `LL` is a list of `list(var)`s. (basic_props:list/2)

82 Cyclic terms handling

Author(s): Daniel Cabeza.

This module implements predicates related to cyclic terms. Cyclic (or infinite) terms are produced when unifying a variable with a term which contains that variable.

82.1 Usage and interface (cyclic_terms)

- **Library usage:**
  `:- use_module(library(cyclic_terms)).`
- **Exports:**
  - *Predicates:*
    `cyclic_term/1`, `acyclic_term/1`, `uncycle_term/2`, `recycle_term/2`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

82.2 Documentation on exports (cyclic_terms)

cyclic_term/1: PREDICATE

Usage: `cyclic_term(T)`

- *Description:* True if `T` is cyclic (infinite).

acyclic_term/1: PREDICATE

Usage: `acyclic_term(T)`

- *Description:* True if `T` is acyclic (finite).

uncycle_term/2: PREDICATE

Usage: `uncycle_term(T,U)`

- *Description:* Given a term `T`, `U` is a finite representation of `T` as an acyclic term. This representation can be converted back to `T` using `recycle_term/2`.

recycle_term/2: PREDICATE

Usage: `recycle_term(U,T)`

- *Description:* Given `U`, a finite representation of a term as an acyclic term as `uncycle_term/2` produces, `T` is the represented term. `U` is modified by the predicate, thus to maintain it untouched `copy_term/2` should be used.

83 A simple pretty-printer for Ciao programs

Author(s): The CLIP Group.

This library module writes out to standard output a clause or a list of clauses.

83.1 Usage and interface (pretty_print)

- **Library usage:**
  `:- use_module(library(pretty_print)).`
- **Exports:**
  - *Predicates:*
    `pretty_print/2`, `pretty_print/3`, `pretty_print/4`.
- **Other modules used:**
  - *System library modules:*
    `operators`, `vndict`, `write`.

83.2 Documentation on exports (pretty_print)

pretty_print/2: PREDICATE

Usage: `pretty_print(Cls,Flags)`

- *Description:* Prints each clause in the list `Cls` after numbering its variables.
- *The following properties should hold at call time:*

pretty_print:clauses(Cls)	(pretty_print:clauses/1)
`Flags` is a list of `flags`.	(basic_props:list/2)

pretty_print/3: PREDICATE

Usage: `pretty_print(Cls,Flags,Ds)`

- *Description:* Prints each clause in the list `Cls` after using the corresponding variable names dictionary in `Ds` to name its variables.
- *The following properties should hold at call time:*

pretty_print:clauses(Cls)	(pretty_print:clauses/1)
`Flags` is a list of `flags`.	(basic_props:list/2)
`Ds` is a dictionary of variable names.	(vndict:varnamedict/1)

pretty_print/4: PREDICATE

No further documentation available for this predicate.

83.3 Documentation on internals (pretty_print)

clauses/1: REGTYPE

A regular type, defined as follows:

```
clauses([]).
clauses([_1|_2]) :-
        clause(_1),
        clauses(_2).
clauses(_1) :-
        clause(_1).
```

clause/1: REGTYPE

A regular type, defined as follows:

```
clause(_1) :-
        clterm(_1).
clause((_1,_2)) :-
        clterm(_1),
        term(_2).
```

clterm/1: REGTYPE

A regular type, defined as follows:

```
clterm(clause(_1,_2)) :-
        callable(_1),
        body(_2).
clterm(directive(_1)) :-
        body(_1).
clterm((_1:-_2)) :-
        callable(_1),
        body(_2).
clterm(_1) :-
        callable(_1).
```

body/1: REGTYPE

A well formed body, including cge expressions and &-concurrent expressions. The atomic goals may or may not have a key in the form `^(goal:any)`, and may or may not be module qualified, but if they are it has to be in the form `^(^(moddesc:goal):any)`.

Usage: `body(X)`

– *Description:* `X` is a printable body.

flag/1: REGTYPE

A keyword `ask/1` flags whether to output *asks* or *whens* and `nl/1` whether to separate clauses with a blank line or not.

Usage: `flag(X)`

– *Description:* `X` is a flag for the pretty-printer.

83.4 Known bugs and planned improvements (pretty_print)

- 2.- If the priority of and operator, &/1 or &/2, is redefined with lower priority than :-/2 or ./1, the written term is incorrect because it does not include parenthesis to make Ciao associate and operator first.

84 Pretty-printing assertions

Author(s): Francisco Bueno.

This module defines some predicates which are useful for writing assertions in a readable form.

84.1 Usage and interface (assrt_write)

- **Library usage:**
  `:- use_module(library(assrt_write)).`
- **Exports:**
  - *Predicates:*
    `write_assertion/6`, `write_assertion/7`, `write_assertion_as_comment/6`, `write_assertion_as_comment/7`, `write_assertion_as_double_comment/6`, `write_assertion_as_double_comment/7`.
- **Other modules used:**
  - *System library modules:*
    `format`, `assertions/assrt_lib`, `messages`, `assertions/assertions_props`, `vndict`.

84.2 Documentation on exports (assrt_write)

write_assertion/6: PREDICATE

Usage: `write_assertion(Goal,Status,Type,Body,Dict,Flag)`

- *Description:* Writes the (normalized) assertion to current output.
- *Call and exit should be compatible with:*

`Status` is an acceptable status for an assertion.	(assertions_props:assrt_status/1)
`Type` is an admissible kind of assertion.	(assertions_props:assrt_type/1)
`Body` is a normalized assertion body.	(assertions_props:nabody/1)
`Dict` is a dictionary.	(dict:dictionary/1)
`Flag` is `status` or `nostatus`.	(assrt_write:status_flag/1)

write_assertion/7: PREDICATE

Usage: `write_assertion(Stream,Goal,Status,Type,Body,Dict,Flag)`

- *Description:* Writes the (normalized) assertion to stream `Stream`.
- *Call and exit should be compatible with:*

`Status` is an acceptable status for an assertion.	(assertions_props:assrt_status/1)
`Type` is an admissible kind of assertion.	(assertions_props:assrt_type/1)
`Body` is a normalized assertion body.	(assertions_props:nabody/1)
`Dict` is a dictionary.	(dict:dictionary/1)
`Flag` is `status` or `nostatus`.	(assrt_write:status_flag/1)

write_assertion_as_comment/6: PREDICATE

Usage: `write_assertion_as_comment(Goal,Status,Type,Body,Dict,Flag)`

- *Description:* Writes the (normalized) assertion to current output as a Prolog comment.
- *Call and exit should be compatible with:*

  `Status` is an acceptable status for an assertion. (assertions_props:assrt_status/1)
  `Type` is an admissible kind of assertion. (assertions_props:assrt_type/1)
  `Body` is a normalized assertion body. (assertions_props:nabody/1)
  `Dict` is a dictionary. (dict:dictionary/1)
  `Flag` is `status` or `nostatus`. (assrt_write:status_flag/1)

write_assertion_as_comment/7: PREDICATE

Usage: `write_assertion_as_comment(Stream,Goal,Status,Type,Body,Dict,Flag)`

- *Description:* Writes the (normalized) assertion to stream `Stream` as a Prolog comment.
- *Call and exit should be compatible with:*

  `Status` is an acceptable status for an assertion. (assertions_props:assrt_status/1)
  `Type` is an admissible kind of assertion. (assertions_props:assrt_type/1)
  `Body` is a normalized assertion body. (assertions_props:nabody/1)
  `Dict` is a dictionary. (dict:dictionary/1)
  `Flag` is `status` or `nostatus`. (assrt_write:status_flag/1)

write_assertion_as_double_comment/6: PREDICATE

Usage: `write_assertion_as_double_comment(Goal,Status,Type,Body,Dict,Flag)`

- *Description:* Writes the (normalized) assertion to current output as a Prolog double comment.
- *Call and exit should be compatible with:*

  `Status` is an acceptable status for an assertion. (assertions_props:assrt_status/1)
  `Type` is an admissible kind of assertion. (assertions_props:assrt_type/1)
  `Body` is a normalized assertion body. (assertions_props:nabody/1)
  `Dict` is a dictionary. (dict:dictionary/1)
  `Flag` is `status` or `nostatus`. (assrt_write:status_flag/1)

write_assertion_as_double_comment/7: PREDICATE

Usage:
`write_assertion_as_double_comment(Stream,Goal,Status,Type,Body,Dict,Flag)`

- *Description:* Writes the (normalized) assertion to stream `Stream` as a Prolog double comment.
- *Call and exit should be compatible with:*

  `Status` is an acceptable status for an assertion. (assertions_props:assrt_status/1)
  `Type` is an admissible kind of assertion. (assertions_props:assrt_type/1)
  `Body` is a normalized assertion body. (assertions_props:nabody/1)
  `Dict` is a dictionary. (dict:dictionary/1)
  `Flag` is `status` or `nostatus`. (assrt_write:status_flag/1)

85 The Ciao library browser

Author(s): Angel Fernandez Pineda.

The `librowser` library provides a set of predicates wich enable the user to interactively find Ciao libraries and/or any predicate exported by them.

This is a simple example:

```
?- apropos('*find*').
persdbrt_sql: dbfindall/4
persdbrtsql: dbfindall/4
conc_aggregates: findall/3
linda: rd_findall/3
vndict: find_name/4
internals: $find_file/8
aggregates: findall/4,findall/3

yes
?-
```

Librowser is specially useful when inside GNU Emacs: just place the cursor over a librowser response and press C-cTAB in order to get help on the related predicate. Refer to the "**Using Ciao inside GNU Emacs**" chapter for further information.

85.1 Usage and interface (`librowser`)

- **Library usage:**

  It is not necesary to use this library at user programs. It is designed to be used at the Ciao *toplevel* shell: `ciaosh`. In order to do so, just make use of `use_module/1` as follows:

  `use_module(library(librowser)).`

  Then, the library interface must be read. This is automatically done when calling any predicate at librowser, and the entire process will take a little moment.So, you should want to perform such a process after loading the Ciao toplevel:

  ```
  Ciao 0.9 #75: Fri Apr 30 19:04:24 MEST 1999
  ?- use_module(library(librowser)).

  yes
  ?- update.
  ```

  Whether you want this process to be automatically performed when loading `ciaosh`, you may include those lines in your *.ciaorc* personal initialization file.
- **Exports:**
  - *Predicates:*

    `update/0`, `browse/2`, `where/1`, `describe/1`, `system_lib/1`, `apropos/1`.
- **Other modules used:**
  - *System library modules:*

    `regexp/regexp_code`, `read`, `fastrw`, `system`, `streams`, `lists`.

85.2 Documentation on exports (librowser)

update/0: PREDICATE

This predicate will scan the Ciao system libraries for predicate definitions. This may be done once time before calling any other predicate at this library.

update/0 will also be automatically called (once) when calling any other predicate at librowser.

Usage:

– *Description:* Creates an internal database of modules at Ciao system libraries.

browse/2: PREDICATE

This predicate is fully reversible, and is provided to inspect concrete predicate specifications. For example:

```
?- browse(M,findall/A).

A = 3,
M = conc_aggregates ? ;

A = 4,
M = aggregates ? ;

A = 3,
M = aggregates ? ;

no
?-
```

Usage: `browse(Module,Spec)`

– *Description:* Asocciates the given `Spec` predicate specification with the `Module` which exports it.

– *The following properties should hold at call time:*

`Module` is a module name (an atom) (librowser:module_name/1)

`Spec` is a **Functor/Arity** predicate specification (librowser:pred_spec/1)

where/1: PREDICATE

This predicate will print at the screen the module needed in order to import a given predicate specification. For example:

```
?- where(findall/A).
findall/3 exported at module conc_aggregates
findall/4 exported at module aggregates
findall/3 exported at module aggregates

yes
?-
```

Usage: `where(Spec)`

– *Description:* Display what module to load in order to import the given `Spec`.

– *The following properties should hold at call time:*

`Spec` is a **Functor/Arity** predicate specification (librowser:pred_spec/1)

describe/1: PREDICATE

This one is used to find out which predicates were exported by a given module. Very usefull when you know the library, but not the concrete predicate. For example:

```
?- describe(librowser).
Predicates at library librowser :

apropos/1
system_lib/1
describe/1
where/1
browse/2
update/0

yes
?-
```

Usage: `describe(Module)`

- *Description:* Display a list of exported predicates at the given `Module`
- *The following properties should hold at call time:*

  `Module` is a module name (an atom) (librowser:module_name/1)

system_lib/1: PREDICATE

It retrieves on backtracking all Ciao system libraries stored in the internal database. Certainly, those which were scanned at `update/0` calling.

Usage: `system_lib(Module)`

- *Description:* `Module` variable will be successively instantiated to the system libaries stored in the internal database.
- *The following properties should hold at call time:*

  `Module` is a module name (an atom) (librowser:module_name/1)

apropos/1: PREDICATE

This tool makes use of regular expresions in order to find predicate specifications. It is very usefull whether you can't remember the full name of a predicate. Regular expresions take the same format as described in library `patterns`. Example:

```
?- apropos('atom_*').

terms: atom_concat/2
concurrency: atom_lock_state/2
atomic_basic: atom_concat/3,atom_length/2,atom_codes/2
iso_byte_char: atom_chars/2

yes
?-
```

Usage: `apropos(RegSpec)`

- *Description:* This will search any predicate specification `Spec` which matches the given `RegSpec` incomplete predicate specification.
- *The following properties should hold at call time:*

  `RegSpec` is a Pattern/Arity specification. (librowser:apropos_spec/1)

85.3 Documentation on internals (librowser)

apropos_spec/1: REGTYPE

Defined as:

```
apropos_spec(_1).
apropos_spec(_1/Arity) :-
        int(Arity).
```

Usage: `apropos_spec(S)`

– *Description:* `S` is a Pattern/Arity specification.

86 Code translation utilities

Author(s): Angel Fernandez Pineda.

This library offers a general way to perform clause body expansions. Goal, fact and spec translation predicates are authomatically called when needed, while this utility navigates through the meta-argument specification of the body itself. All predicates within this library must be called at *second-pass expansions*, since it uses information stored at `c_itf` library.

86.1 Usage and interface (`expansion_tools`)

- **Library usage:**
  This library is provided as a tool for those modules which performs source-to-source code translation, usually known as *code expanders*. It may be loaded as other modules using a `use_module/1`. Nothing special needs to be done.
- **Exports:**
  - *Predicates:*
    `imports_meta_pred/3`, `body_expander/6`, `arg_expander/6`.
- **Other modules used:**
  - *System library modules:*
    `compiler/c_itf`.

86.2 Documentation on exports (`expansion_tools`)

imports_meta_pred/3: PREDICATE

Macro provided in order to know meta-predicate specifications accessible from a module.

Usage: `imports_meta_pred(Module,MetaSpec,AccessibleAt)`

- *Description:* Tells whether `MetaSpec` meta-predicate specification is accessible from `Module`. `AccessibleAt` will be binded to '-' whether meta-predicate is a builtin one. If not, it will be unified with the module which defines the meta-predicate.
- *The following properties should hold at call time:*
  `Module` is an atom. (basic_props:atm/1)
  `MetaSpec` is any term. (basic_props:term/1)

body_expander/6: PREDICATE

This predicate is the main translation tool. It navigates through a clause body, when a single *goal* appears, user-code is called in order to perform a translation. Whether user-code fails to translate the involved goal, it remains the same. Regardless that goal is translated or not, an argument expansion will be performed over all goals if applicable (see `arg_expander/6` predicate).

Variable (unknown at compile time) goals will also be attempt to translate.

Meta-predicate with arguments: `body_expander((pred 3),(pred 3),(pred 3),?,?,?)`.

Usage:
`body_expander(GoalTrans,FactTrans,SpecTrans,Module,Body,ExpandedBody)`

– *Description:* Translates `Body` to `ExpandedBody` by the usage of user-defined translators `GoalTrans`, `FactTrans` and `SpecTrans`. The module where the original body appears must be unified with `Module` argument.

– *The following properties should hold at call time:*

`GoalTrans` is a user-defined predicate which performs *goal* meta-type translation (expansion_tools:goal_expander/1)

`FactTrans` is a user-defined predicate which performs *fact* meta-type translation (expansion_tools:fact_expander/1)

`SpecTrans` is a user-defined predicate which performs *spec* meta-type translation (expansion_tools:spec_expander/1)

`Module` is an atom. (basic_props:atm/1)

`ExpandedBody` is a free variable. (term_typing:var/1)

arg_expander/6: PREDICATE

This predicate is an auxiliary translation tool, which is used by `body_expander/6` predicate. It remains exported as a macro. The predicate navigates through the *meta-argument specification* of a goal. Whether a *goal,fact or spec* argument appears, user-code is called in order to perform a translation. Whether user-code fails to translate the involved argument, it remains the same. Builtins as ','/2 or ';'/2 are treated as meta-predicates defining *goal* meta-arguments. When a *goal* meta-argument is located, `body_expander/6` will be called in order to navigate through it. Notice that a *goal* meta-argument may be unified with another goal defining another meta-argument, so navigation is required. If arguments are not known to arg_expander/6, translation will not occur. This is posible whether goal or qualifing module are variables.

Meta-predicate with arguments: `arg_expander((pred 3),(pred 3),(pred 3),?,?,?).`

Usage:
`arg_expander(GoalTrans,FactTrans,SpecTrans,Module,Goal,ExpandedGoal)`

– *Description:* Translates `Goal` to `ExpandedGoal` by applying user-defined translators (`GoalTrans`, `FactTrans` and `SpecTrans`) to each meta-argument present at such goal. The module where the original goal appears must be unified with `Module` argument.

– *The following properties should hold at call time:*

`GoalTrans` is a user-defined predicate which performs *goal* meta-type translation (expansion_tools:goal_expander/1)

`FactTrans` is a user-defined predicate which performs *fact* meta-type translation (expansion_tools:fact_expander/1)

`SpecTrans` is a user-defined predicate which performs *spec* meta-type translation (expansion_tools:spec_expander/1)

`Module` is an atom. (basic_props:atm/1)

`ExpandedBody` is a free variable. (term_typing:var/1)

86.3 Documentation on internals (`expansion_tools`)

expander_pred/1: PROPERTY

Usage: `expander_pred(Pred)`

– *Description:* `Pred` is a user-defined predicate used to perform code translations. First argument will be binded to the corresponding term to be translated. Second argument must be binded to the corresponding translation. Third argument will be binded to the current module were first argument appears. Additional arguments will be user-defined.

86.4 Known bugs and planned improvements (`expansion_tools`)

- *pred(N)* meta-arguments are not supported at this moment.

87 Low-level concurrency/multithreading primitives

Author(s): Manuel Carro.

This module provides basic mechanisms for using concurrency and implementing multi-goal applications. It provides a means for arbitrary goals to be specified to be run in a separate stack set; in that case, they are assigned a goal identifier with which further accesses (e.g., asking for more solutions) to the goal can be made. Additionally, in some architectures, these goals can be assigned an O.S. thread, separate from the one which made the initial call, thus providing concurrency and, in multiprocessors, parallelism capabilities.

87.1 Usage and interface (concurrency)

- **Library usage:**
  `:- use_module(library(concurrency)).`
- **Exports:**
  - *Predicates:*
    `eng_call/4`, `eng_call/3`, `eng_backtrack/2`, `eng_cut/1`, `eng_release/1`, `eng_wait/1`, `eng_kill/1`, `eng_killothers/0`, `eng_self/1`, `goal_id/1`, `eng_goal_id/1`, `eng_status/0`, `lock_atom/1`, `unlock_atom/1`, `atom_lock_state/2`, `concurrent/1`.
- **Other modules used:**
  - *System library modules:*
    `foreign_interface/foreign_interface_properties`, `prolog_sys`.

87.2 Documentation on exports (concurrency)

eng_call/4: PREDICATE

Meta-predicate with arguments: `eng_call(goal,?,?,?)`.

Usage: `eng_call(Goal,EngineCreation,ThreadCreation,GoalId)`

- *Description:* Calls `Goal` in a new engine (stack set), possibly using a new thread, and returns a `GoalId` to designate this new goal henceforth. `EngineCreation` can be either `wait` or `create`; the distinction is not yet meaningful. `ThreadCreation` can be one of `self`, `wait`, or `create`. In the first case the creating thread is used to execute `Goal`, and thus it has to wait until its first result or failure. The call will fail if `Goal` fails, and succeed otherwise. However, the call will always suceed when a remote thread is started. The space and identifiers reclaimed for the thread must be explicitly deallocated by calling `eng_release/1`. `GoalId`s are unique in each execution of a Ciao Prolog program.
- *The following properties should hold at call time:*

  `Goal` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `EngineCreation` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ThreadCreation` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `GoalId` is a free variable. (term_typing:var/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`EngineCreation` is an atom. (basic_props:atm/1)

`ThreadCreation` is an atom. (basic_props:atm/1)

`GoalId` is an integer. (basic_props:int/1)

eng_call/3: PREDICATE

Meta-predicate with arguments: `eng_call(goal,?,?)`.

Usage: `eng_call(Goal,EngineCreation,ThreadCreation)`

- *Description:* Similar to `eng_call/4`, but the thread (if created) and stack areas are automatically released upon success or failure of the goal. No `GoalId` is provided for further interaction with the goal.
- *The following properties should hold at call time:*

  `Goal` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `EngineCreation` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ThreadCreation` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `EngineCreation` is an atom. (basic_props:atm/1)

  `ThreadCreation` is an atom. (basic_props:atm/1)

eng_backtrack/2: PREDICATE

Usage: `eng_backtrack(GoalId,ThreadCreation)`

- *Description:* Performs backtracking on the goal designed by `GoalId`. A new thread can be used to perform backtracking, according to `ThreadCreation` (same as in `eng_call/4`). Fails if the goal is backtracked over by the local thread, and there are no more solutions. Always succeeds if executed by a remote thread. The engine is **not** automatically released up upon failure: `eng_release/1` must be called to that end.
- *The following properties should hold at call time:*

  `GoalId` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ThreadCreation` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `GoalId` is an integer. (basic_props:int/1)

  `ThreadCreation` is an atom. (basic_props:atm/1)

eng_cut/1: PREDICATE

Usage: `eng_cut(GoalId)`

- *Description:* Performs a *cut* in the execution of the goal `GoalId`. The next call to `eng_backtrack/2` will therefore backtrack all the way and fail.
- *The following properties should hold at call time:*

  `GoalId` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `GoalId` is an integer. (basic_props:int/1)

eng_release/1: PREDICATE

Usage: `eng_release(GoalId)`

- *Description:* Cleans up and releases the engine executing the goal designed by `GoalId`. The engine must be idle, i.e., currently not executing any goal. `eng_wait/1` can be used to ensure this.
- *The following properties should hold at call time:*

  `GoalId` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `GoalId` is an integer. (basic_props:int/1)

eng_wait/1: PREDICATE

Usage: `eng_wait(GoalId)`

- *Description:* Waits for the engine executing the goal denoted by `GoalId` to finish the computation (i.e., it has finished searching for a solution, either with success or failure).
- *The following properties should hold at call time:*

  `GoalId` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `GoalId` is an integer. (basic_props:int/1)

eng_kill/1: PREDICATE

Usage: `eng_kill(GoalId)`

- *Description:* Kills the thread executing `GoalId` (if any), and frees the memory used up by the stack set. Usually one should wait (`eng_wait/1`) for a goal, and then release it, but killing the thread explicitly allows recovering from error states. A goal cannot kill itself. This feature should be used with caution, because there are situations where killing a thread might render the system in an unstable state. Threads should cooperate in their killing, but if the killed thread is blocked in a I/O operation, or inside an internal critical region, this cooperation is not possible and the system, although stopped, might very well end up in a incosistent state.
- *The following properties should hold at call time:*

  `GoalId` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `GoalId` is an integer. (basic_props:int/1)

eng_killothers/0: PREDICATE

Usage:

- *Description:* Kills threads and releases stack sets of all active goals, but the one calling `eng_killothers`. Again, a safety measure. The same cautions as with `eng_kill/1` should be taken.

eng_self/1: PREDICATE

Usage: `eng_self(GoalId)`

- *Description:* `GoalId` is unified with the identifier of the goal within which `eng_self/1` is executed. `eng_self/1` is deprecated, and eng_goal_id/1 should be used instead.
- *The following properties should hold at call time:*

  `GoalId` is an integer. (basic_props:int/1)

goal_id/1: PREDICATE

Usage: `goal_id(GoalId)`

- *Description:* `GoalId` is unified with the identifier of the goal within which `goal_id/1` is executed. `goal_id/1` is deprecated, and eng_goal_id/1 should be used instead.
- *The following properties should hold at call time:*

  `GoalId` is an integer. (basic_props:int/1)

eng_goal_id/1: PREDICATE

Usage: `eng_goal_id(GoalId)`

- *Description:* `GoalId` is unified with the identifier of the goal within which `eng_goal_id/1` is executed.
- *The following properties should hold at call time:*

  `GoalId` is an integer. (basic_props:int/1)

eng_status/0: PREDICATE

Usage:

- *Description:* Prints to standard output the current status of the stack sets.

lock_atom/1: PREDICATE

Usage 1:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

Usage 2: `lock_atom(Atom)`

- *Description:* The semaphore associated to `Atom` is accessed; if its value is nonzero, it is atomically decremented and the execution of this thread proceeds. Otherwise, the goal waits until a nonzero value is reached. The semaphore is then atomically decremented and the execution of this thread proceeds.
- *The following properties should hold at call time:*

  `Atom` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Atom` is an integer. (basic_props:int/1)

unlock_atom/1: PREDICATE

Usage 1:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

Usage 2: `unlock_atom(Atom)`

- *Description:* The semaphore associated to `Atom` is atomically incremented.
- *The following properties should hold at call time:*

  `Atom` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Atom` is an integer. (basic_props:int/1)

atom_lock_state/2: PREDICATE

Usage 1:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

  `Arg2` is an integer. (basic_props:int/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

Usage 2: `atom_lock_state(Atom,Value)`

- *Description:* Sets the semaphore associated to `Atom` to `Value`. This is usually done at the beginning of the execution, but can be executed at any time. If not called, semaphore associated to atoms are by default inited to 1. It should be used with caution: arbitrary use can transform programs using locks in a mess of internal relations. The change of a semaphore value in a place other than the initialization stage of a program is **not** among the allowed operations as defined by Dijkstra [Dij65,BA82].
- *The following properties should hold at call time:*

  `Atom` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Value` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Atom` is an integer. (basic_props:int/1)

  `Value` is an integer. (basic_props:int/1)

Usage 3: `atom_lock_state(Atom,Value)`

- *Description:* Consults the `Value` of the semaphore associated to `Atom`. Use sparingly and mainly as a medium to check state correctness. Not among the operations on semaphore by Djikstra.
- *The following properties should hold at call time:*

  `Atom` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Value` is a free variable. (term_typing:var/1)

  `Atom` is an atom. (basic_props:atm/1)

  `Value` is an integer. (basic_props:int/1)

concurrent/1: PREDICATE

`concurrent PredName`

The predicate named `PredName` is made concurrent in the current module at runtime (useful for predicate names generated on-the-fly). This difficults a better compile-time analysis, but in turn offers more flexibility to applications. It is also faster for some applications: if several agents have to share data in a stuctured fashion (e.g., the generator knows and wants to restrict the data generated to a set of other threads), a possibility

is to use the same concurrent fact and emply a field within the fact to distinguish the receiver/sender. This can cause many threads to access and wait on the same fact, which in turns can create contention problems. It is much better to create a new concurrent fact and to use that new name as a channel to communicate the different threads. `concurrent/1` can either be given a predicate spec in the form `Name/Arity`, with `Name` and `Arity` bound, or to give a value only to `Arity`, and let the system choose a new, unused `Name` for the fact.

Usage:

– *The following properties should hold at call time:*

`PredName` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

87.3 Known bugs and planned improvements (concurrency)

- Available only for Windows 32 environments and for architectures implementing POSIX threads.
- Some implementation of threads have a limit on the total number of threads that can be created by a process. Thread creation, in this case, just hangs. A better solution is planned for the future.

88 All solutions concurrent predicates

Author(s): Manuel Carro (concurrency-safeness).

This module implements thread-safe aggregation predicates. Its use and results should be the same as those in the aggregates library, but several goals can use them concurrently without the interference and wrong results (due to implementation reasons) aggregates might lead to. This particular implementation is completely based on the one used in the aggregates library (whose original authors were Richard A. O'Keefe and David H.D. Warren).

88.1 Usage and interface (conc_aggregates)

- **Library usage:**
  `:- use_module(library(conc_aggregates)).`
- **Exports:**
  - *Predicates:*
    `findall/3`, `setof/3`, `bagof/3`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`, `prolog_sys`.

88.2 Documentation on exports (conc_aggregates)

findall/3: PREDICATE

Meta-predicate with arguments: `findall(?,goal,?)`.

Usage: `findall(Template,Generator,List)` ⟨• ISO •⟩

- *Description:* A special case of bagof, where all free variables in the `Generator` are taken to be existentially quantified. Safe in concurrent applications.
- *The following properties should hold at call time:*

  `Generator` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties should hold upon exit:*

  `Template` is any term. (basic_props:term/1)

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Set` is a list. (basic_props:list/1)
- *The following properties should hold globally:*

  All calls of the form `findall(Template,Generator,List)` are deterministic. (native_props:is_det/1)

setof/3: PREDICATE

Usage: `setof(Template,Goal,Set)` ⟨• ISO •⟩

– *Description:* Finds the `Set` of instances of the `Template` satisfying the `Generator`. The set is in ascending order (see `compare/3` for a definition of this order) without duplicates, and is non-empty. If there are no solutions, `setof/3` fails. `setof/3` may succeed in more than one way, binding free variables in the `Generator` to different values. This can be avoided by using existential quantifiers on the free variables in front of the `Generator`, using `^/2`. E.g., in `A^p(A,B)`, `A` is existentially quantified. Safe in concurrent apllications.

– *The following properties should hold at call time:*

`Goal` is currently a term which is not a free variable. (term_typing:nonvar/1)

– *The following properties should hold upon exit:*

`Template` is any term. (basic_props:term/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`Set` is a list. (basic_props:list/1)

– *The following properties should hold globally:*

`Template` is not further instantiated. (basic_props:not_further_inst/2)

bagof/3: PREDICATE

Usage: `bagof(Template,Generator,Bag)` ⟨• ISO •⟩

– *Description:* Finds all the instances of the `Template` produced by the `Generator`, and returns them in the `Bag` in the order in which they were found. If the `Generator` contains free variables which are not bound in the `Template`, it assumes that this is like any other Prolog question and that you want bindings for those variables. This can be avoided by using existential quantifiers on the free variables in front of the `Generator`, using `^/2`. Safe in concurrent applications.

– *The following properties should hold at call time:*

`Generator` is currently a term which is not a free variable. (term_typing:nonvar/1)

– *The following properties should hold upon exit:*

`Template` is any term. (basic_props:term/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`Set` is a list. (basic_props:list/1)

– *The following properties should hold globally:*

`Template` is not further instantiated. (basic_props:not_further_inst/2)

88.3 Known bugs and planned improvements (conc_aggregates)

- Thread-safe `setof/3` is not yet implemented.
- Thread-safe `bagof/3` is not yet implemented.

89 The socket interface

Author(s): Manuel Carro, Daniel Cabeza.

This module defines primitives to open sockets, send, and receive data from them. This allows communicating with other processes, on the same machine or across the Internet. The reader should also consult standard bibliography on the topic for a proper use of these primitives.

89.1 Usage and interface (sockets)

- **Library usage:**
  `:- use_module(library(sockets)).`
- **Exports:**
  - *Predicates:*
    `connect_to_socket_type/4`, `connect_to_socket/3`, `bind_socket/3`, `socket_accept/2`, `select_socket/5`, `socket_send/2`, `socket_recv_code/3`, `socket_recv/2`, `socket_shutdown/2`, `hostname_address/2`.
  - *Regular Types:*
    `socket_type/1`, `shutdown_type/1`.
- **Other modules used:**
  - *System library modules:*
    `foreign_interface/foreign_interface_properties`.

89.2 Documentation on exports (sockets)

connect_to_socket_type/4: PREDICATE

Usage: `connect_to_socket_type(Host,Port,Type,Stream)`

- *Description:* Returns a `Stream` which connects to `Host`. The `Type` of connection can be defined. A `Stream` is returned, which can be used to `write/2` to, to `read/2`, to `socket_send/2` to, or to `socket_recv/2` from the socket.
- *Calls should, and exit will be compatible with:*
  `Host` is currently instantiated to an atom. (term_typing:atom/1)
  `Port` is an integer. (basic_props:int/1)
  `Type` is a valid socket type. (sockets:socket_type/1)
  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties should hold at call time:*
  `Host` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Port` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Type` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Stream` is a free variable. (term_typing:var/1)
- *The following properties hold globally:*
  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

connect_to_socket/3: PREDICATE

Usage: `connect_to_socket(Host,Port,Stream)`

- *Description:* Calls `connect_to_socket_type/4` with SOCK_STREAM connection type. This is the connection type you want in order to use the `write/2` and `read/2` predicates (and other stream IO related predicates).
- *Call and exit should be compatible with:*

  `Host` is an atom. (basic_props:atm/1)

  `Port` is an integer. (basic_props:int/1)

  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties should hold at call time:*

  `Host` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Port` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Stream` is a free variable. (term_typing:var/1)

bind_socket/3: PREDICATE

Usage: `bind_socket(Port,Length,Socket)`

- *Description:* Returs an AF_INET `Socket` bound to `Port` (which may be assigned by the OS or defined by the caller), and listens to it (hence no listen call in this set of primitives). `Length` specifies the maximum number of pending connections.
- *Calls should, and exit will be compatible with:*

  `Port` is an integer. (basic_props:int/1)

  `Length` is an integer. (basic_props:int/1)

  `Socket` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*

  `Length` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Socket` is a free variable. (term_typing:var/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

socket_accept/2: PREDICATE

Usage: `socket_accept(Sock,Stream)`

- *Description:* Creates a new `Stream` connected to `Sock`.
- *Calls should, and exit will be compatible with:*

  `Sock` is an integer. (basic_props:int/1)

  `Stream` is an open stream. (streams_basic:stream/1)
- *The following properties should hold at call time:*

  `Sock` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Stream` is a free variable. (term_typing:var/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

select_socket/5: PREDICATE

Usage: `select_socket(Socket,NewStream,TO_ms,Streams,ReadStreams)`

- *Description:* Wait for data available in a list of `Streams` and in a `Socket`. `Streams` is a list of Prolog streams which will be tested for reading. `Socket` is a socket (i.e., an integer denoting the O.S. port number) or a free variable. `TO_ms` is a number denoting a timeout. Within this timeout the `Streams` and the `Socket` are checked for the availability of data to be read. `ReadStreams` is the list of streams belonging to `Streams` which have data pending to be read. If `Socket` was a free variable, it is ignored, and `NewStream` is not checked. If `Socket` was instantiated to a port number and there are connections pending, a connection is accepted and connected with the Prolog stream in `NewStream`.
- *Calls should, and exit will be compatible with:*

  `Socket` is an integer. (basic_props:int/1)

  `NewStream` is an open stream. (streams_basic:stream/1)

  `TO_ms` is an integer. (basic_props:int/1)

  `Streams` is a list of `streams`. (basic_props:list/2)

  `ReadStreams` is a list of `streams`. (basic_props:list/2)
- *The following properties should hold at call time:*

  `Socket` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `NewStream` is a free variable. (term_typing:var/1)

  `TO_ms` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Streams` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ReadStreams` is a free variable. (term_typing:var/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

socket_send/2: PREDICATE

Usage: `socket_send(Stream,String)`

- *Description:* Sends `String` to the socket associated to `Stream`. The socket has to be in connected state. `String` is not supposed to be NULL terminated, since it is a Prolog string. If a NULL terminated string is needed at the other side, it has to be explicitly created in Prolog.
- *Calls should, and exit will be compatible with:*

  `Stream` is an open stream. (streams_basic:stream/1)

  `String` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `String` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

socket_recv_code/3: PREDICATE

Usage: `socket_recv_code(Stream,String,Length)`

- *Description:* Receives a `String` from the socket associated to `Stream`, and returns its `Length`. If `Length` is -1, no more data is available.
- *Calls should, and exit will be compatible with:*

  `Stream` is an open stream. (streams_basic:stream/1)

  `String` is a string (a list of character codes). (basic_props:string/1)

  `Length` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*

  `Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

socket_recv/2: PREDICATE

Usage: `socket_recv(Stream,String)`

- *Description:* As `socket_recv_code/3`, but the return code is ignored.
- *Call and exit should be compatible with:*

  `Stream` is an open stream. (streams_basic:stream/1)

  `String` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)

socket_shutdown/2: PREDICATE

Usage: `socket_shutdown(Stream,How)`

- *Description:* Shut down a duplex communication socket with which `Stream` is associated. All or part of the communication can be shutdown, depending on the value of `How`. The atoms `read`, `write`, or `read_write` should be used to denote the type of closing required.
- *Calls should, and exit will be compatible with:*

  `Stream` is an open stream. (streams_basic:stream/1)

  `How` is a valid shutdown type. (sockets:shutdown_type/1)
- *The following properties should hold at call time:*

  `Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `How` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

hostname_address/2: PREDICATE

Usage: `hostname_address(Hostname,Address)`

- *Description:* `Address` is unified with the atom representing the address (in AF_INET format) corresponding to `Hostname`.
- *Calls should, and exit will be compatible with:*

  `Hostname` is an atom. (basic_props:atm/1)

  `Address` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `Hostname` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

socket_type/1: REGTYPE

Defines the atoms which can be used to specify the socket type recognized by `connect_to_socket_type/4`. Defined as follows:

```
socket_type(stream).
socket_type(dgram).
socket_type(raw).
socket_type(seqpacket).
socket_type(rdm).
```

Usage: `socket_type(T)`

- *Description:* `T` is a valid socket type.

shutdown_type/1: REGTYPE

Usage: `shutdown_type(T)`

- *Description:* `T` is a valid shutdown type.

90 Sockets I/O

Author(s): Francisco Bueno.

This module provides two useful predicates for programming with sockets.

90.1 Usage and interface (sockets_io)

- **Library usage:**
  `:- use_module(library(sockets_io)).`
- **Exports:**
  - *Predicates:*
    `serve_socket/3`, `safe_write/2`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `sockets/sockets`.

90.2 Documentation on exports (sockets_io)

serve_socket/3: PREDICATE

Meta-predicate with arguments: `serve_socket(?,(pred 1),(pred 1))`.

Usage: `serve_socket(Socket,Server,Handler)`

- *Description:* Handles the streams associated to `Socket` calling `Server` on one request of each stream (as `Server(Stream)`), and `Handler(Stream)` if the stream is empty (connection closed).
- *The following properties should hold at call time:*

  `Socket` is a socket id. (sockets_io:socket/1)

  `Server` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Handler` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

safe_write/2: PREDICATE

Usage: `safe_write(Stream,Term)`

- *Description:* Writes `Term` to `Stream` in a way that it is safe for a socket connection on `Stream`.
- *The following properties should hold at call time:*

  `Stream` is an open stream. (streams_basic:stream/1)

  `Term` is any term. (basic_props:term/1)

91 The Ciao Make Package

Author(s): Manuel Hermenegildo.

This package is used mainly in two main ways:

- When writing `Makefile`s for `lpmake`.
- When writing *applications* which use the `make` library.

In both cases, this is the package that defines the syntax and meaning of the dependency rules used.

91.1 Usage and interface (`make_doc`)

- **Library usage:**
  - When writing `Makefile`s for `lpmake`, such makefiles start with:

    ```
    :- module(_,_,[make]).
    ```

    or

    ```
    :- make(_,_).
    ```

    (The latter uses the feature that an undefined declaration at the beginning of a file is interpreted by Ciao as a `use_module/3` including as third argument a package with the same name, in this case `make`.)
  - When writing *applications* which use the `make` package, then it is loaded as any other package within the application.

  Note: It is often useful to use the `fsyntax` package inside a `Makefile` (or when when using the `make` library in other applications). If both `make` and `fsyntax` are used, then `make` should appear **before** `fsyntax` in the list of packages.
- **New operators defined:**

  `::/2` [978,xfy], `<-/2` [977,xfy], `<=/2` [975,xfy], `<-/1` [977,yf].
- **Other modules used:**
  - *System library modules:*

    `make/make_rt`.

91.2 Other information (`make_doc`)

91.2.1 The Dependency Rules

The package allows defining the following types of rules:

TargetSuffix `<=` *SourceSuffix* `::` *SourceRoot* `:-` *BodyLiterals*`.`

A rule of this form declares that in order to produce the file with suffix *TargetSuffix* from a source file with the suffix *SourceSuffix* and root name *SourceRoot* the commands in *BodyLiterals* must be executed. *BodyLiterals* is a standard Ciao Prolog clause body, i.e., a comma-separated conjunction of literals. When writing the script, *SourceRoot* is typically left as a variable, to be instantiated by `lpmake` when the script is run to the root of name of the file to be processed. This allows using the value of *SourceRoot* in *BodyLiterals*. For example, the following rule:

```
:- use_module(library(terms), [atom_concat/2]).

dvi <= tex :: FileRoot :-
        atom_concat(['latex ',FileRoot,'.tex'],Command),
        system(Command).
```

states that we can generate a file *File*`.dvi` if we have a file named *File*`.tex` and that the command to do so is `latex` *File*`.tex`. Thus, if this rule appears in file `Makefile.pl` and we issue the command `lpmake paper.dvi` the following occurs:

- If `paper.dvi` does not exist and `paper.tex` exists, then `paper.dvi` is generated from `paper.tex` by issuing the system command `latex paper.tex`.
- If `paper.dvi` already exists, nothing is done.
- If `paper.tex` does not exist, an error is reported.

Target `<- :-` *BodyLiterals*`.`

A rule of this form declares that in order to produce the file *Target* the commands in *BodyLiterals* must be executed. *Target* need not be a real file: it can also be simply the name of the rule, which is used to invoke it (as a procedure name). For example, the following rule, when the command `lpmake realclean` is issued, deletes temporary files in the LaTeX application:

```
:- use_module(library(make(system_extra))).

clean <- :-
        ls('*aux|*log|*~',Files)
        delete_files(Files).
```

Target `<-` *Deps* `:-` *BodyLiterals*`.`

A rule of this form declares that in order to produce the file *Target*, first targets *Deps* will be called (i.e., the elements of *Deps* are either other targets with rules defined for them, or a file or files which are already present or which can –and will be– generated from other available files using other rules). Then, the commands in *BodyLiterals* will be executed. *Deps* may be one target or a list of targets. For example, the following rule, when the command `lpmake realclean` is issued, cleans all the temporary files in the LaTeX application (including `.dvi` and `.ps` files). It requires that clean be executed first:

```
:- use_package(fsyntax).
:- use_module(library(make(system_extra))).

realclean <- clean :-
        delete_files(~ls('*dvi|*ps')).
```

The following rule states that in order to meet the target `view`, target `paper.ps` must be available or generated. For example, `lpmake view` can be used to call the `ghostview` visualizer on `paper.ps`. Note the use of a globally defined *predicate* `main` which is called in two places in the rule, and could be used in other rules in the same file (`main := paper.` is equivalent to the fact `main(paper).` –see the `fsyntax` library):

```
:- use_package(fsyntax).
:- use_module(library(make(system_extra))).
:- use_module(library(terms), [atom_concat/2]).

main := paper.

view <- ~atom_concat([~main,'.ps']) :-
```

```
                        system(~atom_concat(['ghostview ',~main,'.ps'])).
```

In addition to these rules, the configuration file can define normal predicates in the usual way, or import predicates from other modules, all of which can be called from the bodies of the dependency rules. For example, the `system_extra` library (an extension of the `system` library) defines many system predicates in a form which makes them very useful inside `Makefiles`, specially if the `fsyntax` package is used (see the examples below).

If `lpmake` is called without an explicit target as argument, then the first target rule in the Makefile is used. This is useful in that the first rule can be seen as the default rule.

91.2.2 Specifying Paths

Using the `vpath/1` predicate it is possible in configuration files to define several paths in which files related to the rules can be located. In this way, not all files need to be in the same directory as the configuration file. For example:

```
:- use_package(fsyntax).

vpath := '/home/clip/Systems/ciao/lib'.
vpath := '/home/clip/Systems/ciao/library'.
vpath := '/home/clip/Systems/lpdoc/lib'.
```

91.2.3 Documenting Rules

It is also possible to define documentation for the rules:

`target_comment(`*Target*`) :-` *BodyLiterals*`.`

A rule of this form allows documenting the actions related to the target. The body (*BodyLiterals*) will be called in two circumstances:

- If *Target* is called during execution of '`lpmake` *commands*'.
- When calling '`lpmake -h`'.

Using noun forms (*generation of foo* instead of *generating foo*) in comments helps this dual purpose. For example, the following rule:

```
target_comment(realclean) :-
        display('Cleanup of all generated files.').
```

will produce output in the two cases pointed out above.

`dependency_comment(`*SourceSuffix*`,` *TargetSuffix*`,` *SourceRoot*`) :-` *BodyLiterals*`.`

Same as the previous rule, but for suffix rules. See, for example, the following generic rule:

```
:- use_module(library(terms), [atom_concat/2]).

dependency_comment(SSuffix,TSuffix,FileBase) :-
        display(~atom_concat(['Generation of ',FileBase,'.',
        TSuffix, ' from ',FileBase,'.',SSuffix])).
```

91.2.4 An Example of a Makefile

The following is a simple example of a Makefile showing some basic functionality (this is `MakefileExample.pl` in the `example_simple` directory in the `make` library.):

```
%% ---------------------------------------------------------------------------
:- module(_,_,[make,fsyntax]).
:- use_module(library(make(system_extra))).
```

```
:- use_module(library(lists), [append/3]).
:- use_module(library(terms), [atom_concat/2]).

:- discontiguous(comment/2).

%% ---------------------------------------------------------------------------
%% A simple target. Defines how to produce file 'hw'.

hw <-  []    :-
         writef("Hello world", hw).

%% A comment describing this target (see below):
comment(hw,['Generation of file hw']).

%% ---------------------------------------------------------------------------
%% A target with a dependency. 'hwhw' requires 'hw'.

hwhw <- [hw] :-
        readf(hw,Content),
        append(Content,[0'\n|Content],DoubleContent),
        writef(DoubleContent,hwhw).

comment(hwhw,['Generation of file hwhw']).

%% ---------------------------------------------------------------------------
%% A simple target. Defines how to produce file 'datafile.simple'.

'datafile.simple' <-  :-
        writef("Hello world", 'datafile.simple').

comment('datafile.simple',['Generation of file datafile.simple']).

%% ---------------------------------------------------------------------------
%% A dependency based on suffixes:
%% <file>.double is generated always from <file>.simple

double <= simple :: Name :-
        readf(~atom_concat([Name,'.simple']),Content),
        append(Content,[0'\n|Content],DoubleContent),
        writef(DoubleContent,~atom_concat([Name,'.double'])).

%% ---------------------------------------------------------------------------
%% A dependency based on suffixes with a precondition.
%% <file>.double is generated always from <file>.simple, once
%% precond is done

boo <- :-
        display((double <= simple :: name <- precond :- body1, body2)).

%% ---------------------------------------------------------------------------
%% Example using library predicates
```

```
clean <- [] # "Cleanup of temporary files " :-
        delete_files(~ls('*~|*.asr|*.itf|*.po')).

realclean <- clean :-
        delete_files(~ls('hw|hwhw|*simple|*double')).

comment(realclean,['Cleanup of all generated files']).

%% ------------------------------------------------------------------------
%% Reporting progress and documenting commands:
%% If target_comment/1 is defined it can be used to produce user-defined
%% output when targets are processed and/or documentation on what each
%% target does (used for example when lpmake is called with -h). Using
%% 'generation of foo' instead of 'generating foo' in comments helps in this
%% dual purpose.
%% ------------------------------------------------------------------------

:- push_prolog_flag(multi_arity_warnings,off).
%% Make calls target_comment/1 for simple targets:
target_comment(Target) :-
        comment(Target,Comment),
        display(~atom_concat([~atom_concat(Comment), '\n'])).
:- pop_prolog_flag(multi_arity_warnings).

%% Similarly, make calls dependency_comment/3 for dependencies (only
%% during execution, not when documenting -h).
dependency_comment(SSuffix,TSuffix,FileBase) :-
        display(~atom_concat(['Generation of ',FileBase,TSuffix,
                             ' from ',FileBase,SSuffix,'\nl'])).
```

The following are a few commands that can be used on the previous file (see file `CommandsToTry` in the `example_simple` directory in the `make` library):

```
lpmake -m MakefileExample.pl hwhw
(Generate file hwhw --needs to generate file hw first)

lpmake -m MakefileExample.pl datafile.double
(Generate file datafile.double --needs to generate file
datafile.simple first)

lpmake -m MakefileExample.pl realclean
(Cleanup)

lpmake -h -m MakefileExample.pl
(Help on general use of lpmake and commands available in MakefileExample.pl)
```

See also the LaTeX example in the `example_latex` directory in the `make` library.

92 Predicates Available When Using The Make Package

Author(s): Manuel Hermenegildo, Edison Mera.

This is the run-time module which implements the predicates which are provided when using the `make` library package in a given application. For example, they are used internally by `lpmake`.

92.1 Usage and interface (`make_rt`)

- **Library usage:**
  This module is loaded automatically when the `make` library package is used.
- **Exports:**
  - *Predicates:*
    `make/1`, `make_option/1`, `verbose_message/1`, `verbose_message/2`, `dot_concat/2`, `call_unknown/1`, `all_values/2`, `get_value/2`, `get_value_def/3`, `get_all_values/2`, `name_value/2`, `set_name_value/2`, `cp_name_value/2`, `get_name_value/3`, `get_name_value_string/3`, `add_name_value/2`, `del_name_value/1`, `check_var_exists/1`, `find_file/2`, `vpath/1`, `add_vpath/1`, `vpath_mode/3`, `add_vpath_mode/3`, `bold_message/1`, `bold_message/2`, `normal_message/2`, `bolder_message/1`, `bolder_message/2`, `newer/2`, `register_module/1`, `unregister_module/1`, `push_name_value/3`, `pop_name_value/1`, `push_active_config/1`, `pop_active_config/0`, `get_active_config/1`, `dyn_load_cfg_module_into_make/1`, `get_settings_nvalue/1`, `apply_vpath_mode/4`, `get_name/2`.
  - *Regular Types:*
    `target/1`.
- **Other modules used:**
  - *System library modules:*
    `compiler/compiler`, `filenames`, `terms`, `system`, `format`, `lists`, `messages`, `make/up_to_date`, `aggregates`.

92.2 Documentation on exports (`make_rt`)

make/1: PREDICATE

Usage: `make(TargetList)`

- *Description:* This is the main entry point to the make library. It makes the list of targets one by one as well as any intermediate targets needed as dictated by the dependency rules.
- *The following properties should hold at call time:*
  `TargetList` is a list of `targets`. (basic_props:list/2)

target/1: REGTYPE

Usage: `target(T)`

- *Description:* `T` is a Makefile target.

make_option/1: PREDICATE

The predicate is of type *data*.

Usage: `make_option(Option)`

- *Description:* Asserting/retracting facts of this predicate sets/clears library options. Default is no options (i.e., the predicate is undefined). The following values are supported:

```
make_option('-v'). % Verbose: prints progress messages (useful
                   % for debugging rules).
```

- *The following properties should hold at call time:*

  `Option` is an atom. (basic_props:atm/1)

verbose_message/1: PREDICATE

No further documentation available for this predicate.

verbose_message/2: PREDICATE

Usage: `verbose_message(Text,ArgList)`

- *Description:* The text provided in `Text` is printed as a message, using the arguments in `ArgList`, if `make_option('-v')` is defined. Otherwise nothing is printed.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (format:format_control/1)

  `ArgList` is a list. (basic_props:list/1)

dot_concat/2: PREDICATE

No further documentation available for this predicate.

call_unknown/1: PREDICATE

No further documentation available for this predicate.

all_values/2: PREDICATE

No further documentation available for this predicate.

get_value/2: PREDICATE

No further documentation available for this predicate.

get_value_def/3: PREDICATE

No further documentation available for this predicate.

get_all_values/2: PREDICATE

Usage: `get_all_values(Name,Values)`

– *Description:* `Values` are all the possible values of `Name`.

name_value/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *data*.

set_name_value/2: PREDICATE

No further documentation available for this predicate.

cp_name_value/2: PREDICATE

Usage: `cp_name_value(Source,Target)`

– *Description:* Copy the variable values from `Source` to `Target`

– *The following properties should hold at call time:*

`Source` is an atom. (basic_props:atm/1)

`Target` is an atom. (basic_props:atm/1)

get_name_value/3: PREDICATE

No further documentation available for this predicate.

get_name_value_string/3: PREDICATE

No further documentation available for this predicate.

add_name_value/2: PREDICATE

No further documentation available for this predicate.

del_name_value/1: PREDICATE

No further documentation available for this predicate.

check_var_exists/1: PREDICATE

Usage: `check_var_exists(Var)`

– *Description:* Fails printing a message if variable `Var` does not exist.

find_file/2: PREDICATE

No further documentation available for this predicate.

vpath/1: PREDICATE

No further documentation available for this predicate.

The predicate is of type *data*.

add_vpath/1: PREDICATE

No further documentation available for this predicate.

vpath_mode/3: PREDICATE

No further documentation available for this predicate.

The predicate is of type *data*.

add_vpath_mode/3: PREDICATE

No further documentation available for this predicate.

bold_message/1: PREDICATE

No further documentation available for this predicate.

bold_message/2: PREDICATE

No further documentation available for this predicate.

normal_message/2: PREDICATE

No further documentation available for this predicate.

bolder_message/1: PREDICATE

No further documentation available for this predicate.

bolder_message/2: PREDICATE

No further documentation available for this predicate.

newer/2: PREDICATE

No further documentation available for this predicate.

register_module/1: PREDICATE

No further documentation available for this predicate.

unregister_module/1: PREDICATE

No further documentation available for this predicate.

push_name_value/3: PREDICATE

Usage: `push_name_value(Name,Var,R)`

- *Description:* Push variable name `Name` with all values of variable `Var` and returns `R`, an abstract type to pass to `pop_name_value/1` to undo the push changes. Push cannot be nested.

pop_name_value/1: PREDICATE

Usage: `pop_name_value(R)`

- *Description:* Restores the value of the variable indicated by the abstract type `R`. Notice that `R` _must be_ the argument returned by `push_name_value/2`.

push_active_config/1: PREDICATE

No further documentation available for this predicate.

pop_active_config/0: PREDICATE

No further documentation available for this predicate.

get_active_config/1: PREDICATE

No further documentation available for this predicate.

dyn_load_cfg_module_into_make/1: PREDICATE

Usage: `dyn_load_cfg_module_into_make(ConfigFile)`

- *Description:* Used to load dynamically a module (typically, a `Makefile`) into the make library from the application using the library.
- *The following properties should hold at call time:*

  `ConfigFile` is a source name. (streams_basic:sourcename/1)

get_settings_nvalue/1: PREDICATE

Usage: `get_settings_nvalue(Pred)`

- *Description:* Executes `Pred` as unkown call, in other words, it is useful to execute predicates that have been loaded by `register_module/1`.

  Example: get_settings_nvalue(component_options(ciao, A, B)).
- *The following properties should hold at call time:*

  `Pred` is any term. (basic_props:term/1)

apply_vpath_mode/4: PREDICATE

No further documentation available for this predicate.

get_name/2: PREDICATE

Usage: `get_name(Path,Name)`

– *Description:* `Name` is the file name for the path `Path`

up_to_date/2: (UNDOC_REEXPORT)

Imported from `up_to_date` (see the corresponding documentation for details).

92.3 Known bugs and planned improvements (`make_rt`)

- The current handle of help messages is defficient. It must be in a standar form, and the user of this library only must be allowed to add messages, not procedures to print it.
- target_comment/1 does not work, why? :-(.

93 Additional operating system utilities

Author(s): Manuel Hermenegildo.

This is a (temporary) extension to library `system` (which it reexports). It implements functionality that is often convenient in `Makefiles`. Much of this should probably end up eventually in `system`, but once we have worked out the best interface and, in some cases, the proper implementation (the implementations in here are in some cases just calls to Un*x shell primitives or commands).

93.1 Usage and interface (system_extra)

- **Library usage:**
  `:- use_module(library(system_extra)).`
- **Exports:**
  - *Predicates:*
    `del_dir_if_empty/1`, `move_files/2`, `move_file/2`, `copy_files/2`, `copy_files/3`, `copy_files_nofail/3`, `cat/2`, `cat_append/2`, `symbolic_link/2`, `symbolic_link/3`, `delete_files/1`, `del_files_nofail/1`, `del_file_nofail/1`, `del_file_nofail/2`, `del_endings_nofail/2`, `ls/3`, `ls/2`, `filter_alist_pattern/3`, `--/1`, `do/2`, `do/3`, `do/4`, `do/5`, `try_finally/3`, `set_owner/2`, `readf/2`, `datime_string/1`, `datime_string/2`, `datime_atom/1`, `datime_atom/2`, `no_tr_nl/2`, `replace_strings/3`, `replace_strings_in_file/3`, `writef/3`, `writef/2`, `add_suffix/3`, `add_preffix/3`, `writef_list/3`, `writef_list/2`, `etags/2`, `any_to_term/2`, `touch/1`.
  - *Regular Types:*
    `pattern/1`, `do_options/1`.
- **Other modules used:**
  - *System library modules:*
    `regexp/regexp_code`, `system`, `messages`, `terms`, `lists`, `llists`, `sort`, `read`, `write`, `file_utils`, `distutils/setperms`.

93.2 Documentation on exports (system_extra)

del_dir_if_empty/1: PREDICATE

No further documentation available for this predicate.

move_files/2: PREDICATE

`move_files(Files,Dir)`

Move `Files` to directory `Dir` (note that to move only one file to a directory, `rename_file/2` can be used).

Usage:

- *The following properties should hold at call time:*
  `Files` is a list of `atm`s. (basic_props:list/2)
  `Dir` is an atom. (basic_props:atm/1)

move_file/2: PREDICATE

No further documentation available for this predicate.

copy_files/2: PREDICATE

`copy_files(Files,Dir)`

Copy `Files` to directory `Dir` (note that to move only one file to a directory, `rename_file/2` can be used).

Usage:

– *The following properties should hold at call time:*

`Files` is a list of `atm`s. (basic_props:list/2)

`Dir` is an atom. (basic_props:atm/1)

copy_files/3: PREDICATE

No further documentation available for this predicate.

copy_files_nofail/3: PREDICATE

No further documentation available for this predicate.

cat/2: PREDICATE

No further documentation available for this predicate.

cat_append/2: PREDICATE

No further documentation available for this predicate.

symbolic_link/2: PREDICATE

Usage: `symbolic_link(Source,Dir)`

– *Description:* Create a symbolic link in `Dir` pointing to file or directory `Source` (performs a copy in Windows).

symbolic_link/3: PREDICATE

Usage: `symbolic_link(Source,Dir,NewName)`

– *Description:* Create a symbolic link in `Dir` pointing to file or directory `Source` and give it name `NewName` (performs a copy in Windows).

delete_files/1: PREDICATE

No further documentation available for this predicate.

del_files_nofail/1: PREDICATE

No further documentation available for this predicate.

del_file_nofail/1: PREDICATE

No further documentation available for this predicate.

del_file_nofail/2: PREDICATE

No further documentation available for this predicate.

del_endings_nofail/2: PREDICATE

No further documentation available for this predicate.

ls/3: PREDICATE

`ls(Directory,Pattern,FileList)`

`FileList` is the unordered list of entries (files, directories, etc.) in `Directory` whose names match `Pattern`.If `Directory` does not exist `FileList` is empty.

Usage:

- *The following properties should hold at call time:*

  `Directory` is an atom. (basic_props:atm/1)

  system_extra:pattern(Pattern) (system_extra:pattern/1)

  `FileList` is a free variable. (term_typing:var/1)

- *The following properties hold upon exit:*

  `FileList` is a list of `atms`. (basic_props:list/2)

ls/2: PREDICATE

`ls(Pattern,FileList)`

`FileList` is the unordered list of entries (files, directories, etc.) in the current directory whose names match `Pattern` (same as `ls('.',Pattern,FileList)`).

Usage:

- *The following properties should hold at call time:*

  system_extra:pattern(Pattern) (system_extra:pattern/1)

  `FileList` is a free variable. (term_typing:var/1)

- *The following properties hold upon exit:*

  `FileList` is a list of `atms`. (basic_props:list/2)

filter_alist_pattern/3: PREDICATE

`filter_alist_pattern(UnFiltered,Pattern,Filtered)`

`Filtered` contains the elements of `UnFiltered` which match with `Pattern`.

Usage:

– *The following properties should hold at call time:*
`UnFiltered` is a list of `atm`s. (basic_props:list/2)
system_extra:pattern(Pattern) (system_extra:pattern/1)
`Filtered` is a free variable. (term_typing:var/1)
– *The following properties hold upon exit:*
`Filtered` is a list of `atm`s. (basic_props:list/2)

-/1: PREDICATE

No further documentation available for this predicate.
Meta-predicate with arguments: `-goal`.

–/1: PREDICATE

No further documentation available for this predicate.
Meta-predicate with arguments: `--goal`.

do/2: PREDICATE

Usage: `do(Command,Action)`
– *Description:* Same as `do/3` but omitting the return code.
– *The following properties should hold at call time:*
`Command` is a list of `atm`s. (basic_props:list/2)
`Action` is a list of `do_option`ss. (basic_props:list/2)

do/3: PREDICATE

Usage: `do(Command,Action,ReturnCode)`
– *Description:* Same as `do/5` but omitting the files.
– *The following properties should hold at call time:*
`Command` is a list of `atm`s. (basic_props:list/2)
`Action` is a list of `do_option`ss. (basic_props:list/2)
– *The following properties should hold upon exit:*
`ReturnCode` is a number. (basic_props:num/1)

do/4: PREDICATE

Usage: `do(Command,OutputFile,ErrorFile,Action)`
– *Description:* Same as `do/5` but omitting the returned code.
– *The following properties should hold at call time:*
`Command` is a list of `atm`s. (basic_props:list/2)
`OutputFile` is an atom. (basic_props:atm/1)
`ErrorFile` is an atom. (basic_props:atm/1)
`Action` is a list of `do_option`ss. (basic_props:list/2)

do/5: PREDICATE

Usage: `do(Command,OutputFile,ErrorFile,Action,ReturnCode)`

– *Description:* Executes `Command` redirecting standard output to `OutputFile` and standard error to `ErrorFile`. `ReturnCode` is the code returned by the execution of `Command`. `Action` is a list of atoms that specify the actions to be completed in case the `Command` fails. Three of these options: `fail`, `exception`, and `nofail` are mutually exclusive. The rest of the options are flags that mean (type `do_options/1`):

`inform_nofail`: informs about the error code returned by the execution of the command.

`show_output_on_error`: shows the content of `OutputFile` in case of error.

`show_error`: shows the content of `ErrorFile` in case of error.

`silent`: do not print any error message. The option `inform_nofail` overrides this option in case of `fail`.

`verbose_command`: shows the command before being executed. Useful for tracing.

`verbose`: `verbose_command` plus overrides the error and output file settings and outputs everything to `user_output` and `user_error`.

– *The following properties should hold at call time:*

`Command` is a list of `atm`s. (basic_props:list/2)

`OutputFile` is an atom. (basic_props:atm/1)

`ErrorFile` is an atom. (basic_props:atm/1)

`Action` is a list of `do_options`s. (basic_props:list/2)

– *The following properties should hold upon exit:*

`ReturnCode` is a number. (basic_props:num/1)

try_finally/3: PREDICATE

Meta-predicate with arguments: `try_finally(goal,goal,goal)`.

Usage: `try_finally(Start,Goal,End)`

– *Description:* Calls initialization goal `Start` and then calls Goal `Goal`, but always continues with the evaluation of `End`. If `Goal` is non-deterministic, in case of backtracking `Start` is called again before redoing `Goal`.

set_owner/2: PREDICATE

No further documentation available for this predicate.

readf/2: PREDICATE

No further documentation available for this predicate.

datime_string/1: PREDICATE

No further documentation available for this predicate.

datime_string/2: PREDICATE

No further documentation available for this predicate.

datime_atom/1: PREDICATE
No further documentation available for this predicate.

datime_atom/2: PREDICATE
No further documentation available for this predicate.

no_tr_nl/2: PREDICATE
No further documentation available for this predicate.

replace_strings/3: PREDICATE
No further documentation available for this predicate.

replace_strings_in_file/3: PREDICATE
No further documentation available for this predicate.

writef/3: PREDICATE
No further documentation available for this predicate.

writef/2: PREDICATE
No further documentation available for this predicate.

add_suffix/3: PREDICATE
No further documentation available for this predicate.

add_preffix/3: PREDICATE
No further documentation available for this predicate.

writef_list/3: PREDICATE
No further documentation available for this predicate.

writef_list/2: PREDICATE
No further documentation available for this predicate.

etags/2: PREDICATE
No further documentation available for this predicate.

any_to_term/2: PREDICATE

`any_to_term(Any,Term)`

Interprets the result of print `Any` as a term `Term`

touch/1: PREDICATE

`touch(File)`

Updates the access and modification time of `File` to current time.

pattern/1: REGTYPE

A regular type, defined as follows:

```
pattern(A) :-
        atom(A).
```

do_options/1: REGTYPE

A regular type, defined as follows:

```
do_options(fail).
do_options(nofail).
do_options(silent).
do_options(exception).
do_options(halt).
do_options(inform_nofail).
do_options(show_output_on_error).
do_options(show_error_on_error).
do_options(verbose).
do_options(verbose_command).
```

system_error_report/1: (UNDOC_REEXPORT)

Imported from `system` (see the corresponding documentation for details).

replace_characters/4: (UNDOC_REEXPORT)

Imported from `system` (see the corresponding documentation for details).

no_swapslash/3: (UNDOC_REEXPORT)

Imported from `system` (see the corresponding documentation for details).

cyg2win/3: (UNDOC_REEXPORT)

Imported from `system` (see the corresponding documentation for details).

winpath_c/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

winpath/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

winpath/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

using_windows/0: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

rename_file/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

delete_directory/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

delete_file/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

set_exec_mode/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

chmod/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

chmod/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

fmode/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

modif_time0/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

modif_time/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_properties/6: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_property/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_exists/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_exists/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

mktemp_in_tmp/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

mktemp/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

directory_files/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

wait/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

exec/8: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

exec/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

exec/4: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

popen_mode/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

popen/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

system/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

system/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

shell/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

shell/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

shell/0: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

cd/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

working_directory/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

make_dirpath/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

make_dirpath/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

make_directory/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

make_directory/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

umask/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

current_executable/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

current_host/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_address/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_tmp_dir/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_grnam/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_pwnam/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_gid/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_uid/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

get_pid/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

file_dir_name/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

extract_paths/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

dir_path/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

copy_file/3: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

copy_file/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

c_errno/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

del_env/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

set_env/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

current_env/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

setenvstr/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

getenvstr/2: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

datime_struct/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

datime/9: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

datime/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

time/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

pause/1: (UNDOC_REEXPORT)
Imported from `system` (see the corresponding documentation for details).

execute_permissions/4: (UNDOC_REEXPORT)
Imported from `setperms` (see the corresponding documentation for details).

execute_permissions/2: (UNDOC_REEXPORT)
Imported from `setperms` (see the corresponding documentation for details).

convert_permissions/4: (UNDOC_REEXPORT)
Imported from `setperms` (see the corresponding documentation for details).

convert_permissions/2: (UNDOC_REEXPORT)
Imported from `setperms` (see the corresponding documentation for details).

mkdir_perm/2: (UNDOC_REEXPORT)
Imported from `setperms` (see the corresponding documentation for details).

set_exec_perms/2: (UNDOC_REEXPORT)
Imported from `setperms` (see the corresponding documentation for details).

set_perms/2: (UNDOC_REEXPORT)
Imported from `setperms` (see the corresponding documentation for details).

get_perms/2: (UNDOC_REEXPORT)
Imported from `setperms` (see the corresponding documentation for details).

PART VII - Ciao extensions

Author(s): The CLIP Group.

The libraries documented in this part extend the Ciao language in several different ways. The extensions include:

- pure Prolog programming (well, this can be viewed more as a restriction than an extension);
- feature terms or *records* (i.e., structures with names for each field);
- parallel programming (e.g., &-Prolog style);
- functional syntax;
- higher-order library;
- global variables;
- `setarg` and `undo`;
- delaying predicate execution;
- active modules;
- breadth-first execution;
- iterative deepening-based execution;
- constraint logic programming;
- object oriented programming.

94 Pure Prolog package

Author(s): The CLIP Group.

This library package allows the use of *pure Prolog* in a Ciao module/program. It is based on the fact that if an *engine module* is imported explicitly then all of them have to be imported explicitly. The engine modules are:

- `engine(arithmetic)`
  Chapter 20 [Arithmetic], page 151.
- `engine(atomic_basic)`
  Chapter 19 [Basic predicates handling names of constants], page 141.
- `engine(attributes)`
  Chapter 28 [Attributed variables], page 201.
- `engine(basic_props)`
  Chapter 15 [Basic data types and properties], page 105.
- `engine(basiccontrol)`
  Chapter 13 [Control constructs/predicates], page 99.
- `engine(data_facts)`
  Chapter 25 [Fast/concurrent update of facts], page 187.
- `engine(exceptions)`
  Chapter 23 [Exception and Signal handling], page 177.
- `engine(io_aux)`
  Chapter 27 [Message printing primitives], page 197.
- `engine(io_basic)`
  Chapter 22 [Basic input/output], page 169.
- `engine(prolog_flags)`
  Chapter 24 [Changing system behaviour and various flags], page 181.
- `engine(streams_basic)`
  Chapter 21 [Basic file/stream handling], page 159.
- `engine(system_info)`
  Chapter 29 [Gathering some basic internal info], page 205.
- `engine(term_basic)`
  Chapter 17 [Basic term manipulation], page 129.
- `engine(term_compare)`
  Chapter 18 [Comparing terms], page 135.
- `engine(term_typing)`
  Chapter 16 [Extra-logical properties for typing], page 121.

Note that if any of these modules is explicitely imported in a program then the language defaults to Pure Prolog, plus the functionality added by the modules explicitely imported.

It is recommended that if you explicitely import an engine module you also use this package, which will guarantee that the predicate `true/0` is defined (note that this is the only Ciao builtin which cannot be redefined).

94.1 Usage and interface (pure_doc)

- **Library usage:**
  `:- use_package(pure).`
  or
  `:- module(...,...,[pure]).`

94.2 Known bugs and planned improvements (pure_doc)

- Currently, the following builtin predicates/program constructs cannot be redefined, in addition to `true/0`: `(->)/2` `(,)/2` `(+)/1` `if/3`

95 Multiple Argument Indexing

Author(s): Anil Nair (original work), Tom Howland (`http://home.pacbell.net/tomjdnh/pd.html`, derived the original work), Francisco Bueno (port to Ciao).

This package is an extension of the idea of Prolog indexing, usually performed, in a limited way, on the first argument. This package provides more powerful indexing schemes. It lets you pick different arguments to index on, and provides for different combinations of arguments to index on. E.g., it will let you index on the first and third argument or the second and the third argument of a predicate.

The indexing is based on computing a hash value for the terms to be indexed upon. Note, however, that the current implementation of the package is done at the source level, so it may sometimes not be as fast as expected. Given this, this version of the package pays off only when the amount of clashing that your original predicate causes without the package superseeds the cost of the hashing function in the package. Such amount of course depends on the number and the form of the facts in your predicate.

95.1 Usage and interface (`indexer_doc`)

- **Library usage:**
  This facility is used as a package, thus either including `indexer` in the package list of the module, or by using the `use_package/1` declaration. The facility predicate `hash_term/2`, documented here, is defined in library module `indexer(hash)`.
- **Exports:**
  - *Predicates:*
    `hash_term/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`, `indexer/hash`.

95.2 Documentation on exports (`indexer_doc`)

hash_term/2: PREDICATE

`hash_term(Term,HashValue)`

Provides an efficient way to calculate an integer `HashValue` for a ground `Term`.

Usage 1: `hash_term(T,N)`

- *Description:* `N` is a hashing index for `T`.
- *The following properties should hold at call time:*
  `T` is currently ground (it contains no variables). (term_typing:ground/1)
  `N` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `N` is an integer. (basic_props:int/1)

Usage 2: `hash_term(T,N)`

– *The following properties should hold at call time:*

`T` is not ground. (native_props:nonground/1)

`N` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`N` is a free variable. (term_typing:var/1)

95.3 Documentation on internals (`indexer_doc`)

index/1: DECLARATION

Usage: `:- index(IndexSpecs).`

– *Description:* Declares an indexing scheme for a predicate. All specs of `IndexSpecs` must be terms for the same predicate. Each spec declares an indexing on a combination of the arguments. Indexing will be performed using any of the specs in `IndexSpecs` (being thus interpreted as an or).

You should use a `*` in an argument position if you wish to hash on the entire term in that argument. If a `+` is used only one level of the term in the argument is used for hashing. An `i` is used to indicate that argument is already an integer, and therefore its own value will be used for hashing. The argspec `?` simply indicates not to use the argument for indexing.

For example, the index specification:

```
:- index foo(+,?,*,i), foo(?,?,?,i).
```

declares indexing for `foo/4` either on a combination of the first, third, and fourht arguments, or only on the last argument, which is an integer. In the first case, only the principal functor of the first argument will be used for hashing; the third argument will be used in its entirety.

The argspec `n` is a pragmatic extension and can not be used in conjunction with the other specifiers aside from `?`. It stands for "nonvar" and implies that the argument will not be used for hashing, since only ground terms can effectively be used in hashing. Thus, it can not be used in combination with other specifiers within a particular index specification. It is often the fastest thing to use.

– *The following properties should hold upon exit:*

`IndexSpecs` is an index specification. (indexer_doc:indexspecs/1)

indexspecs/1: REGTYPE

An index specification is defined as follows:

```
indexspecs(Spec) :-
        indexspec(Spec).
indexspecs((Spec,Specs)) :-
        indexspec(Spec),
        indexspecs(Specs).
indexspec(Spec) :-
        Spec=..[_F|Args],
        list(Args,argspec).
```

Usage: `indexspecs(IndexSpecs)`

– *Description:* `IndexSpecs` is an index specification.

argspec/1: REGTYPE

An argument hash specification is defined as follows:

```
argspec(+).
argspec(*).
argspec(i).
argspec(n).
argspec(?).
```

Usage: `argspec(Spec)`

– *Description:* `Spec` is an argument hash specification.

96 Higher-order

Author(s): Daniel Cabeza.

This module is a wrapper for the implementation-defined predicate `call/1`, and it implements the `call/2` predicate.

96.1 Usage and interface (`hiord_rt`)

- **Library usage:**
  `:- use_module(library(hiord_rt)).`
- **Exports:**
  - *Predicates:*
    `call/1`, `call/2`, `SYSCALL/1`, `$nodebug_call/1`, `$meta_call/1`.

96.2 Documentation on exports (`hiord_rt`)

call/1: PREDICATE

`call(G)`

Executes goal `G`, restricting the scope of the cuts to the execution of `G`. Equivalent to writing a variable `G` in a goal position.

Meta-predicate with arguments: `call(goal)`.

Usage: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `G` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

call/2: PREDICATE

`call(Pred,Arg1)`

There exists a set of builtin predicates of the form `call/N` with `N > 1` which execute predicate `Pred` given arguments `Arg1` ... `ArgX`. If `Pred` has already arguments `Arg1` is added to the start, the rest to the end. This predicate, when `Pred` is a variable, can be written using the special Ciao syntax `Pred(Arg1,...,ArgX)`.

Usage:

- *Call and exit should be compatible with:*
  `Arg1` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*
  `Pred` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*
  `Arg1` is any term. (basic_props:term/1)
- *The following properties should hold globally:*
  This predicate is understood natively by CiaoPP. (basic_props:native/1)

SYSCALL/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

$nodebug_call/1: PREDICATE

Meta-predicate with arguments: `$nodebug_call(goal)`.

Usage:

– *The following properties should hold at call time:*

`Arg1` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

$meta_call/1: PREDICATE

Usage: `$meta_call(A)`

– *The following properties should hold at call time:*

`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

`A` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties hold globally:*

This predicate is understood natively by CiaoPP as `call(A)`. (basic_props:native/2)

96.3 Known bugs and planned improvements (`hiord_rt`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

97 Higher-order predicates

Author(s): Daniel Cabeza, Manuel Carro, Edison Mera.

This library implements a few basic higher-order predicates. These add functionality to the basic higher-order functionality of Ciao. Examples of the latter are:

Using pred(1):

```
list(L, functor(_,2))
list(L, >(0))
```

Using pred(2):

97.1 Usage and interface (hiordlib)

- **Library usage:**
  `:- use_module(library(hiordlib)).`
- **Exports:**
  - *Predicates:*
    `map/3`, `map/4`, `foldl/4`, `minimum/3`, `split/4`.
- **Other modules used:**
  - *System library modules:*
    `assertions/native_props`.

97.2 Documentation on exports (hiordlib)

map/3: PREDICATE

Meta-predicate with arguments: `map(?,(pred 2),?)`.

General properties: `map(A,B,C)`

- *If the following properties should hold at call time:*
  term_basic:A=[1,3,2] (term_basic:= /2)
  term_basic:B=arg(f(a,b,c,d)) (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:C=[a,c,b] (term_basic:= /2)
  then the following properties should hold globally:
  All the calls of the form `map(A,B,C)` do not fail. (native_props:not_fails/1)
  All calls of the form `map(A,B,C)` are deterministic. (native_props:is_det/1)

`map(A,B,C)`

- *If the following properties should hold at call time:*
  term_basic:A=[1,3,2] (term_basic:= /2)
  term_basic:B=nth([a,b,c,d]) (term_basic:= /2)
  then the following properties should hold upon exit:
  term_basic:C=[a,c,b] (term_basic:= /2)
  then the following properties should hold globally:
  All the calls of the form `map(A,B,C)` do not fail. (native_props:not_fails/1)
  All calls of the form `map(A,B,C)` are deterministic. (native_props:is_det/1)

`map(A,B,C)`

– *If the following properties should hold at call time:*
term_basic:A=[[68],[67]] (term_basic:= /2)
term_basic:B=append([46]) (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:C=[[68,46],[67,46]] (term_basic:= /2)
then the following properties should hold globally:
All the calls of the form `map(A,B,C)` do not fail. (native_props:not_fails/1)
All calls of the form `map(A,B,C)` are deterministic. (native_props:is_det/1)

Usage: `map(LList,Op,RList)`

– *Description:* Examples of use:

```
map([1,3,2], arg(f(a,b,c,d)), [a,c,b]) or
map([1,3,2], nth([a,b,c,d]), [a,c,b])
map(["D","C"], append("."), ["D.","C."])
```

map/4: PREDICATE

Meta-predicate with arguments: `map(?,(pred 3),?,?)`.

General properties: `map(A,B,C,D)`

– *If the following properties should hold at call time:*
term_basic:A=[1,3,2] (term_basic:= /2)
term_basic:B=((L,[E|T],T):-arg(L,f(a,b,c,d),E)) (term_basic:= /2)
term_basic:D=[x,y] (term_basic:= /2)
then the following properties should hold upon exit:
term_basic:C=[a,c,b,x,y] (term_basic:= /2)
then the following properties should hold globally:
All the calls of the form `map(A,B,C,D)` do not fail. (native_props:not_fails/1)
All calls of the form `map(A,B,C,D)` are deterministic. (native_props:is_det/1)

Usage: `map(LList,Op,RList,Tail)`

– *Description:* DCG version of map.

foldl/4: PREDICATE

Meta-predicate with arguments: `foldl(?,?,(pred 3),?)`.

Usage: `foldl(List,Seed,Op,Result)`

– *Description:* Example of use:

```
?- foldl(["daniel","cabeza","gras"], "",
         (''(X,Y,Z) :- append(X, " "||Y, Z)), R).

R = "daniel cabeza gras " ?
```

minimum/3: PREDICATE

Meta-predicate with arguments: `minimum(?,(pred 2),?)`.

Usage: `minimum(List,SmallerThan,Minimum)`

- *Description:* `Minimum` is the smaller in the nonempty list `List` according to the relation `SmallerThan`: `SmallerThan(X, Y)` succeeds iff X is smaller than Y.
- *The following properties should hold at call time:*

  `SmallerThan` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `List` is a list. (basic_props:list/1)

  `SmallerThan` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Minimum` is any term. (basic_props:term/1)

split/4: PREDICATE

Meta-predicate with arguments: `split(?,(pred 1),?,?)`.

General properties: `split(A,B,C,D)`

- *If the following properties should hold at call time:*

  term_basic:A=[1,2,3,4,5,6] (term_basic:= /2)

  term_basic:B= >(4) (term_basic:= /2)

  then the following properties should hold upon exit:

  term_basic:C=[5,6] (term_basic:= /2)

  term_basic:D=[1,2,3,4] (term_basic:= /2)

  then the following properties should hold globally:

  All the calls of the form `split(A,B,C,D)` do not fail. (native_props:not_fails/1)

Usage: `split(List,Condition,Left,Right)`

- *Description:* Divides `List` in two list, where `Left` contains the elements for which the call to `Condition` succeeds, and `Right` the remaining elements.
- *The following properties should hold at call time:*

  `List` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Condition` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `List` is a list. (basic_props:list/1)

  `Condition` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Left` is any term. (basic_props:term/1)

  `Right` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*

  `List` is a list. (basic_props:list/1)

  `Condition` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Left` is a list. (basic_props:list/1)

  `Right` is a list. (basic_props:list/1)

98 Terms with named arguments -records/feature terms

Author(s): Daniel Cabeza, Manuel Hermenegildo, Jose F. Morales.

This library package provides syntax which allows accessing term arguments by name (these terms are sometimes also referred to as *records*, and are also similar to *feature terms* [AKPS92]).

98.1 Usage and interface (argnames_doc)

- **Library usage:**
  `:- use_package(argnames).`
  or
  `:- module(...,...,[argnames]).`
- **Exports:**
  - *Predicates:*
    `$~/3`.
- **New operators defined:**
  `$/2` [150,xfx], `=>/2` [950,xfx], `argnames/1` [1150,fx].
- **New declarations defined:**
  `argnames/1`.

98.2 Documentation on new declarations (argnames_doc)

argnames/1: DECLARATION

Usage: `:- argnames ArgNamedPredSpec.`

- *Description:* An `argnames/1` declaration assigns names to the argument positions of terms (or literal/goals) which use a certain functor/arity. This allows referring to these arguments by their name rather than by their argument position. Sometimes, argument names may be clearer and easier to remember than argument positions, specially for predicates with many arguments. Also, in some cases this may allow adding arguments to certain predicates without having to change the code that uses them. These terms with named arguments are sometimes also referred to as records, and are also similar to feature terms [AKPS92]. For example, in order to write a program for the *zebra* puzzle we might declare:

```
:- use_package([argnames]).
:- argnames house(color, nation, pet, drink, car).
```

  which first includes the package and then assigns a name to each of the arguments of any term (or literal/goal) with `house/5` as the main functor.

  For convenience the package extends the built-in `data/1` declaration so that names to arguments can be asigned as with the `argnames/1` declaration, as for example:

```
:- data product(id, description, brand, quantity).
```

  Once an `argnames/1` is given, it is possible to use the names to refer to the arguments of any term (or literal/goal) which has the same main functor as that of the term which appears in the `argnames/1` declaration. This is done by first writing the functor name, then the infix operator `$`, and then, between curly brackets, zero, one, or more pairs *argument-name*`=>`*argument-value*, separated by commas (i.e., the infix operator

=> is used between the name and the value). Again, argument names must be atomic. Argument values can be any term. Arguments which are not specified are assumed to have a value of "_" (i.e., they are left unconstrained).

Thus, after the declaration for house/5 in the example above, any ocurrence in that code of, for example, house${nation=>Owns_zebra,pet=>zebra} is exactly equivalent to house(_,Owns_zebra,zebra,_,_). Also, house${} is equivalent to house(_,_,_,_,_). The actual zebra puzzle specification might include a clause such as:

```
zebra(Owns_zebra, Drinks_water, Street) :-
   Street = [house${},house${},house${},house${},house${}],
   member(house${nation=>Owns_zebra,pet=>zebra}, Street),
   member(house${nation=>Drinks_water,drink=>water}, Street),
   member(house${drink=>coffee,color=>green}, Street),
   left_right(house${color=>ivory}, house${color=>green}, Street),
   member(house${car=>porsche,pet=>snails}, Street),
        ...
```

Another syntax supported, useful mainly in declarations to avoid specifying the arity, is house${/}, which is equivalent in our example to house/5 (but for data declarations there is a special syntax as we have seen).

Any number of argnames/1 declarations can appear in a file, one for each functor whose arguments are to be accessed by name. As with other packages, argument name declarations are *local to the file* in which they appear. The argnames/1 declarations affect only program text which appears after the declaration. It is easy to make a set of declarations affect several files for example by putting such declarations in a sepatate file which is included by all such files.

An argnames/1 declaration does not change in any way the internal representation of the associated terms and does not affect run-time efficiency. It is simply syntactic sugar.

Runtime support

It is possible to write pairs with unbound argument names. In that case, runtime information is emitted to resolve the argument name at execution time.

98.3 Documentation on exports (argnames_doc)

$~/3: PREDICATE

Usage: $~(Term,Replacement,NewTerm)

– *Description:* NewTerm is as Term but with the arguments specified in Replacement changed (they need to be in argnames syntax). The predicate is in fact virtual, since it is translated by the package to a pair of unifications. For example, given the declaration :- argnames house(color, nation, pet, drink, car), the goal

```
$~(House, house${car => seat, pet => mouse}, NewHouse)
```

would be compiled to the unifications

```
House = house(C,N,_,D,_), NewHouse = house(C,N,mouse,D,seat).
```

98.4 Other information (argnames_doc)

Two simple examples of the use of the argnames library package follow.

98.4.1 Using argument names in a toy database

```
:- module(simple_db,_,[argnames,assertions,regtypes]).
:- use_module(library(aggregates)).

:- doc(title,"A simple database application using argument names").

:- data
product( id,    description,    brand,          quantity        ).
%       ------------------------------------------------------------
product(  1,    "Keyboard",     "Logitech",     6               ).
product(  2,    "Mouse",        "Logitech",     5               ).
product(  3,    "Monitor",      "Philips",      3               ).
product(  4,    "Laptop",       "Dell",         4               ).
% (${/} must go after argnames)
:- pred product${/}
   ::    int    * string        * string        * int.

% Compute the stock of products from a given brand.
% Note call to findall is equivalent to: findall(Q,product(_,_,Brand,Q),L).

brand_stock(Brand,Stock) :-
        findall(Q,product${brand=>Brand,quantity=>Q},L),
        sumlist(L,Stock).

sumlist([],0).
sumlist([X|T],S) :-
        sumlist(T,S1),
        S is X + S1.
```

98.4.2 Complete code for the zebra example

```
:- module(_,zebra/3,[argnames]).

/*     There are five consecutive houses, each of a different
color and inhabited by men of different nationalities. They each
own a different pet, have a different favorite drink, and drive a
different car.

1.   The Englishman lives in the red house.
2.   The Spaniard owns the dog.
3.   Coffee is drunk in the green house.
4.   The Ukrainian drinks tea.
5.   The green house is immediately to the right of the ivory
     house.
6.   The Porsche driver owns snails.
7.   The Masserati is driven by the man who lives in the yellow
     house.
8.   Milk is drunk in the middle house.
9.   The Norwegian lives in the first house on the left.
```

```
10.  The man who drives a Saab lives in the house next to the man
     with the fox.
11.  The Masserati is driven by the man in the house next to the
     house where the horse is kept.
12.  The Honda driver drinks orange juice.
13.  The Japanese drives a Jaguar.
14.  The Norwegian lives next to the blue house.

The problem is: Who owns the Zebra?  Who drinks water?
*/

:- argnames house(color, nation, pet, drink, car).

zebra(Owns_zebra, Drinks_water, Street) :-
        Street = [house${},house${},house${},house${},house${}],
        member(house${nation => Owns_zebra, pet => zebra}, Street),
        member(house${nation => Drinks_water, drink => water}, Street),
        member(house${nation => englishman, color => red}, Street),
        member(house${nation => spaniard, pet => dog}, Street),
        member(house${drink => coffee, color => green}, Street),
        member(house${nation => ukrainian, drink => tea}, Street),
        left_right(house${color => ivory}, house${color => green}, Street),
        member(house${car => porsche, pet => snails}, Street),
        member(house${car => masserati, color => yellow}, Street),
        Street = [_, _, house${drink => milk}, _, _],
        Street = [house${nation => norwegian}|_],
        next_to(house${car => saab}, house${pet => fox}, Street),
        next_to(house${car => masserati}, house${pet => horse}, Street),
        member(house${car => honda, drink => orange_juice}, Street),
        member(house${nation => japanese, car => jaguar}, Street),
        next_to(house${nation => norwegian}, house${color => blue}, Street).


member(X,[X|_]).
member(X,[_|Y]) :- member(X,Y).

left_right(L,R,[L,R|_]).
left_right(L,R,[_|T]) :- left_right(L,R,T).

next_to(X,Y,L) :- left_right(X,Y,L).
next_to(X,Y,L) :- left_right(Y,X,L).
```

98.5 Known bugs and planned improvements (argnames_doc)

- It would be nice to add a mechanism to portray terms with named arguments in a special (user definable) way.
- The predicate `$~` still does not support runtime argnames.

99 Functional notation

Author(s): Daniel Cabeza, Amadeo Casas, Manuel Hermenegildo, Jose F. Morales.

This library package allows the use of functional notation in a Ciao module/program. It supports function application, predefined evaluable functors, functional definitions, quoting, and (combined with the `lazy` library) lazy evaluation. The extensions implemented by this library are also composable with higher-order features and can be combined with other Ciao packages such as constraints, assertions, etc.

The package provides *syntactic sugar* for defining and using predicates as if they were functions. However, they can still retain the power of predicates. Any function definition written using this package is in fact defining a predicate, and any predicate can be used as a function.

The predicate associated with a function has the same name and one more argument, meant as the place holder for the "result" of the function. In fact, this argument is just the one that will be syntactically connected to the surrounding goal or function, but it does not necessarily imply any directionality, i.e., it does not necessarily mean that this argument is an output or an input. This argument is by default added to the right, i.e., it is the last argument, but can be changed by using a declaration, as explained below.

99.1 Function applications

Any term preceded by the `~ /1` operator is a function application, as can be seen in the goal `write(~arg(1,T))`, which is strictly equivalent to the sequence `arg(1,T,A), write(A)`. The declaration `fun_return/1` allows using a predicate argument other than the last as the return argument. For example with `:- fun_return functor(~,_,_)` the expression `~functor(f,2)` will be evaluated to the term `f(_,_)`. This definition of the return argument can also be done on the fly in each invocation in the following way: `~functor(~,f,2)`.

Functors can be declared as evaluable by using the declaration `fun_eval/1`. This allows avoiding the need to use the `~` operator. Thus, `:- fun_eval arg/2` allows writing `write(arg(1,T))` instead of `write(~arg(1,T))` as above. This declaration can be combined with the previous one: `:- fun_eval functor(~,_,_)`.

99.2 Predefined evaluable functors

By using the declaration `:- fun_eval arith(true)`, all the functors understood by `is/2` will be also evaluated. This is active from the declaration downwards until a `:- fun_eval arith(false)` declaration or the end of the module is reached. Beware that arithmetic functors are used in some cases for other purposes than arithmetic: e.g. `abolish(p/2)`. But this is not so disturbing as it may appear because this package is not active in declarations, except for the goal-including declarations `initialization/1` and `on_abort/1`. Note that all the declarations introduced by this package, as is customary in Ciao, are local to the module where they are included.

In addition to functors declared with the declaration `fun_eval/1`, the package defines as evaluable the functors used for disjunctive and conditional expressions: `| /2` and `? /2` (defined as operators). A disjunctive expression has the form `(V1|V2)`, and its value when first evaluated is `V1`, and on backtracking `V2`. A conditional expression has the form `(Cond ? V1)`, or more commonly `(Cond ? V1 | V2)`, and its value, if the execution of `Cond` as a goal succeeds, is `V1`, otherwise in the first form it causes backtracking, and on the second form its value is `V2`. Note that due to the operator precedences, these expressions normally need to be surrounded by parenthesis. Also, a nested expression: `(Cond1 ? V1 | Cond2 ? V2 | V3)` is evaluated as `(Cond1 ? V1 | (Cond2 ? V2 | V3))`.

99.3 Functional definitions

A functional definition is composed of one or more functional clauses. A functional clause is written using the binary operator `:= /2`, as in:

```
opposite(red) := green.
```

which is equivalent to `opposite(red,green).` or

```
addlast(X,L) := ~append(L,[X]).
```

which is equivalent to `addlast(X,L,R) :- append(L,[X],R).`

Functional clauses can also have a body, which is executed before the result value is computed. It can serve as a guard for the clause or to provide the equivalent of where-clauses in functional languages:

```
fact(0) := 1.
fact(N) := N * ~fact(--N) :- N > 0.
```

Note that guards can often be defined more compactly using conditional expressions:

```
fact(N) := N = 0 ? 1
         | N > 0 ? N * ~fact(--N).
```

The declaration `:- fun_eval defined(true)` allows to locally define as evaluable functions being defined, so that the `~` operator does not need to be used within a functional definition for the functor being defined. For example, for the `fact` invocations in the previous definitions, which can now be written as, e.g. (we provide the full module definition):

```
:- module(_,_,[fsyntax]).

:- fun_eval arith(true).
:- fun_eval defined(true).

fact(0) := 1.
fact(N) := N * fact(--N) :- N > 0.

%% Or,alternatively:
%
% fact(N) := N=0 ? 1
%          | N>0 ? N * fact(--N).
```

This behaviour is reverted using `:- fun_eval defined(false)`.

The translation of functional clauses has the following properties:

- The translation produces *steadfast* predicates, that is, output arguments are unified after possible cuts.
- Defining recursive predicates in functional style maintains the tail recursion of the original predicate, thus allowing the usual compiler optimizations.

Some implementation details and a discussion of the recent combination of this library (which dates from Ciao version 0.2) with the lazy evaluation library can be found in [CCH06].

99.4 Quoting functors

Functors (either in functional or predicate clauses) can be prevented from being evaluated by using the `^ /1` prefix operator (read as "quote"), as in

```
:- fun_eval arith(true).
pair(A,B) := ^(A-B).
```

Note that this just prevents the evaluation of the principal functor of the enclosed term, not the possible occurrences of other evaluable functors inside.

99.5 Some scoping issues

When using function applications inside the goal arguments of meta-predicates, there is an ambiguity as they could be evaluated either in the scope of the outer execution or the in the scope of the inner execution. The chosen behavior is by default to evaluate function applications in the scope of the outer execution. If they should be evaluated in the inner scope, the goal containing the function application needs to be escaped with the `^^ /1` prefix operator, as in `findall(X, (d(Y), ^^(X = ~f(Y)+1)), L)` (which could also be written as `findall(X, ^^(d(Y), X = ~f(Y)+1), L)`) and which expands into `findall(X, (d(Y),f(Y,Z),T is Z+1,X=T), L)`. With no escaping the function application is evaluated in the scope of the outer execution, i.e., it expands to `f(Y,Z), T is Z+1, findall(X, (d(Y),X=T), L)`.

99.6 Other functionality

In addition to the basic package `fsyntax`, a package `functional` is also provided, to allow programming with a more functional-flavored style. That package activates the declarations `:- fun_eval arith(true)` and `:- fun_eval defined(true)`, and defines the `. /2` operator for use in lists (but be careful: this period cannot be followed by a whitespace!) and the operator `++ /2` as a function for appending lists. The factorial example above can be written as follows using the `functional` package:

```
:- module(_,_,[fsyntax]).

:- fun_eval arith(true).
:- fun_eval defined(true).

fact(0) := 1.
fact(N) := N * fact(--N) :- N > 0.

%% Or,alternatively:
%
% fact(N) := N=0 ? 1
%          | N>0 ? N * fact(--N).
```

See the end of this chapter for additional examples.

99.7 Combining with higher order

Ciao provides in its standard library the `hiord` package, which supports a form of higher-order untyped logic programming with predicate abstractions [CH99a,Cab04,CHL04]. Predicate abstractions are Ciao's translation to logic programming of the lambda expressions of functional programming: they define unnamed predicates which will be ultimately executed by a higher-order call, unifying its arguments appropriately. A function abstraction is provided as functional syntactic sugar for predicate abstractions:

Predicate abstraction: `''(X,Y) :- p(X,Z), q(Z,Y).`

Function abstraction: `''(X) := ~q(~p(X)).`

and function application is syntactic sugar over predicate application:

Predicate application: `..., P(X,Y), ...` Function application: `..., Y = ~P(X), ...`

The combination of this `hiord` package with the `fsyntax` and `lazy` packages (and, optionally, the type inference and checking provided by the Ciao preprocessor [HPBLG05]) basically provide the functionality present in modern functional languages (currying is not *syntactically* implemented, but its results can be obtained by deriving higher-order data from any other higher-order data (see [Cab04]), as well as some of the functionality of full higher-order logic programming.

At this moment, it is necessary to specify the `:- fun_eval hiord(true)` option to enable correct handling of function abstractions.

99.8 Usage and interface (fsyntax_doc)

- **Library usage:**
  `:- use_package(fsyntax).`
  or
  `:- module(...,...,[fsyntax]).`

99.9 Other information (fsyntax_doc)

99.10 Some examples using functional syntax

We now illustrate some of the uses of the package through examples. The following example defines a simple unary function `der(X)` which returns the derivative of a polynomial arithmetic expression:

```
der(x)      := 1.
der(C)      := 0                  :- number(C).
der(A + B)  := der(A) + der(B).
der(C * A)  := C * der(A)         :- number(C).
der(x ** N) := N * x ** ~(N - 1) :- integer(N), N > 0.
```

Note that if we include the directive mentioned before which makes arithmetic functors evaluable then we would have to write the program in the following (clearly, less pleasant and more obfuscated) way:

```
:- fun_eval(arith(true)).
der(x)          := 1.
der(C)          := 0                       :- number(C).
der(^(A + B))   := ^(der(A) + der(B)).
der(^(C * A))   := ^(C * der(A))           :- number(C).
der(^(x ** N)) := ^(N * ^(x ** (N - 1))) :- integer(N), N > 0.
```

Both of the previous code fragments translate to the following code:

```
der(x, 1).
der(C, 0) :-
          number(C).
der(A + B, X + Y) :-
          der(A, X),
```

```
          der(B, Y).
der(C * A, C * X) :-
          number(C),
          der(A, X).
der(x ** N, N * x ** N1) :-
          integer(N),
          N > 0,
          N1 is N - 1.
```

Functional notation interacts well with other Ciao language features. For example, it provides compact and familiar notation for regular types and other properties:

```
:- module(_,_,[hiord,functional,assertions,regtypes,'bf/bfall']).

:- regtype color/1. color := red | blue | green.

:- regtype slist/1. slist := [] | [ _ | slist].

:- regtype list_of/1. list_of(T) := [] | [~T | list_of(T)].
```

where the functional clauses expand to (note the use of higher-order in the third example):

```
color(red). color(blue). color(green).
list([]).
list([_|T]) :- list(T).
list_of(_, []).
list_of(T, [X|Xs]) :- T(X), list_of(T, Xs).
```

Such types and properties are then admissible in the usual way in assertions, e.g.:

```
:- pred append/3 :: list * list * list.
:- pred color_value/2 :: list(color) * int.
```

The combination of functional syntax and user-defined operators brings significant flexibility, as can be seen in the following definition of a list concatenation (`append`) operator (note that these are the definitions mentioned before which are active by default in the `functional` package):

```
:- op(600, xfy, (.)).
:- op(650, xfy, (++)).
:- fun_eval (++)/2.
[]   ++ L := L.
X.Xs ++ L := X.(Xs ++ L).
```

This definition will be compiled exactly to the standard definition of `append` (and, thus, will be reversible). The functional syntax and user-defined operators allow writing for example `Space = ' ', write("Hello" ++ Space ++ "world!")` instead of the equivalent forms `Space = ' ', write( append("Hello", append(Space, "world!")))` (if `append/2` is defined as evaluable) or `Space = ' ', append(Space, "world!", T1), append("Hello", T1, T2), write(T2)`.

As another example, we can define an array indexing operator for fixed-size, multi-dimensional arrays. Assume that arrays are built using nested structures whose main functor is `a` and whose arities are determined by the specified dimensions, i.e., a two-dimensional array *A* of dimensions *[N,M]* will be represented by the nested structure `a(a(`*A11*`,...,`*A1M*`), a(`*A21*`,..,`*A2M*`), ..., a(`*AN1*`,..., `*ANM*`))`, where *A11*,... *ANM* may be arbitrary terms (we ignore for simplicity arity limitations, solved in any case typically by further nesting with logarithmic access time). The following recursive definition defines the property `fixed_array/2` and also the array access operator `@`:

```
fixed_array([N|Ms],A):-
```

```
functor(A,a,N),
rows(N,Ms,A).
fixed_array([N],A):-
functor(A,a,N).

rows(0,_,_).
rows(N,Ms,A) :-
        N > 0,
        arg(N,A,Arg),
        array(Ms,Arg),
        rows(N-1,Ms,A).

:- pred @(Array,Index,Elem) :: array * list(int) * int
   # "@var{Elem} is the @var{Index}-th element of @var{Array}.".

:- op(55, xfx, '@').
:- fun_eval (@)/2.
V@[I]    := ~arg(I,V).       %% Or: V@[] := V.
V@[I|Js] := ~arg(I,V)@Js.
```

This allows writing, e.g., `M = fixed_array([2,2]), M@[2,1] = 3` (which could also be expressed as `fixed_array([2,2])@[2,1] = 3`), where the call to the `fixed_array` property generates an empty *2 x 2* array *M* and `M@[2,1] = 3` puts *3* in *M[2,1]*. This can be done in the top level:

```
?- M = ~fixed_array([2,2]), M@[2,1] = 3.
```

provided the `op` and `function` declarations are loaded into the top level also. Another example of use is: `A3@[N+1,M] = A1@[N-1,M] + A2@[N,M+2]`.

Such functionality can be grouped into a *package* as follows. The package main file (`arrays.pl`) might be:

```
:- package(arrays).
:- include(arrays_ops).

:- use_module(arrays_rt).
```

where file `arrays_ops.pl` may contain:

```
:- use_package(functional).

:- op(150,xfx,[@]).
:- fun_eval '@'/2.

:- op(500,yfx,<+>).
:- fun_eval '<+>'/2.

:- op(400,yfx,<*>).
:- fun_eval '<*>'/2.
```

The main file is `arrays_rt.pl` which would contain for example (note that it also uses `arrays_ops.pl`, and that is why the contents of `arrays_ops.pl` were not put directly in `arrays.pl`):

```
:- module(arrays_rt,_,[functional,hiord,assertions,regtypes,isomodes]).
```

```
:- include(arrays_ops).

:- doc(title,"Some simple array operations with syntactic support").
:- doc(author,"Pro Grammer").

:- doc(module,"This library implements a very simple set of
   operations on arrays. The idea is to illustrate the use of
   functional syntax (operators) by providing syntactic support for
   invoking array operations such as element access, array (vector)
   addition, etc.").

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Regtypes

%% :- doc(doinclude,array/1).
%% :- doc(doinclude,vector/1).
%% :- doc(doinclude,dim/1).

:- regtype array(A) #"@var{A} is a multi-dimensional array.".
% Should obviously be defined in more detail...
array(A) :- struct(A).

:- regtype dim(D) # "@var{D} represents the dimensions of an array.".
dim(D) :- list(D,int).

:- regtype vector(V) # "@var{V} is a one-dimensional fixed-size array.".
vector(V) :- fixed_array([N],V), int(N).

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

:- pred fixed_array(Dim,Array) :: dim * array
# "@var{Array} is an array of fixed dimensions @var{Dim}.".

fixed_array([N|Ms],A):-
        functor(A,a,N),
        rows(N,Ms,A).
fixed_array([N],A):-
        functor(A,a,N).

rows(0,_Ms,_A).
rows(N,Ms,A):-
        N > 0,
        arg(N,A,Arg),
        fixed_array(Ms,Arg),
        rows(N-1,Ms,A).

:- pred @(Array,Index,Elem):: array * dim * int
# "@var{Elem} is the @var{Index}-th element of @var{Array}.".

V@[I]    := ~arg(I,V).
V@[I|Js] := ~arg(I,V)@Js.
```

```
:- pred <+>(V1,V2,V3) :: vector * vector * vector
# "@var{V3} is @var{V1} + @var{V2}.".

V1 <+> V2 := V3 :-
        V1 = ~fixed_array([N]),
        V2 = ~fixed_array([N]),
        V3 = ~fixed_array([N]),
        V3 = ~vecplus_(N,V1,V2).

vecplus_(0,_,_,_).
vecplus_(N,V1,V2,V3) :-
        N > 0,
        V3@[N] = V1@[N] + V2@[N],
        vecplus_(N-1,V1,V2,V3).

:- pred <*>(V1,V2,V3) :: vector * vector * vector
# "@var{V3} is @var{V1} * @var{V2} (inner product).".

V1 <*> V2 := ~vecmul_(N,V1,V2,0) :-
    V1 = ~fixed_array([N]),
    V2 = ~fixed_array([N]).

vecmul_(0,  _,  _, Acc, Acc).
vecmul_(N, V1, V2, Acc, IP) :-
    N > 0,
    vecmul_( N-1, V1, V2, Acc + ( V1@[N] * V2@[N] ), IP).
```

A file using this package would be:

```
:- module(_,_).

:- use_package(library(fsyntax(examples(arrays)))).

main(M) :-
        V1 = a(1,3,4,5),
        V2 = a(5,4,3,1),
        I = 1,
        display(V2@[I+1]),
        M = V1 <*> ( V2 <+> V1 ).
```

99.11 Examples of combining with higher order

The following `map` and `foldl` definitions (from the `hiordlib` library) illustrate the combination of functional syntax and higher-order logic programming:

```
:- fun_eval map/2.
:- meta_predicate map(_,pred(2),_).
map([], _)     := [].
map([X|Xs], P) := [P(X) | map(Xs, P)].

:- fun_eval foldl/3.
```

```
:- meta_predicate foldl(_,_,pred(3),_).
foldl([], Seed, _Op) := Seed.
foldl([X|Xs], Seed, Op) := ~Op(X,~foldl(Xs,Seed,Op)).
```

With this definition:

```
?- L = ~map([1,2,3], ( _(X,Y):- Y = f(X) ) ).

L = [f(1),f(2),f(3)] ?

?- [f(1),f(2),f(3)] = ~map(L, ( _(X,f(X)) :- true ) ).

L = [1,2,3] ?
```

Also, after running:

```
?- ["helloworld", "byeworld"] = map(["hello", "bye"], ++(X)).
```

(where `(++)/2` corresponds to the above definition of `append`) `X` will be bound to `"world"`, which is the only solution to the equation.

And when calling:

```
map(L, ++(X), ["hello.", "bye."]).
```

several values for `L` and `X` are returned through backtracking:

```
L = ["hello","bye"],   X = "." ? ;
L = ["hello.","bye."], X = [] ?
```

(remember to set the flag `write_strings` to on in these examples so that the top level prints strings as strings of characters instead of lists of ASCII codes).

99.12 Some additional examples using functional syntax

A definition of the Fibonacci function, written in functional notation:

```
:- module(_,_,[functional]).

fib(0) := 0.
fib(1) := 1.
fib(N) := fib(N-1) + fib(N-2) :- integer(N), N > 1.

write_fib(N):-
        message(['The ',N,'. Fibonacci number is: ',~fib(N),'.']).
```

This is the factorial example, written in functional notation and including some assertions:

```
:- module(_,_,[assertions,nativeprops,functional]).

:- pred fact(+int,-int) + is_det.
:- pred fact(-int,+int) + non_det.

fact(N) := N=0 ? 1
         | N>0 ? N * fact(--N).
```

And, the same example written using `clpq` constraints:

```
:- module(_,_,[assertions,nativeprops,fsyntax,clpqf]).

:- fun_eval .=. /1.
```

```
:- op(700,fx,[.=.]).
:- fun_eval fact/1.

:- pred fact(+int,-int) + is_det.
:- pred fact(-int,-int) + non_det.

fact( .=. 0) := .=. 1.
fact(N) := .=. N*fact( .=. N-1 ) :- N .>. 0.
```

which allows for example calling it "backwards:"

```
?- 24 = ~fact(X).

X = 4 ?
```

A very simple example using lazy evaluation:

```
:- module(_,_,[functional,lazy]).
:- use_module(library(lazy(lazy_lib)), [take/3]).

nums(N) := ~take(N,nums_from(0)).

:- lazy fun_eval nums_from/1.

nums_from(X) := [X | nums_from(X+1)].
```

A naive reverse example, using functional notation:

```
:- module(_, [nrev/2], [functional]).

nrev( [] )    := [].
nrev( [H|T] ) := ~conc( nrev(T),[H] ).

conc( [],    L ) := L.
conc( [H|T], K ) := [ H | conc(T,K) ].
```

And the same example using some assertions:

```
:- module(_, [nrev/2], [assertions,fsyntax,nativeprops]).

:- entry nrev/2 : {list, ground} * var.

:- pred nrev(A,B) : list(A) => list(B)
   + ( not_fails, is_det, steps_o( exp(length(A),2) ) ).

nrev( [] )    := [].
nrev( [H|L] ) := ~conc( ~nrev(L),[H] ).


:- pred conc(A,_,_) + ( terminates, is_det, steps_o(length(A)) ).

conc( [],    L ) := L.
conc( [H|L], K ) := [ H | ~conc(L,K) ].
```

Finally, a simple stream creation example where assertions are used to define a safety policy (that no file outside `/tmp` should be opened):

```
:- module(_,[create_streams/2],[fsyntax,assertions,regtypes]).

:- entry create_streams(A,B) : list(A,num).

create_streams([])     := [].
create_streams([N|NL]) := [ ~open_file(Fname,write) | ~create_streams(NL) ]
        :-
         app("/tmp/../",~number_codes(N),Fname).
%        app("/tmp/",~number_codes(N),Fname).

app([],L) := L.
app([X|Xs],L) := [X|~app(Xs,L)].

%%%
```

100 global (library)

100.1 Usage and interface (global)

- **Library usage:**
  `:- use_module(library(global)).`
- **Exports:**
  - *Predicates:*
    `set_global/2`, `get_global/2`, `push_global/2`, `pop_global/2`, `del_global/1`.

100.2 Documentation on exports (global)

set_global/2: PREDICATE
No further documentation available for this predicate.

get_global/2: PREDICATE
No further documentation available for this predicate.

push_global/2: PREDICATE
No further documentation available for this predicate.

pop_global/2: PREDICATE
No further documentation available for this predicate.

del_global/1: PREDICATE
No further documentation available for this predicate.

101 Andorra execution

Author(s): Claudio Vaucheret, Francisco Bueno.

This package allows the execution under the Basic Andorra Model [War88]. The model classifies goals as a *determinate goal*, if at most one clause matches the goal, or nondeterminate goal, otherwise. In this model a goal is delayed until either it becomes determinate or it becomes the leftmost goal and no determinate goal is available. The implementation of this selection rule is based on the use of attributed variables [Hol92,Hol90].

In order to test determinacy we verify only the heads of clauses and builtins in the bodies of clauses before the first cut, if any. By default, determinacy of a goal is detected dynamically: when called, if at most one clause matches, it is executed; otherwise, it is delayed. For goals delayed the test is repeated each time a variable appearing in the goal is instantiated. In addition, efficiency can be improved by using declarations that specify the determinacy conditions. These will be considered for testing instead of the generic test on all clauses that can match.

As with any other Ciao package, the andorra computation rule affects only the module that uses the package. If execution passes across two modules that use the computation rule, determinate goals are run in advance *within* one module and also within the other module. But determinate goals of one module do not run ahead of goals of the other module.

It is however possible to preserve the computation rule for calls to predicates defined in other modules. These modules should obviously also use this package. In addition *all* predicates from such modules should imported, i.e., the directive `:- use_module(module)`, should be used in this case instead of `:- use_module(module,[...])`. Otherwise calls to predicates outside the module will only be called when they became the leftmost goal.

101.1 Usage and interface (andorra_doc)

- **Library usage:**
  `:- use_package(andorra).`
  or
  `:- module(...,...,[andorra]).`
- **Exports:**
  - *Regular Types:*
    `detcond/1`, `path/1`.
- **New operators defined:**
  `?\=/2` [700,xfx], `?=/2` [700,xfx].
- **New declarations defined:**
  `determinate/2`.

101.2 Documentation on new declarations (andorra_doc)

determinate/2: DECLARATION

`:- determinate(Pred,Cond).`

Declares determinacy conditions for a predicate. Conditions `Cond` are on variables of arguments of `Pred`. For example, in:

```
:- determinate(member(A,B,C), ( A ?= term(B,[1])  ; C?=[_|_]) ).

member(A,[A|B],B).
member(A,[B|C],[B|D]) :-
        A==B,
        member(A,C,D).
```

the declaration states that a call `member(A,B,C)` is determinate when either `A` doesn't unify with the first argument of `B` or `C` doesn't unify with `[_|_]`.

Usage: `:- determinate(Pred,Cond).`

– *Description:* States that the predicate `Pred` is determinate when `Cond` holds.

– *The following properties should hold at call time:*

`Pred` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

`Cond` is a determinacy condition. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/library/andorra/andorra_doc):detcond/1)

101.3 Documentation on exports (andorra_doc)

detcond/1: REGTYPE

Defined by:

```
detcond(ground(X)) :-
        var(X).
detcond(nonvar(X)) :-
        var(X).
detcond(instatiated(A,Path)) :-
        var(A),
        list(Path,int).
detcond(?\=(Term1,Term2)) :-
        path(Term1),
        path(Term2).
detcond(?=(Term1,Term2)) :-
        path(Term1),
        path(Term2).
detcond(Test) :-
        ( test Test ).
```

- `ground/1` and `nonvar/1` have the usual meaning.
- `instatiated(A,Path)` means that the subterm of `A` addressed by `Path` is not a variable. `Path` is a list of integer numbers describing a path to the subterm regarding the whole term A as a tree. For example, `instantiated(f(g(X),h(i(Z),Y)),[2,1])` tests whether `i(Z)` is not a variable.
- `Term1 ?\= Term2` means "terms `Term1` and `Term2` do not unify (when instantiated)". `Term1` and `Term2` can be either an argument of the predicate or a term `term(V,Path)`, which refers to the subterm of `V` addressed by `Path`.
- `Term1 ?= Term2` means "terms `Term1` and `Term2` unify (when instantiated)". The same considerations above apply to `Term1` and `Term2`.

- any other test that does not unify variables can also be used (`==/2`, `\==/2`, `atomic/1`).

Usage: `detcond(X)`

– *Description:* `X` is a determinacy condition.

path/1: REGTYPE

Defined by:

```
path(X) :-
        var(X).
path(X) :-
        list(X,int).
```

101.4 Other information (andorra_doc)

The andorra transformation will include the following predicates into the code of the module that uses the package. Be careful not to define predicates by these names:

- `detcond_andorra/4`
- `path_andorra/4`
- `detcond_susp/4`
- `path_susp/4`
- `list_andorra2/5`
- `test_andorra2/4`

102 And-parallel execution

Author(s): Amadeo Casas (`http://www.cs.unm.edu/~amadeo`, University of New Mexico).

This library allows and-parallel execution of goals in (Herbrand-)independent fashion. It resembles the execution rules of &-Prolog.

102.1 Usage and interface (`andprolog_doc`)

- **Library usage:**
  The AND_PARALLEL_EXECUTION flag must be set to "yes" in order to compile the engine with support for the and-parallel execution of goals. Concurrency primitives are defined in the `apll` library. That flag may be set to "visandor" to, in addition, add support for VisAndOr's events for deterministic parallel goals.
- **New operators defined:**
  `&/2` [950,xfy], `&>/2` [950,xfy], `&&>/2` [950,xfy], `&&/2` [950,xfy], `<&/1` [950,xf], `<&&/1` [950,xf], `&/1` [950,xf], `&&/1` [950,xf], `&!/2` [950,xfy], `&!>/2` [950,xfy], `&&!>/2` [950,xfy], `&&!/2` [950,xfy], `<&!/1` [950,xf], `<&&!/1` [950,xf], `&!/1` [950,xf], `&&!/1` [950,xf], `<?/1` [950,xf], `&?/1` [950,xf].
- **Other modules used:**
  - *System library modules:*
    `andprolog/andprolog_rt`.

103 Low-level concurrency primitives for and-parallelism support

Author(s): Amadeo Casas (`http://www.cs.unm.edu/~amadeo`, University of New Mexico).

This module provides basic mechanisms to start threads, wait for their completion, push goals, search for goals, access to locks, etc. Most of these primitives need to refer to an explicit goal and need to use some information related to its state, stored in the data structure `Handler`.

This primitives allow to efficiently implement at a higher-level different approaches to exploiting independent and-parallelism.

103.1 Usage and interface (apll)

- **Library usage:**
  `:- use_package(apll).`
  or
  `:- module(...,...,[apll]).`
- **Exports:**
  - *Predicates:*
    initial/0, $start_thread/1, $number_agents/1, $push_goal/3, $find_goal/3, $goal_available/1, $cancellation/1, $retrieve_goal/2, $goal_det/1, $set_goal_det/1, $set_goal_nondet/1, $goal_not_executed/1, $set_goal_not_executed/1, $goal_rem_executing/1, $set_goal_rem_executing/1, $goal_finished/1, $set_goal_finished/1, $goal_tobacktrack/1, $set_goal_tobacktrack/1, $goal_toreexecute/1, $set_goal_toreexecute/1, $goal_failed/1, $set_goal_failed/1, $goal_cancelled/1, $show_handler/1, $set_goal_cancelled/1, $send_event/1, $read_event/1, $save_init_execution/1, $save_end_execution/1, $more_solutions/1, $move_execution_top/1, $waiting/1, $suspend/0, $release/1, $release_remote/1, $release_some_suspended_thread/0, $release_all_for_unwinding/0, $enter_mutex/1, $enter_mutex_self/0, $enter_mutex_remote/1, $exit_mutex/1, $exit_mutex_self/0, $exit_mutex_remote/1, $clean_measures/0, $print_measures/0, $new_measure/0, $not_measure/0, $incr_num_local_backtr/0, start_thread/1, number_agents/1, push_goal/3, push_goal/1, find_goal/2, find_det_goal/2, goal_available/1, cancellation/1, retrieve_goal/2, goal_det/1, set_goal_det/1, set_goal_nondet/1, goal_not_executed/1, set_goal_not_executed/1, goal_rem_executing/1, set_goal_rem_executing/1, goal_finished/1, set_goal_finished/1, goal_tobacktrack/1, set_goal_tobacktrack/1, goal_toreexecute/1, set_goal_toreexecute/1, goal_failed/1, set_goal_failed/1, show_handler/1, goal_cancelled/1, set_goal_cancelled/1, send_event/1, read_event/1, save_init_execution/1, save_end_execution/1, more_solutions/1, move_execution_top/1, waiting/1, suspend/0, release/1, release_remote/1, release_some_suspended_thread/0, release_all_for_unwinding/0, enter_mutex/1, enter_mutex_self/0, enter_mutex_remote/1, exit_mutex/1, exit_mutex_self/0, exit_mutex_remote/1, clean_measures/0, print_measures/0, new_measure/0, not_measure/0, incr_num_local_backtr/0.
- **New operators defined:**
  ?/1 [200,fy], @/1 [200,fy], ?/1 [500,fx], @/1 [500,fx], regtype/1 [1150,fx], regtype/2 [1150,xfx], -->/2 [1100,xfy].
- **New modes defined:**
  +/1, @/1, -/1, ?/1, */1, +/2, @/2, -/2, ?/2, */2, in/1, out/1, go/1, in/2, out/2, go/2.
- **New declarations defined:**
  regtype/1, regtype/2.
- **Other modules used:**
  - *System library modules:*
    foreign_interface/foreign_interface_properties, apll/visandor.

103.2 Documentation on new declarations (`apll`)

regtype/1: (UNDOC_REEXPORT)

Imported from `basic_props` (see the corresponding documentation for details).

regtype/2: DECLARATION

No further documentation available for this predicate.

103.3 Documentation on new modes (`apll`)

+/1: MODE

Usage 1: `+A`

– *The following properties are added at call time:*
`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

Usage 2: `+A`

– *The following properties are added at call time:*
`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

@/1: MODE

Usage 1: `@A`

– *The following properties are added globally:*
`A` is not further instantiated. (basic_props:not_further_inst/2)

Usage 2: `@A`

– *The following properties are added globally:*
`A` is not further instantiated. (basic_props:not_further_inst/2)

-/1: MODE

Usage 1: `-A`

– *The following properties are added at call time:*
`A` is a free variable. (term_typing:var/1)

Usage 2: `-A`

– *The following properties are added at call time:*
`A` is a free variable. (term_typing:var/1)

?/1: MODE

***/1:** MODE

+/2: MODE

Usage 1: `A+X`

– *The following properties are added at call time:*
undefined:call(X,A) (undefined property)

Usage 2: `A+X`

– *Call and exit are compatible with:*
undefined:call(X,A) (undefined property)

– *The following properties are added at call time:*
`A` is currently a term which is not a free variable. (term_typing:nonvar/1)

@/2: MODE

Usage 1: `@(A,X)`

– *The following properties are added at call time:*
undefined:call(X,A) (undefined property)

– *The following properties are added upon exit:*
undefined:call(X,A) (undefined property)

– *The following properties are added globally:*
`A` is not further instantiated. (basic_props:not_further_inst/2)

Usage 2: `@(A,X)`

– *Call and exit are compatible with:*
undefined:call(X,A) (undefined property)

– *The following properties are added globally:*
`A` is not further instantiated. (basic_props:not_further_inst/2)

-/2: MODE

Usage 1: `A-X`

– *The following properties are added at call time:*
`A` is a free variable. (term_typing:var/1)

– *The following properties are added upon exit:*
undefined:call(X,A) (undefined property)

Usage 2: `A-X`

– *Call and exit are compatible with:*
undefined:call(X,A) (undefined property)

– *The following properties are added at call time:*
`A` is a free variable. (term_typing:var/1)

?/2: MODE

Usage 1: `A?X`

– *Call and exit are compatible with:*
undefined:call(X,A) (undefined property)

– *The following properties are added upon exit:*
undefined:call(X,A) (undefined property)

Usage 2: `A?X`

– *Call and exit are compatible with:*
undefined:call(X,A) (undefined property)

***/2:** MODE

Usage: `A*X`

– *Call and exit are compatible with:*
undefined:call(X,A) (undefined property)

in/1: MODE

Usage: `in(A)`

– *The following properties are added at call time:*
`A` is currently ground (it contains no variables). (term_typing:ground/1)

– *The following properties are added upon exit:*
`A` is currently ground (it contains no variables). (term_typing:ground/1)

out/1: MODE

Usage: `out(A)`

– *The following properties are added at call time:*
`A` is a free variable. (term_typing:var/1)

– *The following properties are added upon exit:*
`A` is currently ground (it contains no variables). (term_typing:ground/1)

go/1: MODE

Usage: `go(A)`

– *The following properties are added upon exit:*
`A` is currently ground (it contains no variables). (term_typing:ground/1)

in/2: MODE

Usage: `in(A,X)`

– *Call and exit are compatible with:*
undefined:call(X,A) (undefined property)

– *The following properties are added at call time:*
`A` is currently ground (it contains no variables). (term_typing:ground/1)

– *The following properties are added upon exit:*
`A` is currently ground (it contains no variables). (term_typing:ground/1)

out/2: MODE

Usage: `out(A,X)`

- *Call and exit are compatible with:*
  undefined:call(X,A) (undefined property)
- *The following properties are added at call time:*
  `A` is a free variable. (term_typing:var/1)
- *The following properties are added upon exit:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)

go/2: MODE

Usage: `go(A,X)`

- *Call and exit are compatible with:*
  undefined:call(X,A) (undefined property)
- *The following properties are added upon exit:*
  `A` is currently ground (it contains no variables). (term_typing:ground/1)

103.4 Documentation on exports (`apll`)

initial/0: PREDICATE

Usage:

- *The following properties hold globally:*
  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$start_thread/1: PREDICATE

Usage:

- *The following properties should hold at call time:*
  `Arg1` is an integer. (basic_props:int/1)
- *The following properties hold globally:*
  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$number_agents/1: PREDICATE

Usage:

- *The following properties should hold at call time:*
  `Arg1` is a free variable. (term_typing:var/1)
- *The following properties hold upon exit:*
  `Arg1` is an integer. (basic_props:int/1)
- *The following properties hold globally:*
  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$push_goal/3: PREDICATE

Usage:

– *Calls should, and exit will be compatible with:*

`Arg3` is an integer. (basic_props:int/1)

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

`Arg2` is an integer. (basic_props:int/1)

– *The following properties hold upon exit:*

`Arg3` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$find_goal/3: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

`Arg2` is an integer. (basic_props:int/1)

`Arg3` is a free variable. (term_typing:var/1)

– *The following properties hold upon exit:*

`Arg3` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_available/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$cancellation/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$retrieve_goal/2: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

  `Arg2` is a free variable. (term_typing:var/1)

- *The following properties hold upon exit:*

  `Arg2` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_det/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_det/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_nondet/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_not_executed/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_not_executed/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_rem_executing/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_rem_executing/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_finished/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_finished/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_tobacktrack/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_tobacktrack/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_toreexecute/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_toreexecute/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_failed/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_failed/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$goal_cancelled/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$show_handler/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$set_goal_cancelled/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$send_event/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$read_event/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is a free variable. (term_typing:var/1)

- *The following properties hold upon exit:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$save_init_execution/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$save_end_execution/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

- *The following properties hold globally:*

  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$more_solutions/1: PREDICATE

Usage:

- *The following properties should hold at call time:*

  `Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$move_execution_top/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$waiting/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$suspend/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$release/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$release_remote/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$release_some_suspended_thread/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$release_all_for_unwinding/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$enter_mutex/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$enter_mutex_self/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$enter_mutex_remote/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$exit_mutex/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$exit_mutex_self/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$exit_mutex_remote/1: PREDICATE

Usage:

– *The following properties should hold at call time:*

`Arg1` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$clean_measures/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$print_measures/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$new_measure/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$not_measure/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

$incr_num_local_backtr/0: PREDICATE

Usage:

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

start_thread/1: PREDICATE

Meta-predicate with arguments: `start_thread(goal)`.

Usage: `start_thread(Goal)`

– *Description:* Executes `Goal` in a new stack set, using a new thread. Used herein to create a number of parallel agents.

– *The following properties should hold at call time:*

`Goal` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

number_agents/1: PREDICATE

Usage: `number_agents(N)`

– *Description:* Returns in `N` the number of agents in the system.

– *The following properties should hold at call time:*

`N` is a free variable. (term_typing:var/1)

`N` is an integer. (basic_props:int/1)

push_goal/3: PREDICATE

Meta-predicate with arguments: `push_goal(goal,?,?)`.

Usage: `push_goal(Goal,Det,Handler)`

– *Description:* Atomically creates the handler (an arbitrary structure in the heap) associated to `Goal`, described as deterministic or not by `Det`, and adds to the goal list a pointer to `Handler`. `Det` states whether the goal is deterministic or not.

– *The following properties should hold at call time:*

`Goal` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Det` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Goal` is an integer.	(basic_props:int/1)
`Det` is an integer.	(basic_props:int/1)
`Handler` is an integer.	(basic_props:int/1)

push_goal/1: PREDICATE

Usage: `push_goal(Handler)`

– *Description:* Atomically adds a pointer to the particular handler `Handler` to the goal list in order to reexecute the goal associated to it.

– *The following properties should hold at call time:*

`Handler` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Handler` is an integer.	(basic_props:int/1)

find_goal/2: PREDICATE

Usage: `find_goal(GS,Handler)`

– *Description:* Searches for a goal handler `Handler` published in some goal list and succeeds if one is found, failing otherwise. The access to each goal list is made atomically.

– *The following properties should hold at call time:*

`GS` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Handler` is a free variable.	(term_typing:var/1)
`GS` is an integer.	(basic_props:int/1)
`Handler` is an integer.	(basic_props:int/1)

find_det_goal/2: PREDICATE

Usage: `find_det_goal(GS,Handler)`

– *Description:* Searches for a deterministic goal associated to `Handler` and succeeds if one is found, failing otherwise. The access to each goal list is made atomically.

– *The following properties should hold at call time:*

`GS` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Handler` is a free variable.	(term_typing:var/1)
`GS` is an integer.	(basic_props:int/1)
`Handler` is an integer.	(basic_props:int/1)

goal_available/1: PREDICATE

Usage: `goal_available(Handler)`

– *Description:* Succeeds if `Handler` is still in the goal list, and fails otherwise.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

cancellation/1: PREDICATE

Usage: `cancellation(Handler)`

– *Description:* Frees the memory used by `Handler`.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

retrieve_goal/2: PREDICATE

Usage: `retrieve_goal(Handler,Goal)`

– *Description:* Returns in `Goal` the parallel goal associated to `Handler`.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Goal` is a free variable. (term_typing:var/1)
`Handler` is an integer. (basic_props:int/1)
`Goal` is an integer. (basic_props:int/1)

goal_det/1: PREDICATE

Usage: `goal_det(Handler)`

– *Description:* Succeeds if the the goal associated to `Handler` is deterministic, and fails otherwise.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

set_goal_det/1: PREDICATE

Usage: `set_goal_det(Handler)`

– *Description:* Marks the goal associated to `Handler` as deterministic.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

set_goal_nondet/1: PREDICATE

Usage: `set_goal_nondet(Handler)`

– *Description:* Marks the goal associated to `Handler` as non-deterministic.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

goal_not_executed/1: PREDICATE

Usage: `goal_not_executed(Handler)`

- *Description:* Succeeds if the goal associated to `Handler` has not been executed yet, and fails otherwise.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

set_goal_not_executed/1: PREDICATE

Usage: `set_goal_not_executed(Handler)`

- *Description:* Sets the execution of the goal associated to `Handler` to never executed.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

goal_rem_executing/1: PREDICATE

Usage: `goal_rem_executing(Handler)`

- *Description:* Succeeds if the goal associated to `Handler` is remotely executing, and fails otherwise.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

set_goal_rem_executing/1: PREDICATE

Usage: `set_goal_rem_executing(Handler)`

- *Description:* Sets the execution of the goal associated to `Handler` to being remotely executing.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

goal_finished/1: PREDICATE

Usage: `goal_finished(Handler)`

- *Description:* Succeeds if the execution of the goal associated to `Handler` has finished, and fails otherwise.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

set_goal_finished/1: PREDICATE

Usage: `set_goal_finished(Handler)`

- *Description:* Sets the execution of the goal associated to `Handler` to finished.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

goal_tobacktrack/1: PREDICATE

Usage: `goal_tobacktrack(Handler)`

- *Description:* Succeeds if the execution of the goal associated to `Handler` has to backtrack, and fails otherwise.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

set_goal_tobacktrack/1: PREDICATE

Usage: `set_goal_tobacktrack(Handler)`

- *Description:* Sets the execution of the goal associated to `Handler` to backtrack.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

goal_toreexecute/1: PREDICATE

Usage: `goal_toreexecute(Handler)`

- *Description:* Succeeds if the execution of the goal associated to `Handler` has to backtrack, and fails otherwise.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

set_goal_toreexecute/1: PREDICATE

Usage: `set_goal_toreexecute(Handler)`

- *Description:* Sets the execution of the goal associated to `Handler` to be reexecuted.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

goal_failed/1: PREDICATE

Usage: `goal_failed(Handler)`

- *Description:* Succeeds if the execution of the goal associated to `Handler` has failed, and fails otherwise.

– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

set_goal_failed/1: PREDICATE

Usage: `set_goal_failed(Handler)`

– *Description:* Sets the execution of the goal associated to `Handler` to failed.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

show_handler/1: PREDICATE

Usage: `show_handler(Handler)`

– *Description:* Succeeds if the execution of the goal associated to `Handler` has cancelled, and fails otherwise.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

goal_cancelled/1: PREDICATE

Usage: `goal_cancelled(Handler)`

– *Description:* Succeeds if the execution of the goal associated to `Handler` has cancelled, and fails otherwise.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

set_goal_cancelled/1: PREDICATE

Usage: `set_goal_cancelled(Handler)`

– *Description:* Sets the execution of the goal associated to `Handler` to cancelled.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

send_event/1: PREDICATE

Usage: `send_event(Handler)`

– *Description:* Sends the handler to the agent that picked up the goal associated to the handler `Handler` in order to perform backtracking over it.
– *The following properties should hold at call time:*
`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Handler` is an integer. (basic_props:int/1)

read_event/1: PREDICATE

Usage: `read_event(Handler)`

- *Description:* Succeeds if the event queue of the agent is not empty and unifies `Handler` with the handler associated to the goal to backtrack over.
- *The following properties should hold at call time:*

  `Handler` is a free variable. (term_typing:var/1)

  `Handler` is an integer. (basic_props:int/1)

save_init_execution/1: PREDICATE

Usage: `save_init_execution(Handler)`

- *Description:* Saves the choice point that marks the starting point of the execution of the parallel goal associated to the handler `Handler`.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

save_end_execution/1: PREDICATE

Usage: `save_end_execution(Handler)`

- *Description:* Saves the choice point that marks the final point of the execution of the parallel goal associated to the handler `Handler`.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

more_solutions/1: PREDICATE

Usage: `more_solutions(Handler)`

- *Description:* Succeeds whether the goal associated to `Handler` has more solutions to compute, and fails otherwise.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

move_execution_top/1: PREDICATE

Usage: `move_execution_top(Handler)`

- *Description:* Moves the choice point of the goal saved into the handler `Handler` to the top of the stack.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

waiting/1: PREDICATE

Usage: `waiting(Handler)`

- *Description:* Succeeds when the execution of the publishing agent associated to `Handler` is suspended, and fails otherwise.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

suspend/0: PREDICATE

Usage:

- *Description:* Suspends the execution of the current thread.

release/1: PREDICATE

Usage: `release(Handler)`

- *Description:* Releases the execution of the publishing agent associated to `Handler`.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

release_remote/1: PREDICATE

Usage: `release_remote(Handler)`

- *Description:* Releases the execution of the agent that picked up the goal associated to `Handler`.
- *The following properties should hold at call time:*

  `Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Handler` is an integer. (basic_props:int/1)

release_some_suspended_thread/0: PREDICATE

Usage:

- *Description:* Selects one out of any suspended threads and sends it a signal to resume its execution.

release_all_for_unwinding/0: PREDICATE

Usage:

- *Description:* Releases the execution of all agents to perform stack unwinding.

enter_mutex/1: PREDICATE

Usage: `enter_mutex(Handler)`

- *Description:* Attemps to enter into a mutual exclusion to access shared variables of the publishing agent associated to `Handler`.

– *The following properties should hold at call time:*

`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Handler` is an integer. (basic_props:int/1)

enter_mutex_self/0: PREDICATE

Usage:

– *Description:* The mutual exclusion is to access the shared variables of the calling thread.

enter_mutex_remote/1: PREDICATE

Usage: `enter_mutex_remote(Handler)`

– *Description:* The mutual exclusion is to access the shared variables of the remote thread associated to `Handler`.

– *The following properties should hold at call time:*

`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Handler` is an integer. (basic_props:int/1)

exit_mutex/1: PREDICATE

Usage: `exit_mutex(Handler)`

– *Description:* Exits from the mutual exclusion of the publishing agent associated to `Handler`.

– *The following properties should hold at call time:*

`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Handler` is an integer. (basic_props:int/1)

exit_mutex_self/0: PREDICATE

Usage:

– *Description:* Exits from the local mutual exclusion.

exit_mutex_remote/1: PREDICATE

Usage: `exit_mutex_remote(Handler)`

– *Description:* Exits from the mutual exclusion of the remote agent associated to `Handler`.

– *The following properties should hold at call time:*

`Handler` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Handler` is an integer. (basic_props:int/1)

clean_measures/0: PREDICATE

Usage:

– *Description:* Restarts the statistical measures for nondeterministic parallel programs.

print_measures/0: PREDICATE

Usage:

– *Description:* Prints the value of the statistical measures for nondeterministic parallel goals.

new_measure/0: PREDICATE

Usage:

– *Description:* Prepares the statistical values for a new execution.

not_measure/0: PREDICATE

Usage:

– *Description:* Avoids measuring.

incr_num_local_backtr/0: PREDICATE

Usage:

– *Description:* Increments the number of times that backwards execution has been performed over nondeterministic parallel goals.

104 Call on determinate

Author(s): Jose F. Morales, Manuel Carro.

Offers an enriched variant of call and cut `!!/0` which executes pending goals when the computation has no more alternatives.

This library is useful to, for example, get rid of external connections once the necessary data has been obtained.

104.1 Usage and interface (`det_hook_doc`)

- **Library usage:**
  `:- use_module(library(det_hook_rt)).`
  in which case, `!!/0` is not available.
  Typically, this library is used as a package:
  `:- use_package(det_hook).`
- **New operators defined:**
  `?/1` [200,fy], `@/1` [200,fy].
- **New modes defined:**
  `+/1`, `@/1`, `-/1`, `?/1`, `*/1`, `+/2`, `@/2`, `-/2`, `?/2`, `*/2`.
- **Other modules used:**
  - *System library modules:*
    `det_hook/det_hook_rt`.

104.2 Documentation on new modes (`det_hook_doc`)

+/1: MODE

Usage: `+A`

- *The following properties are added at call time:*
  `A` is currently a term which is not a free variable. (term_typing:nonvar/1)

@/1: MODE

Usage: `@A`

- *The following properties are added globally:*
  `A` is not further instantiated. (basic_props:not_further_inst/2)

-/1: MODE

Usage: `-A`

- *The following properties are added at call time:*
  `A` is a free variable. (term_typing:var/1)

?/1: MODE

***/1:** MODE

+/2: MODE

Usage: `A+X`

- *The following properties are added at call time:*
  undefined:call(X,A) (undefined property)

@/2: MODE

Usage: `@(A,X)`

- *The following properties are added at call time:*
  undefined:call(X,A) (undefined property)
- *The following properties are added upon exit:*
  undefined:call(X,A) (undefined property)
- *The following properties are added globally:*
  `A` is not further instantiated. (basic_props:not_further_inst/2)

-/2: MODE

Usage: `A-X`

- *The following properties are added at call time:*
  `A` is a free variable. (term_typing:var/1)
- *The following properties are added upon exit:*
  undefined:call(X,A) (undefined property)

?/2: MODE

Usage: `A?X`

- *Call and exit are compatible with:*
  undefined:call(X,A) (undefined property)
- *The following properties are added upon exit:*
  undefined:call(X,A) (undefined property)

***/2:** MODE

Usage: `A*X`

- *Call and exit are compatible with:*
  undefined:call(X,A) (undefined property)

104.3 Other information (det_hook_doc)

As an example, the program

```
:- module(_, _, [det_hook]).

enumerate(X):-
        display(enumerating), nl,
        OnCut = (display('goal cut'), nl),
        OnFail = (display('goal failed'), nl),
        det_try(enum(X), OnCut, OnFail).

enum(1).
enum(2).
enum(3).
```

behaves as follows:

```
?- enumerate(X).
enumerating

X = 1 ? ;

X = 2 ? ;

X = 3 ? ;
goal failed
```

(note the message inserted on failure). The execution can be cut as follows:

```
?- use_package(det_hook).
{Including /home/clip/lib/ciao/ciao-1.7/library/det_hook/det_hook.pl
}

yes
?- enumerate(X), '!!'.
enumerating
goal cut

X = 1 ? ;

no
```

104.4 Known bugs and planned improvements (det_hook_doc)

- If the started goals do not exhaust their solutions, and '!!'/0 is not used, the database will populate with facts which will be consulted the next time a '!!'/0 is used. This could cause incorrect executions.

105 Runtime predicates for call on determinate

Author(s): Jose F. Morales, Manuel Carro.

Implementation of variant of call and cut which executes pending goals when the computation has no more alternatives.

105.1 Usage and interface (det_hook_rt)

- **Library usage:**
  `:- use_module(library(det_hook_rt)).`
- **Exports:**
  - *Predicates:*
    `det_try/3`.

105.2 Documentation on exports (det_hook_rt)

det_try/3: PREDICATE

Meta-predicate with arguments: `det_try(goal,goal,goal)`.

Usage: `det_try(Goal,OnCut,OnFail)`

- *Description:* `Action` is called, and `OnCut` and `OnFail` are goals to be executed when `Goal` is cut or when it finitely fails, respectively. In order for this to work, cutting must be performed in a special way, by using the `!!/0` predicate, also provided by this module.
- *The following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `OnCut` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `OnFail` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

106 Miscellaneous predicates

Author(s): Manuel Carro, Daniel Cabeza.

This module implements some miscellaneous non-logical (but sometimes very useful) predicates.

106.1 Usage and interface (odd)

- **Library usage:**
  `:- use_module(library(odd)).`
- **Exports:**
  - *Predicates:*
    `setarg/3`, `undo/1`.

106.2 Documentation on exports (odd)

setarg/3: PREDICATE

Usage: `setarg(Index,Term,NewArg)`

- *Description:* Replace destructively argument `Index` in `Term` by `NewArg`. The assignment is undone on backtracking. This is a major change to the normal behavior of data assignment in Ciao Prolog.
- *The following properties should hold at call time:*

  `Index` is currently instantiated to an integer. (term_typing:integer/1)

  `Term` is a compound term. (basic_props:struct/1)

  `NewArg` is any term. (basic_props:term/1)

undo/1: PREDICATE

Meta-predicate with arguments: `undo(goal)`.

Usage: `undo(Goal)`

- *Description:* `call(Goal)` is executed on backtracking. This is a major change to the normal control of Ciao Prolog execution.
- *The following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

107 Delaying predicates (freeze)

Author(s): Manuel Carro, Daniel Cabeza.

This library offers a simple implementation of `freeze/2`, `frozen/2`, etc. [Col82,Nai85,Nai91,Car87] based on the use of attributed variables [Hol92,Hol90].

107.1 Usage and interface (freeze)

- **Library usage:**
  `:- use_module(library(freeze)).`
- **Exports:**
  - *Predicates:*
    `freeze/2`, `frozen/2`.

107.2 Documentation on exports (freeze)

freeze/2: PREDICATE

Meta-predicate with arguments: `freeze(?,goal)`.

Usage: `freeze(X,Goal)`

- *Description:* If `X` is free delay `Goal` until `X` is non-variable.
- *The following properties should hold at call time:*
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

frozen/2: PREDICATE

Meta-predicate with arguments: `frozen(?,goal)`.

Usage: `frozen(X,Goal)`

- *Description:* `Goal` is currently delayed until variable `X` becomes bound.
- *The following properties should hold upon exit:*
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

107.3 Known bugs and planned improvements (freeze)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

108 Delaying predicates (when)

Author(s): Manuel Carro.

`when/2` delays a predicate until some condition in its variable is met. For example, we may want to find out the maximum of two numbers, but we are not sure when they will be instantiated. We can write the standard `max/3` predicate (but changing its name to `gmax/3` to denote that the first and second arguments must be ground) as

```
gmax(X, Y, X):- X > Y, !.
gmax(X, Y, Y):- X =< Y.
```

and then define a 'safe' `max/3` as

```
max(X, Y, Z):-
        when((ground(X),ground(Y)), gmax(X, Y, Z)).
```

which can be called as follows:

```
?- max(X, Y, Z) , Y = 0, X = 8.

X = 8,
Y = 0,
Z = 8 ?

yes
```

Alternatively, `max/3` could have been defined as

```
max(X, Y, Z):-
        when(ground((X, Y)), gmax(X, Y, Z)).
```

with the same effects as above. More complex implementations are possible. Look, for example, at the `max.pl` implementation under the `when` library directory, where a `max/3` predicate is implemented which waits on all the arguments until there is enough information to determine their values:

```
?- use_module(library(when(max))).

yes
?- max(X, Y, Z), Z = 5, Y = 4.

X = 5,
Y = 4,
Z = 5 ?

yes
```

108.1 Usage and interface (when)

- **Library usage:**
  `:- use_module(library(when)).`
- **Exports:**
  - *Predicates:*
    `when/2`.
  - *Regular Types:*
    `wakeup_exp/1`.
- **Other modules used:**
  - *System library modules:*
    `terms_vars`, `sort`, `sets`.

108.2 Documentation on exports (when)

when/2: PREDICATE

Meta-predicate with arguments: `when(?,goal)`.

Usage: `when(WakeupCond,Goal)`

- *Description:* Delays / executes `Goal` according to `WakeupCond` given. The `WakeupCond`s now acceptable are `ground(T)` (`Goal` is delayed until `T` is ground), `nonvar(T)` (`Goal` is delayed until `T` is not a variable), and conjunctions and disjunctions of conditions:

```
wakeup_exp(ground(_1)).
wakeup_exp(nonvar(_1)).
wakeup_exp((C1,C2)) :-
        wakeup_exp(C1),
        wakeup_exp(C2).
wakeup_exp((C1;C2)) :-
        wakeup_exp(C1),
        wakeup_exp(C2).
```

  `when/2` only fails it the `WakeupCond` is not legally formed. If `WakeupCond` is met at the time of the call no delay mechanism is involved — but there exists a time penalty in the condition checking.

  In case that an instantiation fires the execution of several predicates, the order in which these are executed is not defined.

- *The following properties should hold at call time:*

  `WakeupCond` is a legal expression for delaying goals. (when:wakeup_exp/1)

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

wakeup_exp/1: REGTYPE

Usage: `wakeup_exp(T)`

- *Description:* `T` is a legal expression for delaying goals.

108.3 Known bugs and planned improvements (`when`)

- Redundant conditions are not removed.
- Floundered goals are not appropriately printed.

109 Active modules (high-level distributed execution)

Author(s): Manuel Hermenegildo, Daniel Cabeza.

Active modules [CH95] provide a high-level model of inter-process communication and distributed execution (note that this is also possible using Ciao's communication and concurrency primitives, such as sockets, concurrent predicates, etc., but at a lower level of abstraction). An *active module* (or an *active object*) is an ordinary module to which computational resources are attached, and which resides at a given location on the network. Compiling an active module produces an executable which, when running, acts as a *server* for a number of predicates: the predicates exported by the module. Predicates exported by an active module can be accessed by a program on the network by simply "using" the module, which then imports such "remote predicates." The process of "using" an active module does not involve transferring any code, but rather setting up things so that calls in the module using the active module are executed as remote procedure calls to the active module. This occurs in the same way independently of whether the active module and the using module are in the same machine or in different machines across the network.

Except for having to compile it in a special way (see below), an active module is identical from the programmer point of view to an ordinary module. A program using an active module imports it and uses it in the same way as any other module, except that it uses "`use_active_module`" rather than "`use_module`" (see below). Also, an active module has an address (network address) which must be known in order to use it. In order to use an active module it is necessary to know its address: different "protocols" are provided for this purpose (see below).[1]

From the implementation point of view, active modules are essentially daemons: executables which are started as independent processes at the operating system level. Communication with active modules is implemented using sockets (thus, the address of an active module is an IP socket address in a particular machine). Requests to execute goals in the module are sent through the socket by remote programs. When such a request arrives, the process running the active module takes it and executes it, returning through the socket the computed answers. These results are then taken and used by the remote processes. Backtracking over such remote calls works as usual and transparently. The only limitation (this may change in the future, but it is currently done for efficiency reasons) is that all alternative answers are precomputed (and cached) upon the first call to an active module and thus *an active module should not export a predicate which has an infinite number of answers.*

The first thing to do is to select a method whereby the client(s) (the module(s) that will use the active module) can find out in which machine/port (IP address/socket number) the server (i.e., the active module) will be listening once started, i.e., a "protocol" to communicate with the active module. The easiest way to do this is to make use of the rendezvous methods which are provided in the Ciao distribution in the `library/actmods` directory; currently, `tmpbased...`, `filebased...`, `webbased...`, and `platformbased...`.

The first one is based on saving the IP address and socket number of the server in a file in a predefined directory (generally `/tmp`, but this can be changed by changing `tmpbased_common.pl`).

The second one is similar but saves the info in the directory in which the server is started (as `<`*module_name*`>.addr`), or in the directory that a `.addr` file, if it exists, specifies. The clients must be started in the same directory (or have access to a file `.addr` specifying the same directory). However, they can be started in different machines, provided this directory is shared (e.g., by NFS or Samba), or the file can be moved to an appropriate directory on a different machine –provided the full path is the same.

[1] It is also possible to provide active modules via a WWW address. However, we find it more straightforward to simply use socket addresses. In any case, this is generally hidden inside the access method and can be thus made transparent to the user.

The third one is based on a name server for active modules. When an active module is started, it communicates its address to the name server. When the client of the active module wants to communicate with it, it asks the name server the active module address. This is all done transparently to the user. The name server must be running when the active module is started (and, of course, when the application using it is executed). The location of the name server for an application must be specified in an application file named `webbased_common.pl` (see Section 3.1 below).

The fourth one is also based on a name server, but the address of the name server is given as a parameter to the active modules when started.

The rendezvous methods (or protocols) are encoded in two modules: a first one, called `...publish.pl`, is used by the server to publish its info. The second one, called `...locate.pl`, is used by the client(s) to locate the server info. For efficiency, the client methods maintain a cache of addresses, so that the server information only needs to be read from the file system the first time the active module is accessed.

Active modules are compiled using the `-a` option of the Ciao compiler (this can also be done from the interactive top-level shell using `make_actmod/2`). For example, issuing the following command:

```
ciaoc -a 'actmods/filebased_publish' simple_server
```

compiles the simple server example that comes with the distribution (in the `actmods/example` directory). The `simple_client_with_main` example (in the same directory) can be compiled as usual:

```
ciaoc simple_client_with_main
```

Note that the client uses the `actmods` package, specifies the rendezvous method by importing `library(actmods(filebased_locate))`, and explicitely imports the "remote" predicates (*implicit imports will not work*). Each module using the `actmods` package *should only use one of the rendezvous methods.*

Now, if the server is running (e.g., `simple_server &` in Un*x or double-clicking on it in Win32) when the client is executed it will connect with the server to access the predicate(s) that it imports from it.

A simpler even client `simple_client.pl` can be loaded into the top level and its predicates called as usual (and they will connect with the server if it is running).

109.1 Active modules as agents

It is rather easy to turn Ciao active modules into agents for some kind of applications. The directory `examples/agents` contains a (hopefully) self-explanatory example.

109.2 Usage and interface (`actmods_doc`)

- **Library usage:**
  `:- use_package(actmods).`
  or
  `:- module(...,...,[actmods]).`
- **New declarations defined:**
  `use_active_module/2`.

109.3 Documentation on new declarations (actmods_doc)

use_active_module/2: DECLARATION

Usage: :- use_active_module(AModule,Imports).

- *Description:* Specifies that this code imports from the *active module* defined in AModule the predicates in Imports. The imported predicates must be exported by the active module.
- *The following properties should hold at call time:*

  AModule is a source name. (streams_basic:sourcename/1)

  Imports is a list of prednames. (basic_props:list/2)

109.4 Other information (actmods_doc)

The protocols webbased and platformbased are described in this section with a bit more detail.

109.5 Active module name servers (webbased protocol)

An application using a name server for active modules must have a file named webbased_common.pl that specifies where the name server resides. It must have the URL and the path which corresponds to that URL in the file system of the server machine (the one that hosts the URL) of the file that will hold the name server address.

The current distribution provides a file webbased_common.pl that can be used (after proper setting of its contents) for a server of active modules for a whole installation. Alternatively, particular servers for each application can be set up (see below).

The current distribution also provides a module that can be used as name server by any application. It is in file examples/webbased_server/webbased_server.pl.

To set up a name server edit webbased_common.pl to change its contents appropriately as described above (URL and corresponding complete file path). Then recompile this library module:

```
ciaoc -c webbased_common
```

The name server has to be compiled as an active module itself:

```
ciaoc -a actmods/webserver_publish webbased_server
```

It has to be started in the server machine before the application and its active modules are compiled.

Alternatively, you can copy webbased_common.pl and use it to set up name servers for particular applications. Currently, this is a bit complicated. You have to ensure that the name server, the application program, and all its active modules are compiled and executed with the same webbased_common.pl module. One way to do this is to create a subdirectory actmods under the directory of your application, copy webbased_common.pl to it, modify it, and then compile the name server, the application program, and its active modules using a library path that guarantees that your actmods directory is located by the compiler before the standard Ciao library. The same applies for when running all of them if the library loading is dynamic.

One way to do the above is using the -u compiler option. Assume the following file:

```
:- module(paths,[],[]).
:- multifile library_directory/1.
:- dynamic library_directory/1.
```

```
:- initialization(asserta_fact(
library_directory('/root/path/to/my/particular/application') )).
```

then you have file `webbased_common.pl` in a subdirectory `actmods` of the above cited path. You have to compile the name server, the active modules, and the rest of the application with:

```
ciaoc -u paths -s ...
```

to use your particular `webbased_common.pl` and to make executables statically link libraries. If they are dynamic, then you have to provide for the above library_directory path to be set up upon execution. This can be done, for example, by including module `paths` into your executables.

Addresses of active modules are saved by the name server in a subdirectory `webbased_db` of the directory where you start it —see `examples/webbased_server/webbased_db/webbased_server`). This allows to restart the server right away if it dies (since it saves its state). This directory should be cleaned up regularly of addresses of active modules which are no more active. To do this, stop the server —by killing it (its pid is in `PATH/FILE`), and restart it after cleaning up the files in the above mentioned directory.

109.6 Platforms (platformbased protocol)

This protocol is also based on a name server. There are, however, two differences with the above one: the name server address and the active modules names are dynamic. On the one hand, the name server address (IP address/socket number) is given to the active modules when they are started up. This might be convenient when using the same name server executable for different applications starting up a different name server process for each application. On the other hand, the name assigned to a given active module can also be given as a parameter to the active module when it is started up. This makes it easier to maintain a local name space for particular applications (e.g., two modules with the same name can be used as active modules in the same application).

The code of a name server for the previous section protocol can also be used for this protocol (e.g., file `examples/webbased_server/webbased_server.pl`).

109.7 Known bugs and planned improvements (`actmods_doc`)

- The package provides no means for security: the accessing application must take care of this (?).
- It can happen that there is a unique process for an active module serving calls from several different simultaneous executions of the same application (or even different applications). In this case, there might be unwanted interactions (e.g., if the active module has state).
- Applications may fail if the name server or an active module is restarted during execution of the application (since they might restart at a different port than the one cached by the application).
- One may want name servers to reside at a fixed and known machine and port number (this is known as a *service* and is defined in `/etc/services` in a Un*x machine).

110 Agents

Author(s): Francisco Bueno.

An agent is an active module which has a main execution thread. Simultaneously (i.e., in concurrent execution with the main thread), the agent receives messages from other agents, which trigger the execution of a predicate by the name of the message. Messages can also be sent to other agents, by calling the predicate by the name of the message in the context of the receiver agent (see `::/2` below). Agents are identified by name. The name of an agent is usually the name of its (main) file, but this depends on the protocol used (see `protocol/1` below).

A simple agent that sends inform messages and at the same time receives them from other agents, answering back ok, will look like:

```
:- agent(simple,[inform/2,ok/1]).
:- protocol('actmods/filebased').

agent :-
    repeat,
    display('Agent id:message?- '), read(Agent:Mess),
    Agent::inform(Mess),
    fail.

inform(Agent,Mess):-
    display(Agent), display(' has sent: ', display(Mess), nl,
    Agent::ok.

ok(_Agent).
```

110.1 Usage and interface (agent_doc)

- **Library usage:**
  `:- agent(AgentName,[Message|...]).`
  for the main file of the agent.
  `:- use_module(library(agent(agent_call))).`
  for the rest of modules of the agent that need to send messages.
- **New operators defined:**
  `::/2` [550,xfx].
- **New declarations defined:**
  `protocol/1`.

110.2 Documentation on new declarations (agent_doc)

protocol/1: DECLARATION

A protocol is formed by a pair of modules which allow to locate connection addresses of agents. By convention, the names of these modules have a common prefix, which makes reference to the protocol, and have suffixes '_locate' and '_publish'. The 'publish' part of the protocol must define a multifile predicate `save_addr_actmod/1` and the 'locate' part export a predicate `module_address/2`. The first one publishes an agent address; the

second one locates the address of an agent. Together, both make it possible for agents to send and receive messages. All agents in a multi-agent system must therefore use the same protocol. Upon compilation, they will then be (automatically) instrumented as active modules under the corresponding rendezvous method.

Usage: `:- protocol(Protocol).`

– *Description:* `Protocol` is the prefix to a library path where an active module rendezvous protocol can be found.

110.3 Documentation on multifiles (agent_doc)

save_addr_actmod/1: PREDICATE

The predicate is *multifile*.

Usage: `save_addr_actmod(Address)`

– *Description:* (protocol defined) publishes the agent's `Address`.

110.4 Documentation on internals (agent_doc)

module_address/2: PREDICATE

Usage: `module_address(Agent,Address)`

– *Description:* (protocol defined) gives the `Address` of `Agent`.

::/2: PREDICATE

No further documentation available for this predicate.

self/1: PREDICATE

No further documentation available for this predicate.

110.5 Other information (agent_doc)

This package is intended as a sample of how to program agents in Ciao, based on active modules. It probably lacks many features that an agent might need. In particular, it lacks language-independence: it is thought for multi-agent systems where all agents are programmed in Ciao.

You are welcome to add any feature that you may be missing!

110.5.1 Platforms

A platform is an active module which holds connection addresses of agents in a multi-agent system. A protocol is provided which enables the use of platforms: `agent/platformbased`. A suitable platform must be up and running when agents which run under this protocol are started up. The host id and port number (IP address/socket number) of the platform must then be given as arguments to the agents executables. The protocol also allows to give an agent name to the agent upon start-up. A module suitable for a platform can be found in `library(actmods/examples/webbased_server/webbased_server)`.

110.6 Known bugs and planned improvements (`agent_doc`)

- Currently, the agent has to be compiled explicitely as an active module. The same protocol than in the agent source code must be used for this. Automatic compilation is not working.
- It seems that there are running-ahead problems with threads that prevent to correctly publish agent addresses, sometimes.

111 Breadth-first execution

Author(s): Daniel Cabeza, Manuel Carro, Manuel Hermenegildo.

This package implements breadth-first execution of predicates. This may be useful in search problems when a proof procedure is needed that will find all solutions (even if it may still loop for some failures). This is in contrast with the default depth-first search, which may loop in some cases even if there are correct answers to a given query. This library is also useful when experimenting with pure programs as well as when teaching logic programming, for illustrating the expected theoretical results that should be expected from the declarative semantics (see for example the slides in `http://www.cliplab.org/proglog`).

It is important to realize, however, that the improved behaviour of breadth first execution comes at a high (exponential!) price in terms of both time ad memory. This library allows the programmer to control this overhead by selecting which predicates will be executed in breadth-first mode and which predicates in depth-first mode. More concretely, predicates written with operators `'<-'/1` (facts) and `'<-'/2` (clauses) are executed using breadth-first search, while predicates using the standard syntax will be executed depth-first.

The following example implements two versions of a predicate meant to succeed if two nodes of a directed graph are connected. The `chain/2` predicate (which will be executed depth-first) loops without finding the connection between `a` and `d`, while the `bfchain/2` predicate (which will be executed breadth-first) will find the connection correctly:

```
:- module(chain, _, [bf]).

test(bf) :- bfchain(a,d).
test(df) :- chain(a,d).   % loops!

bfchain(X,X) <- .
bfchain(X,Y) <- arc(X,Z), bfchain(Z,Y).

chain(X,X).
chain(X,Y) :- arc(X,Z), chain(Z,Y).

arc(a,b).
arc(a,d).
arc(b,c).
arc(c,a).
```

A second package, `'bf/bfall'`, allows executing *all* the predicates in a given module in breadth-first mode. In this case, predicates should be written using the standard syntax. This is useful to be able to switch easily between depth-first and breadth-first execution (e.g., for testing purposes) for all predicates in a given module without having to modify the program. The following program (written in standard syntax) runs breadth-first:

```
:- module(chain_bfall, _, ['bf/bfall']).

test :- chain(a,d).

chain(X,X).
chain(X,Y) :- arc(X,Z), chain(Z,Y).

arc(a,b).
arc(a,d).
arc(b,c).
```

```
arc(c,a).
```

There is another version, package `'bf/af'`, which ensures AND-fairness by goal shuffling. This reduces the number of cases in which an execution that is a failure loops instead (infinite failures) at a small additional cost. For example, by using `'bf/af'` the following code correctly answers "`no`" when executing `test/0`:

```
:- module(sublistapp, [test/0, sublistapp/2], ['bf/af']).

:- push_prolog_flag(unused_pred_warnings, no).

test :- sublistapp([a], [b]).

sublistapp(S, L) <- append(_, S, Y), append(Y, _, L).

append([], L, L) <- .
append([X|Xs], L, [X|Ys]) <- append(Xs, L, Ys).

:- pop_prolog_flag(unused_pred_warnings).
```

There is also a package `'bf/bfall'` which again allows executing *all* the predicates in a given module in breadth-first, and-fair mode, where also all predicates should be written using the standard syntax. This package offers (at a cost, of course) very nice results for many programs, and is used extensively in programming courses by the Ciao developers.

Finally, it should be noted that a separate library, `id`, implements *iterative-deepening* search, which can in many cases be a better alternative to breadth-first search, since it achieves the same improvement in the completeness results in many cases at a greatly reduced execution cost (but the enumeration order of solutions is not as nice, and that is why these packages are very attractive for prototyping and teaching).

111.1 Usage and interface (`bf_doc`)

- **Library usage:**
  `:- use_package(bf).`
  or
  `:- module(...,...,[bf]).`
- **New operators defined:**
  `<-/2` [1200,xfx], `<-/1` [1200,xf].

111.2 Known bugs and planned improvements (`bf_doc`)

- Does not correctly work in user files.

112 Iterative-deepening execution

Author(s): Rémy Haemmerlé, Manuel Carro, Claudio Vaucheret, Manuel Hermenegildo.

This package applies a *compiling control* technique to implement *depth first iterative deepening* execution [Kor85]. It changes the usual *depth-first* computation rule by *iterative-deepening* on those predicates specifically marked. This is very useful in search problems when a complete proof procedure is needed.

When this computation rule is used, first all goals are expanded only up to a given depth. If no solution is found or more solutions are needed by backtracking, the depth limit is incremented and the whole goal is repeated. Although it might seem that this approach is very inefficient because all higher levels are repeated for the deeper ones, it has been shown that is performs only about b/(b - 1) times as many operations than the corresponding breadth-first search, (where b is the branching factor of the proof tree) while the waste of memory is the same as depth first.

The usage is by means of the following directive:

```
:- iterative(Name, FirstCut, Formula).
```

which states than the predicate 'Name' given in functor/arity form will be executed using iterative deepening rule starting at the depth 'FirstCut' with depth being incremented by the predicate 'Formula'. This predicate compute the new depth using the previous one. It must implement a dilating function i.e. the new depth must be greater. For example, to start with depth 5 and increment by 10 you can write:

```
:- iterative(p/1,5,f).
f(X,Y) :- Y is X + 10.
```

or if you prefer,

```
:- iterative(p/1,5,(_(X,Y):- Y is X + 10)).
```

You can also use a fourth parameter to set a limiting depth. All goals below the given depth limit simply fail. Thus, with the following directive:

```
:- iterative(p/1,5,(_(X,Y):- Y is X + 10),100).
```

all goals deeper than 100 will fail.

An example of code using this package would be:

```
:- module(example_id, _,[id]).

test(id) :-
        idchain(a,d).
test(df) :-
        chain(a,d).   % loops!

:- iterative(idchain/2, 3, ( _(X,Z) :- Z is X + 1) ).

idchain(X,X).
idchain(X,Y) :-
        arc(X,Z),
        idchain(Z,Y).

chain(X,X).
chain(X,Y) :-
        arc(X,Z),
        chain(Z,Y).

arc(a,b).
```

```
arc(a,d).
arc(b,c).
arc(c,a).
```

The order of solutions are first the shallower and then the deeper. Solutions which are between two cutoff are given in the usual left to right order. For example,

```
:- module(_,_,[id]).

% All goals deeper than 2 will fail
:- iterative(p/1,0,(_(X,Z) :- Z is X + 1),2).

% Change the solutions' order to goal p(X).
%:- iterative(p/1,1,(_(X,Z) :- Z is X + 3)).

p(X) :- q(X).
p(a).

q(X) :- r(X).
q(b).

r(X) :- s(X).
r(c).

s(d).
```

Another complete proof procedure implemented is the `bf` package (breadth first execution).

112.1 Usage and interface (`id_doc`)

- **Library usage:**
  `:- use_package(id).`
  or
  `:- module(...,...,[id]).`

113 Constraint programming over rationals

Author(s): Christian Holzbaur, Daniel Cabeza, Samir Genaim (Meta-programming predicates).

Note: This package is currently being adapted to the new characteristics of the Ciao module system. This new version works right now with limitations, but it is under further development at the moment. Use with (lots of) caution.

113.1 Usage and interface (`clpq_doc`)

- **Library usage:**
  `:- use_package(clpq).`
  or
  `:- module(...,...,[clpq]).`
- **New operators defined:**
  `.=./2` [700,xfx], `.<>./2` [700,xfx], `.<./2` [700,xfx], `.=<./2` [700,xfx], `.>./2` [700,xfx], `.>=./2` [700,xfx].

113.2 Other information (`clpq_doc`)

113.2.1 Some CLP(Q) examples

(Other examples can be found in the source and library directories.)

- 'Reversible' Fibonacci (clpq):

```
:- module(_, [fib/2], []).
:- use_package(clpq).

fib(X,Y):- X .=. 0, Y .=. 0.
fib(X,Y):- X .=. 1, Y .=. 1.
fib(N,F) :-
        N .>. 1,
        N1 .=. N - 1,
        N2 .=. N - 2,
        fib(N1, F1),
        fib(N2, F2),
        F .=. F1+F2.
```

- Matrix multiplication (clpq):

```
:- use_package(clpq).
:- use_module(library(write)).

mmultiply([],_,[]).
mmultiply([V0|Rest], V1, [Result|Others]):-
            mmultiply(Rest, V1, Others),
                multiply(V1,V0,Result).
```

```
multiply([],_,[]).
multiply([V0|Rest], V1, [Result|Others]):-
            multiply(Rest, V1, Others),
                vmul(V0,V1,Result).

vmul([],[],0).
vmul([H1|T1], [H2|T2], Result):-
        vmul(T1,T2, Newresult),
        Result .=. H1*H2+Newresult.

matrix(1,[[1,2,3,4,5],[4,0,-1,5,6],[7,1,-2,8,9],[-1,0,1,3,2],[1,5,-3,2,4]]).
matrix(2,[[3,2,1,0,-1],[-2,1,3,0,2],[1,2,0,-1,5],[1,3,2,4,5],[-5,1,4,2,2]]).

%% Call with: ?- go(M).

go(M):-
        matrix(1,M1),
        matrix(2,M2),
        mmultiply(M1, M, M2).
```

- Queens (clpq):

```
:- use_package(clpq).

queens(N, Qs) :- constrain_values(N, N, Qs), place_queens(N, Qs).

constrain_values(0, _N, []).
constrain_values(N, Range, [X|Xs]) :-
        N .>. 0, X .>. 0, X .=<. Range,
        N1 .=. N - 1,
        constrain_values(N1, Range, Xs), no_attack(Xs, X, 1).

no_attack([], _Queen, _Nb).
no_attack([Y|Ys], Queen, Nb) :-
        Queen .<>. Y+Nb,
        Queen .<>. Y-Nb,
        Nb1 .=. Nb + 1,
        no_attack(Ys, Queen, Nb1).

place_queens(0, _).
place_queens(N, Q) :-
        N > 0, member(N, Q), N1 is N-1, place_queens(N1, Q).
```

113.2.2 Meta-programming with CLP(Q)

The implementation of CLP(Q) in Ciao compiles the constraints in the program to a sequence of calls to the underlying constraints solver (at compile-time). This results in efficient implementation, since the structure of the constraints is processed only at compile-time, but requires the constraints to be known at static time which can be a limitation for metaprogramming-based applications such as static program analyzers. For example, the call:

```
?- X=(A+B), Y=(C-D), X .>. Y.

no
```

fails because `X .>. Y` is translated first to a sequence of calls that require (when they invoked) `X` and `Y` to be either numbers or free variables. To overcome this limitation, you can use `clp_meta/1` which delays the translation of the constraints from compile-time to run-time (i.e., when `clp_meta/1` is called), For example:

```
?- X=(A+B),Y=(C-D), clp_meta([X .>. Y]).

X = A+B,
Y = C-D,
C.<.D+A+B ?
```

The argument of `clp_meta/1` accepts a goal or lists of goals, where each goal is limited to conjunctions, disjunctions, or CLP(Q) constraints. Other operations on constraints which are extensively used in meta-programming, in particular in static program analysis, are *projection* and *entailment check*. The projection operation restricts the constraints (that are available in the store) to a given set of variables and turns the answer into terms. You can use the multifile predicate `dump_constraints/3` for that purpose:

```
?- A .>. C, C .>. B, dump_constraints([A,B],[X,Y],Cs).

Cs = [X.>.Y],
C.>.B,
C.<.A ?

?- C=(B+D), clp_meta([A .>. C, D .>. 0]), dump_constraints([A,B],[X,Y],Cs).

C = B+D,
Cs = [Y.<.X],
D.<. -B+A,
D.>.0 ?
```

The *entailment check* is used to check if a list of constrains is entailed by the store. You can use the predicate `clp_entailed/1` for that purpose:

```
?- A .>. C, C .>. B, B .>. D, clp_entailed([ A .>. B, A .>. D]).

B.>.D,
C.>.B,
C.<.A ?

yes

?- A .>=. B, clp_entailed([ A .>. B ]).

no
```

113.3 Known bugs and planned improvements (`clpq_doc`)

- clp(Q) and clp(R) cannot be used simultaneously in the same program, or even within the same toplevel session.

114 Constraint programming over reals

Author(s): Christian Holzbaur, Daniel Cabeza, Samir Genaim (Meta-programming predicates).

Note: This package is currently being adapted to the new characteristics of the Ciao module system. This new version now works right now to some extent, but it under further development at the moment. Use with (lots of) caution.

114.1 Usage and interface (`clpr_doc`)

- **Library usage:**
  `:- use_package(clpr).`
  or
  `:- module(...,...,[clpr]).`
- **New operators defined:**
  `.=./2` [700,xfx], `.<>./2` [700,xfx], `.<./2` [700,xfx], `.=<./2` [700,xfx], `.>./2` [700,xfx], `.>=./2` [700,xfx].

114.2 Other information (`clpr_doc`)

114.2.1 Some CLP(R) examples

(Other examples can be found in the source and library directories.)

- 'Reversible' Fibonacci (clpr):

```
:- module(_, [fib/2], []).
:- use_package(clpr).

fib(X,Y):- X .=. 0, Y .=. 0.
fib(X,Y):- X .=. 1, Y .=. 1.
fib(N,F) :-
        N .>. 1,
        N1 .=. N - 1,
        N2 .=. N - 2,
        fib(N1, F1),
        fib(N2, F2),
        F .=. F1+F2.
```

- Dirichlet problem for Laplace's equation (clpr):

```
%
% Solve the Dirichlet problem for Laplace's equation using
% Leibman's five-point finit-differenc approximation.
% The goal ?- go1 is a normal example, while the goal ?- go2
% shows output constraints for a small region where the boundary conditions
```

```
% are not specified.
%
:- use_package(clpq).
:- use_module(library(format)).

laplace([_, _]).
laplace([H1, H2, H3|T]):-
        laplace_vec(H1, H2, H3),
        laplace([H2, H3|T]).

laplace_vec([_, _], [_, _], [_, _]).
laplace_vec([_TL, T, TR|T1], [ML, M, MR|T2], [_BL, B, BR|T3]):-
        B + T + ML + MR - 4 * M .=. 0,
        laplace_vec([T, TR|T1], [M, MR|T2], [B, BR|T3]).

printmat([]).
printmat([H|T]):-
        printvec(H),
        printmat(T).

printvec([]):- nl.
printvec([H|T]):-
        printrat(H),
        printvec(T).

printrat(rat(N,D)) :- !,
        X is N/D,
        format(" ~2f",X).
printrat(N) :-
        X is N*100,
        format(" ~2d",X).

go1:-
        X =  [
      [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100]
    ],
        laplace(X),
        printmat(X).

% Answer:
% 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
```

```
% 100.00 51.11 32.52 24.56 21.11 20.12 21.11 24.56 32.52 51.11 100.00
% 100.00 71.91 54.41 44.63 39.74 38.26 39.74 44.63 54.41 71.91 100.00
% 100.00 82.12 68.59 59.80 54.97 53.44 54.97 59.80 68.59 82.12 100.00
% 100.00 87.97 78.03 71.00 66.90 65.56 66.90 71.00 78.03 87.97 100.00
% 100.00 91.71 84.58 79.28 76.07 75.00 76.07 79.28 84.58 91.71 100.00
% 100.00 94.30 89.29 85.47 83.10 82.30 83.10 85.47 89.29 94.30 100.00
% 100.00 96.20 92.82 90.20 88.56 88.00 88.56 90.20 92.82 96.20 100.00
% 100.00 97.67 95.59 93.96 92.93 92.58 92.93 93.96 95.59 97.67 100.00
% 100.00 98.89 97.90 97.12 96.63 96.46 96.63 97.12 97.90 98.89 100.00
% 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0 100.0

go2([B31, M32, M33, B34, B42, B43, B12, B13, B21, M22, M23, B24]) :-
        laplace([
            [_B11, B12, B13, _B14],
            [B21, M22, M23, B24],
            [B31, M32, M33, B34],
            [_B41, B42, B43, _B44]
    ]).


% Answer:
%
% B34.=. -4*M22+B12+B21+4*M33-B43,
% M23.=.4*M22-M32-B12-B21,
% B31.=. -M22+4*M32-M33-B42,
% B24.=.15*M22-4*M32-4*B12-4*B21-M33-B13 ?
```

114.2.2 Meta-programming with CLP(R)

see Section 113.2.2 [Meta-programming with CLP(Q)], page 596

114.3 Known bugs and planned improvements (`clpr_doc`)

- clp(Q) and clp(R) cannot be used simultaneously in the same program, or even within the same toplevel session.

115 Fuzzy Prolog

Author(s): Claudio Vaucheret, Sergio Guadarrama, Francisco Bueno.

This package impements an extension of prolog to deal with uncertainty. We implement a fuzzy prolog that models interval-valued fuzzy logic. This approach is more general than other fuzzy prologs in two aspects:

1. Truth values are sub-intervals on [0,1]. In fact, it could be a finite union of sub-intervals, as we will see below. Having a unique truth value is a particular case modeled with a unitary interval.
2. Truth values are propagated through the rules by means of a set of *aggregation operators*. The definition of an *aggregation operator* is a generalization that subsumes conjunctive operators (triangular norms as min, prod, etc.), disjunctive operators (triangular co-norms as max, sum, etc.), average operators (averages as arithmetic average, cuasi-linear average, etc.) and hybrid operators (combinations of previous operators).

We add uncertainty using CLP(R) instead of implementing a new fuzzy resolution as other fuzzy prologs. In this way, we use the original inference mechanism of Prolog, and we use the constraints and its operations provided by CLP(R) to handle the concept of partial truth. We represent intervals as constrains over real numbers and *aggregation operators* as operations with constraints.

Each fuzzy predicate has an additional argument which represents its truth value. We use ":~" instead of ":-" to distinguish fuzzy clauses from prolog clauses. In fuzzy clauses, truth values are obtained via an aggregation operator. There is also some syntactic sugar for defining fuzzy predicates with certain membership functions, the fuzzy counterparts of crisp predicates, and the fuzzy negation of a fuzzy predicate.

115.1 Usage and interface (`fuzzy_doc`)

- **Library usage:**
  `:- use_package(fuzzy).`
  or
  `:- module(...,...,[fuzzy]).`
- **Exports:**
  - *Predicates:*
    `:#/2`, `fuzzy_predicate/1`, `fuzzy/1`, `fnot/1`, `:~/2`, `=>/4`.
  - *Properties:*
    `fuzzybody/1`.
  - *Regular Types:*
    `faggregator/1`.
- **New operators defined:**
  `:~/2` [1200,xfx], `:~/1` [1200,xf], `:=/2` [1200,xfx], `:=/1` [1200,xf], `:#/2` [1200,xfx], `=>/1` [1175,fx], `fnot/1` [1150,fx], `aggr/1` [1150,fx], `##/2` [1120,xfy], `<#/2` [1120,xfy], `#>/2` [1120,xfy], `fuzzy/1` [1150,fx], `fuzzy_predicate/1` [1190,fx], `fuzzy_discrete/1` [1190,fx].
- **New declarations defined:**
  `aggr/1`.

115.2 Documentation on new declarations (fuzzy_doc)

aggr/1: DECLARATION

Usage: `:- aggr(Name).`

– *Description:* Declares `Name` an aggregator. Its binary definition has to be provided. For example:

```
:- aggr myaggr.

myaggr(X,Y,Z):- Z .=. X*Y.
```

defines an aggregator identical to `prod`.

– *The following properties hold at call time:*

`Name` is an atomic term (an atom or a number). (basic_props:constant/1)

115.3 Documentation on exports (fuzzy_doc)

:#/2: PREDICATE

Usage: `:#(Name,Decl)`

– *Description:* Defines fuzzy predicate `Name` from the declaration `Decl`.

– *The following properties hold upon exit:*

`Name` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

`Decl` is one of the following three:

```
fuzzydecl(fuzzy_predicate(_1)).
fuzzydecl(fuzzy(_1)).
fuzzydecl(fnot(_1)).
```

(user(/home/ciaotester/tests/auto/CiaoDE/ciao/library/fuzzy/fuzzy_doc):fuzzydecl/1)

fuzzy_predicate/1: PREDICATE

Usage: `fuzzy_predicate(Domain)`

– *Description:* Defines a fuzzy predicate with piecewise linear continuous membership function. This is given by `Domain`, which is a list of pairs of domain-truth values, in increasing order and exhaustive. For example:

```
young :# fuzzy_predicate([(0,1),(35,1),(45,0),(120,0)]).
```

defines the predicate:

```
young(X,1):- X .>=. 0, X .<. 35.
young(X,M):- X .>=. 35, X .<. 45, 10*M .=. 45-X.
young(X,0):- X .>=. 45, X .=<. 120.
```

– *The following properties should hold at call time:*

`Domain` is a list. (basic_props:list/1)

fuzzy/1: PREDICATE

Usage: `fuzzy(Name)`

– *Description:* Defines a fuzzy predicate as the fuzzy counterpart of a crisp predicate `Name`. For example,

```
p_f :# fuzzy p/2
```

defines a new fuzzy predicate `p_f/3` (the last argument is the truth value) with truth value equal to 0 if `p/2` fails and 1 otherwise.

– *The following properties should hold at call time:*

`Name` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

fnot/1: PREDICATE

Usage: `fnot(Name)`

– *Description:* Defines a fuzzy predicate as the fuzzy negation of another fuzzy predicate `Name`. For example,

```
notp_f :# fnot p_f/3
```

defines the predicate:

```
notp_f(X,Y,M) :-
        p_f(X,Y,Mp),
        M .=. 1 - Mp.
```

– *The following properties should hold at call time:*

`Name` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

:~/2: PREDICATE

Usage: `:~(Head,Body)`

– *Description:* Defines a fuzzy clause for a fuzzy predicate. The clause contains calls to either fuzzy or crisp predicates. Calls to crisp predicates are automatically fuzzified. The last argument of `Head` is the truth value of the clause, which is obtained as the aggregation of the truth values of the body goals. An example:

```
:- module(young2,_,[fuzzy]).

young_couple(X,Y,Mu) :~ min
        age(X,X1),
        age(Y,Y1),
        young(X1,MuX),
        young(Y1,MuY).

age(john,37).
```

```
age(rose,39).

young :# fuzzy_predicate([(0,1),(35,1),(45,0),(120,0)]).
```

so that:

```
?- young_couple(john,rose,M).

M .=. 0.6 ?
```

– *The following properties should hold at call time:*

`Head` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`Body` is a clause body plus an optional aggregation operator. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/library/fuzzy/fuzzy_doc):fuzzybody/1)

fuzzybody/1: PROPERTY

A clause body, optionally prefixed by the name of an aggregation operator. The agregators currently provided are listed under `faggregator/1`. By default, the aggregator used is `min`.

Usage: `fuzzybody(B)`

– *Description:* `B` is a clause body plus an optional aggregation operator.

faggregator/1: REGTYPE

The first three are, respectively, the T-norms: minimum, product, and Lukasiewicz's. The last three are their corresponding T-conorms. Aggregators can be defined by the user, see `aggr/1`.

```
faggregator(min).
faggregator(prod).
faggregator(luka).
faggregator(max).
faggregator(dprod).
faggregator(dluka).
```

Usage: `faggregator(Aggr)`

– *Description:* `Aggr` is an aggregator which is cumulative, i.e., its application to several values by iterating pairwise the binary operation is safe.

=>/4: PREDICATE

Usage: `=>(Aggr,A,B,Truth)`

– *Description:* The fuzzy implication `A => B` defined by aggregator `Aggr`, resulting in the truth value `Truth`.

– *The following properties should hold at call time:*

`Aggr` is an aggregator which is cumulative, i.e., its application to several values by iterating pairwise the binary operation is safe. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/library/fuzzy/fuzzy_doc):faggregator/1)

`A` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`B` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`Truth` is a free variable. (term_typing:var/1)

115.4 Other information (fuzzy_doc)

An example program:

```
:- module(dicesum5,_,[fuzzy]).

% this example tries to measure which is the possibility
% that a couple of values, obtained throwing two loaded dice, sum 5. Let
% us suppose we only know that one die is loaded to obtain a small value
% and the other is loaded to obtain a large value.
%
% the query is  ? sum(5,M)
%

small :# fuzzy_predicate([(1,1),(2,1),(3,0.7),(4,0.3),(5,0),(6,0)]).
large :# fuzzy_predicate([(1,0),(2,0),(3,0.3),(4,0.7),(5,1),(6,1)]).

die1(X,M) :~
        small(X,M).

die2(X,M) :~
        large(X,M).


two_dice(X,Y,M):~ prod
        die1(X,M1),
        die2(Y,M2).

sum(2,M) :~
        two_dice(1,1,M1).


sum(5,M) :~ dprod
        two_dice(4,1,M1),
        two_dice(1,4,M2),
        two_dice(3,2,M3),
        two_dice(2,3,M4).
```

There are more examples in the subdirectory `fuzzy/examples` of the distribution.

115.5 Known bugs and planned improvements (fuzzy_doc)

- General aggregations defined by users.
- Inconsistent behaviour of meta-calls in fuzzy clauses.
- Some meta-predicate constructions need be added, specially for 'disjunctive' fuzzy clauses, e.g., `sum/2` in the dice example.

116 Object oriented programming

Author(s): Angel Fernandez Pineda.

O'Ciao is a set of libraries which allows object-oriented programming in Ciao Prolog. It extends the Ciao Prolog module system by introducing two new concepts:

- Inheritance.
- Instantiation.

Polymorphism is the third fundamental concept provided by object oriented programming. This concept is not mentioned here since **traditional PROLOG systems are polymorphic by nature**.

Classes are declared in the same way as modules. However, they may be enriched with inheritance declarations and other object-oriented constructs. For an overview of the fundamentals of O'Ciao, see `http://www.clip.dia.fi.upm.es/~clip/papers/ociao-tr.ps.gz`. However, we will introduce the concepts in a tutorial way via examples.

116.1 Early examples

The following one is a very simple example which declares a class – a simple stack. Note that if you replace *class/1* declaration with a *module/1* declaration, it will compile correctly, and can be used as a normal Prolog module.

```
%%-----------------------------------------------%%
%% A class for stacks.                           %%
%%-----------------------------------------------%%

%% Class declaration: the current source defines a class.
:- class(stack,[],[]).

% State declaration: storage/1 is an attribute.
:- dynamic storage/1.

% Interface declaration: the following predicates will
% be available at run-time.
:- export(push/1).
:- export(pop/1).
:- export(top/1).
:- export(is_empty/0).

% Methods

push(Item) :-
        nonvar(Item),
        asserta_fact(storage(Item)).

pop(Item) :-
        var(Item),
        retract_fact(storage(Item)).

top(Top) :-
        storage(Top), !.
```

```
is_empty :-
        storage(_), !, fail.
is_empty.
```

If we load this code at the Ciao toplevel shell:

```
?- use_package(objects).

yes
?- use_class(library('class/examples/stack')).

yes
?-
```

we can create two stack *instances* :

```
?- St1 new stack,St2 new stack.

St1 = stack('9254074093385163'),
St2 = stack('9254074091') ? ,
```

and then, we can operate on them separately:

```
1 ?- St1:push(8),St2:push(9).

St1 = stack('9254074093385163'),
St2 = stack('9254074091') ?

yes
1 ?- St1:top(I),St2:top(K).

I = 8,
K = 9,
St1 = stack('9254074093385163'),
St2 = stack('9254074091') ?

yes
1 ?-
```

The interesting point is that there are two stacks. If the previous example had been a normal module, we would have a stack , but **only one** stack.

The next example introduces the concepts of *inheritable* predicate, *constructor*, *destructor* and *virtual method*. Refer to the following sections for further explanation.

```
%%-----------------------------------------------%%
%% A generic class for item storage.            %%
%%-----------------------------------------------%%
:- class(generic).

% Public interface declaration:
:- export([set/1,get/1,callme/0]).

% An attribute
:- data datum/1.

% Inheritance declaration: datum/1 will be available to
% descendant classes (if any).
```

```
:- inheritable(datum/1).

% Attribute initialization: attributes are easily initialized
% by writing clauses for them.
datum(none).

% Methods

set(X) :-
        type_check(X),
        set_fact(datum(X)).

get(X) :-
        datum(X).

callme :-
        a_virtual(IMPL),
        display(IMPL),
        display(' implementation of a_virtual/0 '),
        nl.

% Constructor: in this case, every time an instance
% of this class is created, it will display a message.
generic :-
        display(' generic class constructor '),
        nl.

% Destructor: analogous to the previous constructor,
% it will display a message every time an instance
% of this class is eliminated.
destructor :-
        display(' generic class destructor '),
        nl.

% Predicates:
% cannot be called as messages (X:method)

% Virtual declaration: tells the system to use the most
% descendant implementation of a_virtual/1 when calling
% it from inside this code (see callme/0).
% If there is no descendant implementation for it,
% the one defined bellow will be used.
:- virtual a_virtual/1.

a_virtual(generic).

:- virtual type_check/1.

type_check(X) :-
        nonvar(X).
```

And the following example, is an extension of previous class. This is performed by establishing an inheritance relationship:

```
%%-----------------------------------------------%%
%% This class provides additional functionality %%
%% to the "generic" class.                      %%
%%-----------------------------------------------%%
:- class(specific).

% Establish an inheritance relationship with class "generic".
:- inherit_class(library('class/examples/generic')).

% Override inherited datum/1.
% datum/1 is said to be overriden because there are both an
% inherited definition (from class "generic") and a local one,
% which overrides the one inherited.
:- data datum/1.
:- inheritable datum/1.

% Extend the public interface inherited from "generic".
% note that set/1 and a_virtual/0 are also overriden.
% undo/0 is a new functionality added.
:- export([set/1,undo/0]).

% Methods

set(Value) :-
        inherited datum(OldValue),
        !,
        inherited set(Value),
        asserta_fact(datum(OldValue)).
set(Value) :-
        inherited set(Value).

undo :-
        retract_fact(datum(Last)), !,
        asserta_fact(inherited(datum(Last))).
undo :-
        retractall_fact(inherited(datum(_))).

% Constructor
specific :-
        generic,
        retractall_fact(inherited(datum(_))),
        display(' specific class constructor '),
        nl.

% Destructor
destructor :-
        display(' specific class destructor '),
        nl.
```

```
% Predicates

% New implementation of a_virtual/1.
% Since this predicate was declared virtual, the
% implementation below will be called from the inherited
% method callme/0 instead of the version defined at "generic".
a_virtual(specific).
```

Additional examples may be found on the *library/class/examples* directory relative to your Ciao Prolog instalation.

116.2 Recommendations on when to use objects

We would like to give some advice in the use of object oriented programming, in conjunction with the declarative paradigm.

You should reconsider using O'Ciao in the following cases:

- The pretended "objects" have no state,i.e., no data or dynamic predicates. In this case, a normal module will suffice.
- There is state, but there will be only one instance of a pretended class. Again, a module suffices.
- The "objects" are data structures (list,trees,etc) already supported by Prolog. However, it does make sense to model, using objects, data structures whose change implies a side-effect such as drawing a particular window on the screen.

We recommend the usage of O'Ciao in the following cases:

- You feel you will need to have several copies of a "module".
- Local copies of a module are needed instead of a global module beeing modified by several ones.
- The "classes" are a representation of external entities to Prolog. For example: the X-Window system.
- There is state or code outside the Prolog system which needs to be manipulated. For example: interfaces to Java or Tcl/Tk code.
- You are not familiar with Prolog, but you know about object oriented programming. O'Ciao may be used as a learning tool to introduce yourself on the declarative programming paradigm.

116.3 Limitations on object usage

O'Ciao run-time speed is limited by the usage of meta-programming structures, for instance: `X = (Object:mymethod(25)), call(X)`. O'Ciao will optimize static manipulation of objects (those that can be determined at compile time).

117 Declaring classes and interfaces

Author(s): Angel Fernandez Pineda.

O'Ciao classes are declared in the same way as traditional prolog modules. The general mechanism of *source expansion* will translate object-oriented declarations to normal prolog code. This is done transparently to the user.

Abstract *interfaces* are restricted classes which declare exported predicates with no implementation. The implementation itselt will be provided by some class using an `implements/1` declaration. Only `export/1` and `data/1` declarations are allowed when declaring an interface. Normal classes may treated as interfaces just ignoring all exported predicate implementations.

117.1 Usage and interface (`class_doc`)

- **Library usage:**

  To declare a class the compiler must be told to use the `class` *source expansion*. To do so, source code must start with a module declaration which loads the class package:

  ```
  :- class(ClassName).
  ```

  or a `module/3` declaration, as follows:

  ```
  :- module(ClassName,[],[class]).
  ```

  interfaces are declared in a similar way:

  ```
  :- interface(InterfaceName).
  ```

  Please, do not use SICStus-like module declaration, with a non-empty export list. In other case, some non-sense errors will be reported by normal Ciao module system.

  Most of the regular Ciao declarations may be used when defining a class, such as `concurrent/1`, `dynamic/1`, `discontiguous/1`, `multifile/1`, and so on.

  However, there are some restrictions wich apply to those declarations:

  - `meta_predicate/1` declaration is not allowed to hold *addmodule and pred(N) meta-arguments*, except for previously declared multifiles.
  - Attribute and multifile predicates must be declared before any clause of the related predicate.
  - There is no sense in declaring an attribute as meta_predicate.

  It is a good practique to put all your declarations at the very begining of the file, just before the code itself.
- **Exports:**
  - *Predicates:*

    `inherited/1`, `self/1`, `constructor/0`, `destructor/0`.
- **New declarations defined:**

  `export/1`, `public/1`, `inheritable/1`, `data/1`, `dynamic/1`, `concurrent/1`, `inherit_class/1`, `implements/1`, `virtual/1`.
- **Other modules used:**
  - *System library modules:*

    `objects/objects_rt`.

117.2 Documentation on new declarations (class_doc)

export/1: DECLARATION

Declares a method or attribute to be part of the *public interface*.

The public interface is the set of predicates wich will be accesible from any code establishing an usage relationship with this class (see `use_class/1` for further information).

Publishing an attribute or method is very similar to *exporting* a predicate in a Prolog module.

Whether an inherited and exported predicate is overriden, it must be explicitly exported again.

An inherited (but not exported) predicate may become exported, without overriding it by the usage of this declaration.

Usage: `:- export(Spec).`

- *Description:* `Spec` will be part of the public (exported) interface.
- *The following properties should hold at call time:*

  `Spec` is a method or attribute specification. (objects_rt:method_spec/1)

public/1: DECLARATION

Just an alias for `export/1`.

Usage: `:- public(Spec).`

- *Description:* This declaration may be used instead of `export/1`.
- *The following properties should hold at call time:*

  `Spec` is a method or attribute specification. (objects_rt:method_spec/1)

inheritable/1: DECLARATION

Declares a method or attribute to be inherited by descendant classes. Notice that all **public predicates are inheritable by default**. There is no need to mark them as inheritable.

Traditionaly, object oriented languages makes use of the *protected* concept. Inheritable/1 may be used as the same concept.

The set of inheritable predicates is called the *inheritable interface*.

Usage: `:- inheritable(MethodSpec).`

- *Description:* `MethodSpec` is accessible to descendant classes.
- *The following properties should hold at call time:*

  `MethodSpec` is a method or attribute specification. (objects_rt:method_spec/1)

data/1: DECLARATION

Declares an *attribute* at current class. Attributes are used to build the internal state of instances. So, each instance will own a particular copy of those attribute definitions. In this way, one instance may have different state from another.

O'Ciao attributes are restricted to hold simple facts. It is not possible to hold a Head :- Body clause at an instance attribute.

Notice that attributes are *multi-evaluated* by nature, and may be manipulated by the habitual **assert/retract** family of predicates.

Attributes may also be initialized. In order to do so, simply put some clauses after the attribute definition. Each time an instance is created, its initial state will be built from those *initialization clauses*.

Note: whether a data/1 declaration appears inside an interface, it will be automatically exported.

Usage: :- `data Spec`.

- *Description:* `Spec` is an attribute.
- *The following properties should hold at call time:*
  `Spec` is a method or attribute specification. (objects_rt:method_spec/1)

dynamic/1: DECLARATION

Just an alias for `data/1`.

Usage: :- `dynamic Spec`.

- *Description:* You may use this declaration instead of `data/1`.
- *The following properties should hold at call time:*
  `Spec` is a method or attribute specification. (objects_rt:method_spec/1)

concurrent/1: DECLARATION

Declares a *concurrent attribute* at current class. Concurrent attributes are just the same as normal attributes, those declared using `data/1`, except for they may freeze the calling thread instead of failing when no more choice points are remaining on the concurrent attribute.

In order to get more information about concurrent behavior take a look to the concurrent/1 built-in declaration on Ciao Prolog module system.

Usage: :- `concurrent Spec`.

- *Description:* Declares `Spec` to be a concurrent attribute.
- *The following properties should hold at call time:*
  `Spec` is a method or attribute specification. (objects_rt:method_spec/1)

inherit_class/1: DECLARATION

Makes any public and/or inheritable predicate at inherited class to become accesible by any instance derived from current class.

Inherited class is also called the *super class*.

Only one inherit_class/1 declaration is allowed to be present at current source.

Notice that inheritance is public by default. Any public and/or inheritable declaration will remain the same to descendant classes. However, any inherited predicate may be *overriden* (redefined).

A predicate is said to be *overriden* when it has been inherited from super class, but there are clauses (or a `data/1` declaration) present at current class for such a predicate.

Whether a **public** predicate is overriden, the local definition must also be exported, otherwise an error is reported.

Whether an **inheritable** predicate (not public) is overriden, the local definition must also be marked as inheritable or exported, otherwise an error is also reported.

Note: whether inherit_class/1 appears inside an interface, it will be used as an `implements/1` declaration.

Usage: :- `inherit_class(Source)`.

– *Description:* Establish an *inheritance relationship* between current class and the class defined at `Source` file.
– *The following properties should hold at call time:*

  `Source` is a valid path to a prolog file containing a class declaration (without .pl extension). (objects_rt:class_source/1)

implements/1: DECLARATION

Forces current source to provide an implementation for the given interface file. Such interface file may declare another class or a specific interface.

Every public predicate present at given interface file will be automatically declared as public at current source, so you **must** provide an implementation for such predicates.

The effect of this declaration is called *interface inheritance*,and there is no restriction on the number of implements/1 declarations present at current code.

Usage: `:- implements(Interface).`

– *Description:* Current source is supposed to provide an implementation for `Interface`.
– *The following properties should hold at call time:*

  `Interface` is a valid path to a prolog file containing a class declaration or an interface declaration (without .pl extension). (objects_rt:interface_source/1)

virtual/1: DECLARATION

This declaration may be used whenever descendant classes are to implement different versions of a given predicate.

virtual predicates give a chance to handle, in an uniform way, different implementations of the same functionality.

Whether a virtual predicate is declared as a method, there must be at least one clause of it present at current source. Whenever no special implementation is needed at current class, a never-fail/allways-fail clause may be defined (depending on your needs). For example:

```
:- virtual([ test1/1 , test2/2 ]).
test1(_).
test2(_,_) :- fail.
```

This kind of virtual methods are also known as *abstract methods*, since implementation is fully delegated to descendant classes.

An attribute may be also declared as a virtual one, but there is no need to write clauses for it.

Usage: `:- virtual(VirtualMethodSpec).`

– *Description:* All calls to `VirtualMethodSpec` predicate in current source will use the most descendant implementation of it.
– *The following properties should hold at call time:*

  `VirtualMethodSpec` is a method specification. (objects_rt:virtual_method_spec/1)

117.3 Documentation on exports (`class_doc`)

inherited/1: PREDICATE

This predicate qualificator may be used whenever you need to reference an attribute or method on the super class.

Since methods and attributes may be redefined, this qualificator is need to distinguish between a locally declared predicate and the inherited one, which has the same name.

There is no need to use inherited/1 if a particular inherited predicate has not been redefined at current class.

Usage: `inherited(Goal)`

- *Description:* References a given `Goal` at the super class
- *The following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

self/1: PREDICATE

Determines which instance is currently executing self/1 goal.

Predicate will fail if argument is not a free variable. Otherwise, it will allways succeed, retrieving the instance identifier which is executing current code.

This functionality is very usefull since an object must have knowledge of other object's identifier in order to send messages to it.For example:

:- concurrent ack/0.

send_data_to_object(Data,Obj) :- self(X), Obj:take_this(Data,X), current_fact(ack).

acknowledge :- asserta_fact(ack).

take_this(Data,Sender) :- validate_data(Data), Sender:acknowledge.

Usage: `self(Variable)`

- *Description:* Retrieves current instance identifier in `Variable`
- *The following properties should hold at call time:*

  `Variable` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Variable` is an unique term which identifies an object. (objects_rt:instance_id/1)

constructor/0: PREDICATE

A *constructor* is a special case of method which complains the following conditions:

- The constructor functor matches the current class name.
- A constructor may hold any number of arguments.
- If an inheritance relationship was defined, an inherited constructor must be manually called (see below).
- When instance creation takes place, any of the declared constructors are implicitly called. The actual constructor called depends on the `new/2` goal specified by the user.

This is a simple example of constructor declaration for the foo class:

```
foo :-
    display('an instance was born').
```

Constructor declaration is not mandatory, and there may be more than one constructor declarations (with different arity) at the source code.

This functionality is usefull when some computation is needed at instance creation. For example: opening a socket, clearing the screen, etc.

Whenever an inheritance relationship is established, and there is any constructor defined at the super class, you must call manually an inherited constructor. Here is an example:

```
:- class(foo).
:- inherit_class(myclass).

foo :-
    myclass(0),
    display('an instance was born').

foo(N) :- myclass(N).
```

Consequences may be unpredictable, if you forget to call an inherited constructor. You should also take care not to call an inherited constructor twice.

All defined constructors are inheritable by default. A constructor may also be declared as public (by the user), but it is not mandatory.

Usage:

– *Description:* Constructors are implicitly declared

destructor/0: PREDICATE

A *destructor* is a special case of method which will be automatically called when instance destruction takes place.

A destructor will never be wanted to be part of the public interface, and there is no need to mark them as inheritable, since all inherited destructors are called by O'Ciao just before yours.

This is a simple example of destructor declaration:

```
destructor :-
    display('goodbye, cruel world!!!').
```

Destructor declaration is not mandatory. Failure or sucess of destructors will be ignored by O'Ciao, and they will be called only once.

This functionality is useful when some computation is need at instance destruction. For example: closing an open file.

Usage:

– *Description:* Destructors are implicitly declared

117.4 Other information (class_doc)

This describes the errors reported when declaring a class or an interface. The first section will explain compile-time errors, this is, any semantic error which may be determined at compile time. The second section will explain run-time errors, this is, any exception that may be raisen by the incorrect usage of O'Ciao. Some of those errors may be not reported at compile time, due to the use of meta-programational structures. For example:

```
functor(X,my_method,0),call(X).
```

O'Ciao is not able to check whether my_method/0 is a valid method or not. So, this kind of checking is left to run time.

117.4.1 Class and Interface error reporting at compile time

- **ERROR : multiple inheritance not allowed.**

  There are two or more inherit_class/1 declarations found at your code. Only one declaration is allowed, since there is no multiple code inheritance support.
- **ERROR : invalid inheritance declaration.**

  The given parameter to inherit_class/1 declaration is not a valid path to a Prolog source.
- **ERROR : sorry, addmodule meta-arg is not allowed at** *F/A*.

  You are trying to declare *F/A* as meta-predicate, and one of the meta-arguments is *addmodule*. This is not allowed in O'Ciao due to implementation restrictions. For example:

  ```
  :- meta_predicate example(addmodule).
  example(X,FromModule) :- call(FromModule:X).
  ```
- **ERROR : invalid attribute declaration for** *Arg*.

  Argument to data/1 or dynamic/1 declaration is not a valid predicate specification of the form *Functor/Arity*. For example:

  ```
  :- data attr.
  :- dynamic attr(_).
  :- data attr/m.
  ```

  etc,etc...
- **ERROR : pretended attribute** *F/A* **was assumed to be a method.**

  You put some clauses of *F/A* before the corresponding data/1 or dynamic/1 declaration. For example:

  ```
  attr(initial_value).
  :- data attr/1.
  ```

  It is a must to declare attributes before any clause of the given predicate.
- **ERROR : destructor/0 is not allowed to be an attribute.**

  There is a :- data(destructor/0) or :- dynamic(destructor/0). declaration in your code. This is not allowed since destructor/0 is a reserved predicate, and must be allways a method.
- **ERROR :** *Constructor* **is not allowed to be an attribute.**

  As the previos error, you are trying to declare a constructor as an attribute. A constructor must be allways a method.
- **ERROR : invalid multifile: destructor/0 is a reserved predicate.**

  There is a :- multifile(destructor/0). declaration in your code. This is not allowed since destructor/0 is a reserved predicate, and must be allways a method.
- **ERROR : invalid multifile:** *Constructor* **is a reserved predicate.**

  As the previos error, you are trying to declare a constructor as a multifile. Any constructor must allways be a method.
- **ERROR : multifile declaration of** *F/A* **ignored: it was assumed to be a method.**

  You put some clauses of *F/A* before the corresponding multifile/1 declaration. For example:

  example(a,b).

  ```
  :- multifile example/2.
  ```

  Multifile predicates must be declared before any clause of the given predicate.
- **ERROR : invalid multifile declaration: multifile(***Arg***).**

  Given argument to multifile/1 declaration is not a valid predicate specification, of the form *Functor/Arity*.

- **ERROR : invalid public declaration:** *Arg*.
  Given argument *Arg* to public/1 or export/1 declaration is not a valid predicate specification, of the form *Functor/Arity*.
- **ERROR : invalid inheritable declaration: inheritable(***Arg***).**
  Given argument *Arg* to inheritable/1 declaration is not a valid predicate specification, of the form *Functor/Arity*.
- **ERROR : destructor/0 is not allowed to be virtual.**
  There is a :- virtual(destructor/0) declaration present at your code. Destructors and/or constructors are not allowed to be virtual.
- **ERROR :** *Constructor* **is not allowed to be virtual.**
  As the previous error, you are trying to declare a constructor as virtual. This is not allowed.
- **ERROR : invalid virtual declaration: virtual(***Arg***).**
  Given argument to virtual/1 declaration is not a valid predicate specification, of the form *Functor/Arity*.
- **ERROR : clause of** *F/A* **ignored : only facts are allowed as initial state.**
  You declared *F/A* as an attribute, then you put some clauses of that predicate in the form *Head :- Body*. For example:
  ```
  :- data my_attribute/1.
  my_attribute(X) :- X>=0 , X<=2.
  ```
  This is not allowed since attributes are assumed to hold simple facts. The correct usage for those *initialization clauses* is:
  ```
  :- data my_attribute/1.
  my_attribute(0).
  my_attribute(1).
  my_attribute(2).
  ```
- **ERROR : multifile** *F/A* **is not allowed to be public.**
  The given *F/A* predicate is both present at multifile/1 and public/1 declarations. For example:
  ```
  :- public(p/1).
  :- multifile(p/1).
  ```
  This is not allowed since multifile predicates are not related to Object Oriented Programming.
- **ERROR : multifile** *F/A* **is not allowed to be inheritable.**
  Analogous to previous error.
- **ERROR : multifile** *F/A* **is not allowed to be virtual.**
  Analogous to previous error.
- **ERROR : virtual** *F/A* **must be a method or attribute defined at this class.**
  There is a virtual/1 declaration for *F/A*, but there is not any clause of that predicate nor a `data/1` declaration. You must declare at least one clause for every virtual method. Virtual attributes does not require any clause but a `data/1` declaration must be present.
- **ERROR : implemented interface** *Module* **is not a valid interface.**
  There is an `implements/1` declaration present at your code where given *Module* is not declared as class nor interface.
- **ERROR : predicate** *F/A* **is required both as method (at** *Itf1* **interface) and attribute (at** *Itf2* **interface).**
  There is no chance to give a correct implementation for *F/A* predicate since *Itf1* and *Itf2* interfaces require different definitions. To avoid this error, you must remove one of the related `implements/1` declaration.

- **ERROR : inherited** *Source* **must be a class.**

  There is an :- inherit_class(*Source*) declaration, but that source was not declared as a class.
- **ERROR : circular inheritance:** *Source* **is not a valid super-class.**

  Establishing an inheritance relationship with *Source* will cause current class to be present twice in the inheritance line. This is not allowed. The cause of this is error is simple : There is some inherited class from *Source* which also establishes an inheritance relationship with current source.
- **ERROR : method/attribute** *F/A* **must be implemented.**

  Some of the implemented interfaces requires *F/A* to be defined, but there is no definition for such predicate, even an inherited one.
- **ERROR : local implementation of** *F/A* **hides inheritable/public definition.**

  There is an inherited definition for *F/A* which is been redefined at current class, but there is no valid inheritable/public declaration for the last one. Overriden public predicates must be also declared as public. Overriden inheritable predicates must be declared either as public or inheritable.
- **ERROR : public predicate** *F/A* **was not defined nor inherited.**

  There is a `public/1` declaration for *F/A*, but there is no definition for it at current class nor an inherited one.
- **ERROR : argument to self/1 must be a free variable.**

  Argument to self/1 is not a variable, for example: `self(abc)`.
- **ERROR : unknown inherited attribute in** *Goal***.**

  Goal belongs to assert/retract family of predicates, and given argument is not a valid inherited attribute. The most probable causes of this error are:
  - The given predicate is defined at super-class, but you forgot to mark it as inheritable (or public), at such class.
  - The given predicate was not defined (at super-class) as an attribute, just as a method.
- **ERROR : unknown inherited goal:** *Goal***.**

  The given *Goal* was not found at super-class, or it is not accessible. Check whether *Goal* was marked as inheritable (or public) at super-class.
- **ERROR : invalid argument:** *F/A* **is not an attribute.**

  You are trying to pass a method as an argument to any predicate which expect a *fact* predicate.
- **ERROR : unknown inherited fact:** *Fact***.**

  There is a call to any predicate which expects a *fact* argument (those declared as data or dynamic),but the actual argument is not an inherited attribute.For example:

  ```
  asserta_fact(inherited(not_an_attribute(8)))
  ```

  where not_an_attribute/1 was not declared as data or dynamic by the super-class (or corresponding ascendant).
- **ERROR : unknown inherited spec:** *F/A***.**

  There is a reference to an inherited predicate specification, but the involved predicate has not been inherited.
- **WARNING : meta-predicate specification of** *F/A* **ignored since this is an attribute.**

  You declared *F/A* both as an attribute and a meta-predicate. For example:

  ```
  :- meta_predicate attr(goal).
  :- data attr/1.
  ```

  There is no sense in declaring an attribute as meta-predicate.

- **WARNING : class destructor is public**

  There is a :- public(destructor/0) declaration present at your code. Marking a destructor as public is a very bad idea since anybody may destroy or corrupt an instance before the proper time.
- **WARNING : class destructor is inheritable**

  Analogous to previous error.
- **WARNING : There is no call to inherited constructor/s**

  You have not declared any constructor at your class, but there is any inherited constructor that should be called. Whenever you do not need constructors, but there is an inheritance relationship (where super-class declares a constructor), you should write a simple constructor as the following example:

```
:- class(myclass).
:- inherit_class(other_class).

myclass :-
        other_class.
```

- **WARNING : multifile** *F/A* **hides inherited predicate.**

  You declared as multifle a predicate which matches an inherited predicate name. Any reference to the inherited predicate must be done by the ways of the inherited/1 qualificator.

117.4.2 Class and Interface error reporting at run time

- **EXCEPTION : error(existence_error(object_goal,***Goal***),***Mod***).**

  Called *Goal* from module (or class) *Mod* is unknown or has not been published.

117.4.3 Normal Prolog module system interaction

O'Ciao works in conjunction with the Ciao Prolog module system, which also reports its own error messages. This will cause Ciao to report a little criptic error messages due to the general mechanism of source-to-source expansion. Those are some tips you must consider when compiling a class:

- Any error relative to method 'm' with arity A will be reported for predicate 'obj$m'/A+1. For example :

  `WARNING: (lns 28-30) [Item,Itema] - singleton variables in obj$remove/2`

  This error is relative to method remove/1.
- `set_prolog_flag/1` declaration will be usefull when declaring multiple constructors. It will avoid some awful warnings. Example:

```
:- class(myclass).

%% Use this declaration whenever several constructors are needed.

:- set_prolog_flag(multi_arity_warnings,off).

myclass(_).

myclass(_,_).

:- set_prolog_flag(multi_arity_warnings,on).
```

117.5 Known bugs and planned improvements (`class_doc`)

- addmodule and pred(N) meta-arguments are not allowed on meta-predicates.

118 Compile-time usage of objects

Author(s): Angel Fernandez Pineda.

This package is required to enable user code to create objects and manipulate them, as well as loading any needed class.

118.1 Usage and interface (`objects_doc`)

- **Library usage:**
  Any code which needs to use objects must include the objects package:
  `:- module(`*ModuleName*`,`*Exports*`,[objects]).`
  You can use objects even if your code is a class. Note that declaring a class does not automatically enables the code to create instances.
  `:- class(`*ModuleName*`,[],[objects]).`
  This package enables both static and dynamic usage of objects.
- **New declarations defined:**
  `use_class/1`, `instance_of/2`, `new/2`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

118.2 Documentation on new declarations (`objects_doc`)

use_class/1: DECLARATION

It establishes an usage relationship between the given file (which is supposed to declare a class) and current source. Usage relationships are needed in order to enable code to create instances of the given class, and to make calls to instances derived from such class.

Since an interface is some kind of class, they may be used within this declaration but only for semantic checking porpouses. Instances will not be derived from interfaces.

use_class/1 is used in the same way as `use_module/1`.

Usage: `:- use_class(ClassSource).`

- *Description:* Establish usage relationship with `ClassSource`.
- *The following properties should hold at call time:*
  `ClassSource` is a valid path to a prolog file containing a class declaration (without .pl extension). (objects_rt:class_source/1)

instance_of/2: DECLARATION

Statically declares an identifier to be an instance of a given class.

It may be used as `new/2` predicate except for:

- The instance identifier will not be a variable, it must be provided by the user, and must be unique.
- Instance creation will never fail, even if the constructor fails.

For every statically declared object the given constructor will be called at program startup. Those instances may be destroyed manually, but it is not recommended.

When reloading the involved class from the Ciao toplevel shell. It may destroy statically declared instances, and create them again.

Statically declared instances must be called using a specifically designed module-qualification: `ClassName(Object):Goal`. For example:

```
:- module(example,[main/0],[objects]).
:- use_class(library(counter)).
:- cnt instance_of counter(10).

main :-
     counter(cnt):decrease(1),
     counter(cnt):current_value(X),
     display(X).
```

But **statically written code** (only) is allowed to use module-style qualifications as a macro:

```
main :-
     cnt:decrease(1),
     cnt:current_value(X),
     display(X).
```

Notice that dynamically expanded goals such as `X=cnt,X:decrease(1)` will not work, use `X=counter(cnt),X:decrease(1)` instead.

Usage: :- `instance_of(Object,Constructor)`.

- *Description:* Declares `Object` to be an instance of the class denoted by `Constructor`.
- *The following properties should hold at call time:*

  `Object` is an unique term which identifies an object. (objects_rt:instance_id/1)

  `Constructor` is a term whose functor matches a class name. (objects_rt:constructor/1)

new/2: DECLARATION

This declaration has the same effect as `instance_of/2`.

Usage: :- `new(Object,Constructor)`.

- *Description:* Just an alias for `instance_of/2`.
- *The following properties should hold at call time:*

  `Object` is an unique term which identifies an object. (objects_rt:instance_id/1)

  `Constructor` is a term whose functor matches a class name. (objects_rt:constructor/1)

118.3 Other information (`objects_doc`)

Compile-time errors are restricted to some local analysis. Since there is no type declaration in the Prolog language, there is no posibility to determine whenever a given variable will hold an instance of any class.

However, little semantic analysis is performed. User may aid to perform such an analysis by the usage of run time checks (which are also detected at compile time), or static declarations. For example:

```
clause(Obj) :- Obj:a_method(334).
```

O'Ciao may be not able to determine whenever a_method/1 is a valid method for instance Obj, unless some help is provided:

```
clause(Obj) :- Obj instance_of myclass,Obj:a_method(334).
```

In such case, O'Ciao will report any semantic error at compile-time.

Most of the run-time errors are related to normal Ciao Prolog module system. Since objects are treated as normal Prolog modules at run time, there is no further documentation here about that stuff.

118.3.1 Error reporting at compile time (objects)

- **ERROR : invalid instance identifier *ID*: must be an atom**

  There is a `instance_of/2` or `new/2` declaration where first argument *ID* must be an unique atom, but currently it is not. Statically declared instances needs an identifier to be provided by the user.
- **ERROR : instance identifier *ID* already in use**

  There are two or more `instance_of/2` declarations with the same first argument *ID*. Instance identifiers must be unique.
- **ERROR : invalid use_class/1 declaration: *SourceFile* is not a class**

  Those are the causes for this error:
  - The given *SourceFile* does not exist, or is not accesible.
  - The given *SourceFile* is not a Prolog source.
  - The given *SourceFile* is a valid Prolog source, but it does not declare a class.
- **ERROR : unknown class on *ID* instance declaration**

  The class defined on the `instance_of/2` declaration for *ID* instance has not been loaded by a `use_class/1` declaration.
- **ERROR : instance identifier *ID* is an exisisting Prolog module**

  There is an statically declared instance whose identifier may cause interference with the Ciao Prolog module system. Use another instance identifier.
- **ERROR : unknown constructor on *ID* instance declaration**

  The given constructor on the `instance_of/2` declaration for *ID* has not been defined at the corresponding class.
- **ERROR : constructor is needed on *ID* instance declaration**

  No constructor was defined on the `instance_of/2` declaration for *ID* and default constructor is not allowed. You must provide a constructor.
- **ERROR : static instance *ID* was derived from a different constructor at *AnotherModule***

  ID has been declared to be an static instance both on *AnotherModule* and current source, but different constructors were used. The most probable causes for this error are:
  - Occasionally, there is another module using the same instance identifier and it was not noticed by you. Another different identifier may be used instead.
  - It was you intention to use the same object as declared by the other module. In this case, the same constructor must be used.
- **ERROR : invalid first argument in call to new(*Arg*,_)**

  There is a new/1 goal in your code where first argument is not a free variable. For example:

  `myobj new myclass`

  First argument must be a variable in order to receive a run-time generated object identifier.
- **ERROR : unknown class in call to new(?,*Constructor*)**

  The given *Constructor* in call to new/2 does not correspond to any used class at current code. The most probable cause of this may be:

- You forgot to include a `use_class/1` declaration in your code.
- There is a spelling mistake in the constructor.For example:
  :- use_class(myclass).
  foo(X) :- X new mclass.

- **ERROR : can not create an instance from an interface: new(?,*Constructor*)**
  Given *Constructor* references an interface rather than a class. Instances can not be derived from interface-expanded code.
- **ERROR : unknown constructor in call to new(?,*Constructor*)**
  As the previous error, there is a mistake in the given *Constructor*. This error is reported when you are trying to call a constructor which was not defined at the corresponding class. Check the class definition to find what is going on.
  Another cause for this error is the incorrect usage of the default constructor. Whenever there are one or more constructors defined at the involved class, you are restricted to chose one of them. This seems that default constructor will be available, if and only if, there are no constructors defined at the involved class.
- **ERROR : call to non-public** *ID:Goal*
  You are trying to call a method which was not declared as public by the class specified in `instance_of/2` declaration for *ID*.
- **ERROR : call to inaccessible predicate at instance** *ID:Goal*
  There is a call to *Goal* at statically declared instance *ID* which is unknown or was not declared as public.
- **ERROR : unknown instance** *ID* **of class** *Class* **at** *Goal*
  There is a call to *Goal* where involved statically declared instance *ID* is unknown or is not derived from *Class*. Check whether it was declared by a `instance_of/2` declaration.
- **ERROR : inaccessible attribute** *Fact* **at instance** *ID*
  There is an attempt to use *ID:Fact* but it was not declared as public.
- **ERROR : unknown attribute** *Fact* **at instance** *ID*
  There is an attempt to use *ID:Fact* but it is unknown or it is not an attribute (may be a method).
- **WARNING : invalid call to new(?,_)**
  There is a call to new/2 in you code where first argument variable has been determined to hold any other instance. For example:
  `foo :- X new myclass,X new otherclass.`
  or
  `foo(X) :- X instance_of myclass, X new myclass.`
  The related call to new/2 will allways fail.
- **WARNING : called** *Goal* **is not public at any used class**
  There is a call to *Var*:*Goal* where *Var* has not been determined to be compatible with any class. However, *Goal* is not public at any class specified by the `use_class/1` declaration.
  This is a warning (not an error) since *Var*:*Goal* may be not related to Object Oriented Programing.

118.3.2 Error reporting at run time (objects)

- **EXCEPTION : instantiation_error('1st argument must be free variable')**
  Calling to new/1 requieres first argument to be a free variable. For example:
  `X = this_will_raise_an_exception,X new myclass.`

- **EXCEPTION : instantiation_error('class not given')**
  You called new/2 using a free variable as second argument.
- **EXCEPTION : instantiation_error(inaccesible_class(*Class*), from(*Module*))**
  Module tried to create an instance of *Class* by the ways of new/2, but there is no usage relationship between *Module* and *Class*.
- **EXCEPTION : instantiation_error(invalid_constructor(*Constructor*))**
  Constructor was not defined by the corresponding class.

119 Run time usage of objects

Author(s): Angel Fernandez Pineda, Angel Fernandez Pineda.

This library provides run-time support for object creation and manipulation. Objects are also called class instances, or simply instances.

Objects in Ciao are treated as normal modules. This is, an object is a run-time generated Prolog module, which may be identified by an unique term across the whole application.

This is a very simple example of how to create an instance, and how to make calls to it:

```
AnObj new myclass,
AnObj:mymethod.
```

In order to make any object accessible from code, an usage relationship must be established between the class (from which instances are derived) and the code itself. Refer to `use_class/1` predicate or `use_class/1` declaration in order to do so.

119.1 Usage and interface (`objects_rt`)

- **Library usage:**
  This library is automatically loaded when using the *objects* package:
  `:- module(`*ModuleName*`,`*Exports*`,[objects]).`
  Nothing special needs to be done.
- **Exports:**
  - *Predicates:*
    `new/2`, `instance_of/2`, `derived_from/2`, `interface/2`, `instance_codes/2`, `destroy/1`, `use_class/1`.
  - *Properties:*
    `constructor/1`, `class_name/1`, `interface_name/1`, `instance_id/1`, `class_source/1`, `interface_source/1`, `method_spec/1`, `virtual_method_spec/1`.
- **Other modules used:**
  - *System library modules:*
    `compiler/compiler`, `prolog_sys`.

119.2 Documentation on exports (`objects_rt`)

new/2: PREDICATE

Dynamic instance creation takes place by the ways of this predicate.

It takes a free variable as first argument which will be instantiated to an internal object identifier.

Second argument must be instantiated to a class constructor. Class constructors are designed to perform an initialization on the new created instance. Notice that instance initialization may involve some kind of computation, not only *state initialization*.

A class constructor is made by a functor, which must match the intended class name, and any number of parameters. For example:

```
Obj new myclass(1500,'hello, world!!!')
```

Those parameters depends (obviously) on the constructors defined at the class source. If no constructors where defined, no parameters are needed. This is called the default constructor. An example:

```
Obj new myclass
```

The default constructor can not be called if there is any constructor available at the class source.

Instantiation will raise an exception and fail whenever any of this conditions occur:

- First argument is not a free variable.
- Second argument functor is a class, but there is no usage relationship with it.
- Second argument functor is not a class.
- The given constructor is unknown.
- The given constructor fails (notice that default constructor never fails).

Objects may also be statically declared, refer to `instance_of/2` declaration.

Usage: `new(InstanceVar,Constructor)`

- *Description:* Creates a new instance of the class specified by `Constructor` returning its identifier in `InstanceVar`
- *The following properties should hold at call time:*

  `InstanceVar` is a free variable. (term_typing:var/1)

  `Constructor` is a term whose functor matches a class name. (objects_rt:constructor/1)
- *The following properties should hold upon exit:*

  `InstanceVar` is an unique term which identifies an object. (objects_rt:instance_id/1)

instance_of/2: PREDICATE

This predicate is used to perform dynamic type checking. You may check whether a particular instance belongs to a particular class or related descendants.

instance_of/2 is used to perform static semantic analisys over object oriented code constructions.

By the use of instance_of/2 you may help to perform such analisys.

Usage 1: `instance_of(Instance,Class)`

- *Description:* Test whether `Instance` was derived from any descendant of `Class`, or that class itself
- *The following properties should hold at call time:*

  `Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)

  `Class` is an atom denoting a class. (objects_rt:class_name/1)

Usage 2: `instance_of(Instance,Class)`

- *Description:* Retrieves, on backtracking, the inheritance line of `Instance` commencing on the creation class (that specified on call to `new/2`) and continuing on the rest of ascendant classes, if any.
- *The following properties should hold at call time:*

  `Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)

  `Class` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*
`Class` is an atom denoting a class. (objects_rt:class_name/1)

derived_from/2: PREDICATE

Test whether an object identifier was derived directly from a class, by the usage of `new/2` or a static instance declaration (`instance_of/2`).

Usage 1: `derived_from(Instance,Class)`

– *Description:* Test derivation of `Instance` from `Class`
– *The following properties should hold at call time:*
`Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)
`Class` is an atom denoting a class. (objects_rt:class_name/1)

Usage 2: `derived_from(Instance,Class)`

– *Description:* Retrieves the `Class` responsable of the derivation of `Instance`.
– *The following properties should hold at call time:*
`Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)
`Class` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Class` is an atom denoting a class. (objects_rt:class_name/1)

interface/2: PREDICATE

This predicate is used to ensure a given interface to be implemented by a given instance.

Usage 1: `interface(Instance,Interface)`

– *Description:* Check whether `Instance` implements the given `Interface`.
– *The following properties should hold at call time:*
`Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)
`Interface` is an unique atom which identifies a public interface. (objects_rt:interface_name/1)

Usage 2: `interface(Instance,Interfaces)`

– *Description:* Retrieves on backtracking all the implemented `Interfaces` of `Instance`.
– *The following properties should hold at call time:*
`Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)
`Interfaces` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Interfaces` is an unique atom which identifies a public interface. (objects_rt:interface_name/1)

instance_codes/2: PREDICATE

Retrieves a character string representation from an object identifier and vice-versa.

Usage 1: `instance_codes(Instance,String)`

– *Description:* Retrieves a `String` representation of given `Instance`.

– *The following properties should hold at call time:*

`Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)

`String` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`String` is a string (a list of character codes). (basic_props:string/1)

Usage 2: `instance_codes(Instance,String)`

– *Description:* Reproduces an `Instance` from its `String` representation. Such an instance must be alive across the application: this predicate will fail whether the involved instance has been destroyed.

– *The following properties should hold at call time:*

`Instance` is a free variable. (term_typing:var/1)

`String` is a string (a list of character codes). (basic_props:string/1)

– *The following properties should hold upon exit:*

`Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)

destroy/1: PREDICATE

As well as instances are created, they must be destroyed when no longer needed in order to release system resources.

Unfortunately, current O'Ciao implementation does not support automatic instance destruction, so user must manually call *destroy/1* in order to do so.

The programmer **must ensure** that no other references to the involved object are left in memory when destroy/1 is called. If not, unexpected results may be obtained.

Usage: `destroy(Instance)`

– *Description:* Destroys the object identified by `Instance`.

– *The following properties should hold at call time:*

`Instance` is an unique term which identifies an object. (objects_rt:instance_id/1)

use_class/1: PREDICATE

The behaviour of this predicate is identical to that provided by the declaration of the same name `use_class/1`. It allows user programs to dynamically load classes. Whether the given source is not a class it will perform a `use_module/1` predicate call.

Usage: `use_class(ClassSource)`

– *Description:* Dynamically loads the given `ClassSource`

– *The following properties should hold at call time:*

`ClassSource` is a valid path to a prolog file containing a class declaration (without .pl extension). (objects_rt:class_source/1)

constructor/1: PROPERTY

Usage: `constructor(Cons)`

– *Description:* `Cons` is a term whose functor matches a class name.

class_name/1: PROPERTY

Usage: `class_name(ClassName)`

– *Description:* `ClassName` is an atom denoting a class.

interface_name/1: PROPERTY

Usage: `interface_name(Interface)`

– *Description:* `Interface` is an unique atom which identifies a public interface.

instance_id/1: PROPERTY

Usage: `instance_id(ID)`

– *Description:* `ID` is an unique term which identifies an object.

class_source/1: PROPERTY

Usage: `class_source(Source)`

– *Description:* `Source` is a valid path to a prolog file containing a class declaration (without .pl extension).

interface_source/1: PROPERTY

Usage: `interface_source(Source)`

– *Description:* `Source` is a valid path to a prolog file containing a class declaration or an interface declaration (without .pl extension).

method_spec/1: PROPERTY

There is no difference between method or attribute specifications, and habitual predicate specifications. It is just a Functor/Arity term.

Usage: `method_spec(Spec)`

– *Description:* `Spec` is a method or attribute specification.

virtual_method_spec/1: PROPERTY

Usage: `virtual_method_spec(Spec)`

– *Description:* `Spec` is a method specification.

119.3 Known bugs and planned improvements (`objects_rt`)

- Usage of objects from the `user` module does not work properly. It is better to use the `objects` package in a (proper) module.
- Not really a bug: when loading code which declares static instances from the toplevel shell, predicate `use_module/1`) will not work properly: those instances may be not correctly created, and predicates will fail whenever they are not supposed to do. This may be avoided by reloading again the involved module, but make sure it is modified and saved to disk before doing so.

PART VIII - Interfaces to other languages and systems

Author(s): The CLIP Group.

The following interfaces to/from Ciao are documented in this part:

- External interface (e.g., to C).
- Socket interface.
- Tcl/tk interface.
- Web interface (http, html, xml, etc.);
- Persistent predicate databases (interface between the Ciao internal database and the external file system).
- SQL-like database interface (interface between the Ciao internal database and external SQL/ODBC systems).
- Java interface.
- Calling emacs from Ciao.

120 Foreign Language Interface

Author(s): Jose F. Morales, Manuel Carro.

Ciao Prolog includes a high-level, flexible way to interface C and Prolog, based on the use of assertions to declare what are the expected types and modes of the arguments of a Prolog predicate, and which C files contain the corresponding code. To this end, the user provides:

- A set of C files, or a precompiled shared library,
- A Ciao Prolog module defining whith predicates are implemented in the C files and the types and modes of their arguments, and
- an (optional) set of flags required for the compilation of the files.

The Ciao Prolog compiler analyzes the Prolog code written by the user and gathers this information in order to generate automatically C "glue" code implementing the data translation between Prolog and C, and to compile the C code into dynamically loadable C object files, which are linked automatically when needed.

120.1 Declaration of Types

Each predicate implemented as a foreign C function must have accompanying declarations in the Ciao Prolog associated file stating the types and modes of the C function. A sample declaration for `prolog_predicate` which is implemented as `foreign_function_name` is:

```
:- true pred prolog_predicate(m1(Arg1), ... mN(ArgN)) ::
             type1 * ... * typeN +
             (foreign(foreign_function_name), returns(ArgR)).
```

where `m1`, ..., `mN` and `type1`, ..., `typeN` are respectively the modes and types of the arguments. `foreign_function_name` is the name of the C function implementing `prolog_predicate/N`, and the result of this function is unified with `ArgR`, which must be one of `Arg1` ... `ArgN`.

This notation can be simplified in several ways. If the name of the foreign function is the same as the name of the Ciao Prolog predicate, `foreign(foreign_function_name)` can be replaced by `foreign/0`. `returns(ArgR)` specifies that the result of the function corresponds to the `ArgR` argument of the Ciao Prolog predicate. If the foreign function does not return anything (or if its value is ignored), then `returns(ArgR)` must be removed. Note that `returns` cannot be used without `foreign`. A simplified, minimal form is thus:

```
:- true pred prolog_predicate(m1(Arg1), ... mN(ArgN)) ::
             type1 * ... * typeN + foreign.
```

120.2 Equivalence between Ciao Prolog and C types

The automatic translation between Ciao Prolog and C types is defined (at the moment) only for some simple but useful types. The translation to be performed is solely defined by the types of the arguments in the Ciao Prolog file (i.e., no inspection of the corresponding C file is done). The names (and meaning) of the types known for performing that translation are to be found in Chapter 121 [Foreign Language Interface Properties], page 657; they are also summarized below (Prolog types are on the left, and the corresponding C types on the right):

- num <-> double
- int <-> int
- atm <-> char *
- string <-> char * (with trailing zero)

- byte_list <-> char * (a buffer of bytes, with associated length)
- int_list <-> int * (a buffer of integers, with associated length)
- double_list <-> double * (a buffer of doubles, with associated length)
- address <-> void *

Strings, atoms, and lists of bytes are passed to (and from) C as dynamically (`ciao_malloc`) created arrays of characters (bytes). Those arrays are freed by Ciao Prolog upon return of the foreign function unless the property `do_not_free/2` is specified (see examples below). This caters for the case in which the C files save in a private state (either by themselves, or by a library function being called by them) the values passed on from Prolog. The type `byte_list/1` requires an additional property, `size_of/2`, to indicate which argument represents its size.

Empty lists of bytes and integers are converted into C `NULL` pointers, and vice versa. Empty strings (`[]`) and null atoms (”) are converted into zero-length, zero-ended C strings (`""`). C `NULL` strings and empty buffers (i.e., buffers with zero length) are transformed into the empty list or the null atom (`''`).

Most of the work is performed by the predicates in the Chapter 123 [Foreign Language Interface Builder], page 665, which can be called explicitly by the user. Doing that is not usually needed, since the Ciao Prolog Compiler takes care of building glue code files an of compiling and linking whatever is necessary.

120.3 Equivalence between Ciao Prolog and C modes

The (prefix) `+/1` ISO mode (or, equivalently, the in/1 mode) states that the corresponding Prolog argument is ground at the time of the call, and therefore it is an input argument in the C part; this groundness is automatically checked upon entry. The (prefix) `-/1` ISO mode (or, equivalently, the go/1 mode) states that Prolog expects the C side to generate a (ground) value for that argument. Arguments with output mode should appear in C functions as pointers to the corresponding base type (as it is usual with C), i.e., an argument which is an integer generated by the C file, declared as

```
:- true pred get_int(go(ThisInt)) :: int + foreign
```

or as

```
:- true pred get_int(-ThisInt) :: int + foreign
```

should appear in the C code as

```
void get_int(int *thisint)
{
        ....
}
```

Note the type of the (single) argument of the function. Besides, the return value of a function can always be used as an output argument, just by specifying to which Prolog arguments it corresponds, using the `foreing/1` property. The examples below illustrate this point, and the use of several assertions to guide the compilation.

120.4 Custom access to Prolog from C

Automatic type conversions does not cover all the possible cases. When the automatic type conversion is not enough (or if the user, for any reason, does not want to go through the automatic conversion), it is possible to instruct Ciao Prolog not to make implicit type conversion. The strategy in that case is to pass the relevant argument(s) with a special type (a `ciao_term`) which can represent any term which can be built in Prolog. Operations to construct, traverse, and test this data abstraction from C are provided. The prototypes of these operations are placed on the `"ciao_prolog.h"` file, under the `include` subdirectory of the installation directory

(the Ciao Prolog compiler knowns where it has been installed, and gives the C compiler the appropriate flags). This *non direct correspondence* mode is activated whenever a Ciao Prolog type unknown to the foreign interface (i.e., none of these in Chapter 121 [Foreign Language Interface Properties], page 657) or the type `any_term` (which is explicitly recognised by the foreign language interface) is found. The latter is preferred, as it is much more informative, and external tools, as the the CiaoPP preprocessor, can take advantage of them.

120.4.1 Term construction

All term construction primitives return an argument of type `ciao_term`, which is the result of constructing a term. All Ciao Prolog terms can be built using the interface operations `ciao_var()`, `ciao_structure()`, `ciao_integer()`, and `ciao_float()`. There are, however, variants and specialized versions of these operations which can be freely intermixed. Using one version or another is a matter of taste and convenience. We list below the prototypes of the primitives in order of complexity.

Throughout this section, **true**, when referred to a boolean value, correspond to the integer value `1`, and **false** correspond to the integer value `0`, as is customary in C boolean expressions. These values also available as the (predefined) constants `ciao_true` and `ciao_false`, both of type `ciao_bool`.

- `ciao_term ciao_var();`

  Returns a fresh, unbound variable.
- `ciao_term ciao_integer(int i);`

  Creates a term, representing an integer from the Prolog point of view, from a C integer.
- `ciao_term ciao_float(double i);`

  Creates a term, representing a floating point number, from a floating point number.
- `ciao_term ciao_put_number_chars(char *number_string);`

  It converts `number_string` (which must a string representing a syntactically valid number) into a `ciao_term`.
- `ciao_term ciao_atom(char *name);`

  Creates an atom whose printable name is given as a C string.
- `ciao_term ciao_structure_a(char *name, int arity, ciao_term *args);`

  Creates a structure with name 'name' (i.e., the functor name), arity 'arity' and the components of the array 'args' as arguments: `args[0]` will be the first argument, `args[1]` the second, and so on. The 'args' array itself is not needed after the term is created, and can thus be a variable local to a procedure. An atom can be represented as a 0-arity structure (with `ciao_structure(name, 0)`), and a list cell can be constructed using the '.'/2 structure name. The `_a` suffix stands for *array*.
- `ciao_term ciao_structure(char *name, int arity, ...);`

  Similar to ciao_structure_a, but the C arguments after the arity are used to fill in the arguments of the structure.
- `ciao_term ciao_list(ciao_term head, ciao_term tail);`

  Creates a list from a `head` and a `tail`. It is equivalent to `ciao_structure(".", 2, head, tail)`.
- `ciao_term ciao_empty_list();`

  Creates an empty list. It is equivalent to `ciao_atom("[]")`.
- `ciao_term ciao_listn_a(int len, ciao_term *args);`

  Creates a list with 'len' elements from the array `args`. The *nth* element of the list (starting at 1) is `args[n-1]` (starting at zero).

- `ciao_term ciao_listn(int length, ...);`

  Like `ciao_listn_a()`, but the list elements appear explicitly as arguments in the call.
- `ciao_term ciao_dlist_a(int len, ciao_term *args, ciao_term base);`

  Like `ciao_listn_a`, but a difference list is created. `base` whill be used as the tail of the list, instead of the empty list.
- `ciao_term ciao_dlist(int length, ...);`

  Similar to `ciao_dlist_a()` with a variable number of arguments. The last one is the tail of the list.
- `ciao_term ciao_copy_term(ciao_term src_term);`

  Returns a new copy of the `term`, with fresh variables (as `copy_term/2` does).

120.4.2 Testing the Type of a Term

A `ciao_term` can contain *any* Prolog term, and its implementation is opaque to the C code. Therefore the only way to know reliably what data is passed on is using explicit functions to test term types. Below, `ciao_bool` is a type defined in `"ciao_prolog.h"` which can take the values 1 (for **true**) and 0 (for **false**).

- `ciao_bool ciao_is_variable(ciao_term term);`

  Returns true if `term` is currently an uninstantiated variable.
- `ciao_bool ciao_is_number(ciao_term term);`

  Returns true if `term` is an integer (of any length) or a floating point number.
- `ciao_bool ciao_is_integer(ciao_term term);`

  Returns true if `term` is instantiated to an integer.
- `ciao_bool ciao_fits_in_int(ciao_term term);`

  Returns true if `term` is instantiated to an integer which can be stored in an `int`, and false otherwise.
- `ciao_bool ciao_is_atom(ciao_term atom);`

  Returns true if `term` is an atom.
- `ciao_bool ciao_is_list(ciao_term term);`

  Returns true if `term` is a list (actually, a `cons` cell).
- `ciao_bool ciao_is_empty_list(ciao_term term);`

  Returns true if `term` is the atom which represents the empty list (i.e., `[]`).
- `ciao_bool ciao_is_structure(ciao_term term);`

  Returns true if `term` is a structure of any arity. This includes atoms (i.e., structures of arity zero) and lists, but excludes variables and numbers.

120.4.3 Term navigation

The functions below can be used to recover the value of a `ciao_term` into C variables, or to inspect Prolog structures.

- `int ciao_to_integer(ciao_term term);`

  Converts `term` to an integer. `ciao_is_integer(term)` must hold.
- `ciao_bool ciao_to_integer_check(ciao_term term, int *result);`

  Checks whether `term` fits into the size of an integer. If so, true is returned and `*result` is unified with the integer `term` represents. Otherwise, false is returned and `*result` is not touched.

- `double ciao_to_float(ciao_term term);`
  Converts `term` to a float value. `ciao_is_number(term)` must hold.
- `char *ciao_get_number_chars(ciao_term term);`
  It converts `ciao_term` (which must be instantiated to a number) into a C string representing the number in the current radix. The string returned is a copy, which must (eventually) be explicitly deallocated by the user C code using the operation `ciao_free()`
- `char *ciao_atom_name(ciao_term atom);`
  Returns the name of the atom. The returned string *is the one internally used by Ciao Prolog*, and should not be deallocated, changed or altered in any form. The advantage of using it is that it is fast, as no data copying is needed.
- `char *ciao_atom_name_dup(ciao_term atom);`
  Obtains a **copy** of the name of the atom. The string can be modified, and the programmer has the responsibility of deallocating it after being used. Due to the copy, it is slower than calling `char *ciao_atom_name()`.
- `ciao_term ciao_list_head(ciao_term term);`
  Extracts the head of the list `term`. Requires `term` to be a list.
- `ciao_term ciao_list_tail(ciao_term term);`
  Extracts the tail of the list `term`. Requires `term` to be a list.
- `char *ciao_structure_name(ciao_term term);`
  Extracts the name of the structure `term`. Requires `term` to be a structure.
- `int ciao_structure_arity(ciao_term term);`
  Extracts the arity of the structure `term`.
  Requires `term` to be a structure.
- `ciao_term ciao_structure_arg(ciao_term term, int n);`
  Extracts the *nth* argument of the structure `term`. It behaves like `arg/3`, so the first argument has index 1. Requires `term` to be a structure.

120.4.4 Testing for Equality and Performing Unification

Variables of type `ciao_term` cannot be tested directly for equality: they are (currently) implemented as a sort of pointers which may be aliased (two different pointers may refer to the same object). The interface provides helper functions for testing term equality and to perform unification of terms.

- `ciao_bool ciao_unify(ciao_term x, ciao_term y);`
  Performs the unification of the terms `x` and `y`, and returns true if the unification was successful. This is equivalent to calling the (infix) Prolog predicate `=/2`. The bindings are trailed and undone on backtracking.
- `ciao_bool ciao_equal(ciao_term x, ciao_term y);`
  Performs equality testing of terms, and returns true if the test was successful. This is equivalent to calling the (infix) Prolog predicate `==/2`. Equality testing does not modify the terms compared.

120.4.5 Raising Exceptions

The following functions offers a way of throwing exceptions from C that can be caught in Prolog with `catch/3`. The term that reaches Prolog is exactly the same which was thrown by C. The execution flow is broken at the point where `ciao_raise_exception()` is executed, and it returns to Prolog.

- `void ciao_raise_exception(ciao_term ball);`
  Raises an exception an throws the term `ball`.

120.4.6 Creating and disposing of memory chunks

Memory to be used solely by the user C code can be reserved/disposed of using, e.g., the well-known `malloc()/free()` functions (or whatever other functions the user may have available). However, memory explicitly allocated by Ciao Prolog and passed to C code, or allocated by C code and passed on to Ciao Prolog (and subject to garbage collection by it) should be allotted and freed (when necessary) by using the functions:

- `void *ciao_malloc(int size);`
- `void ciao_free(void *pointer);`

whose behavior is similar to `malloc()/free()`, but which will cooordinate properly with Ciao Prolog's internal memory management.

120.4.7 Calling Prolog from C

It is also possible to make arbitraty calls to Prolog predicates from C. There are two basic ways of make a query, depending on whether only one solution is needed (or if the predicate to be called is known to generate only one solution), or if several solutions are required.

When only one solution is needed `ciao_commit_call` obtains it (the solution obtained will obviously be the first one) and discards the resources used for finding it:

- `ciao_bool ciao_commit_call(char *name, int arity, ...);`

  Makes a call to a predicate and returns true or false depending on whether the query has succedeed or not. In case of success, the (possibly) instantiated variables are reachable from C.
- `ciao_bool ciao_commit_call_term(ciao_term goal);`

  Like `ciao_commit_call()` but uses the previously built term `goal` as goal.

If more than one solution is needed, it is necessary to use the `ciao_query` operations. A consult begins with a `ciao_query_begin` which returns a `ciao_query` object. Whenever an additional solution is required, the `ciao_query_next` function can be called. The query ends by calling `ciao_query_end` and all pending search branches are pruned.

- `ciao_query *ciao_query_begin(char *name, int arity, ...);`

  The predicate with the given name, arity and arguments (similar to the `ciao_structure()` operation) is transformed into a `ciao_query` object which can be used to make the actual query.
- `ciao_query *ciao_query_begin_term(ciao_term goal);`

  Like ciao_query_begin but using the term `goal` instead.
- `ciao_bool ciao_query_ok(ciao_query *query);`

  Determines whether the query may have pending solutions. A false return value means that there are no more solutions; a true return value means that there are more possible solutions.
- `void ciao_query_next(ciao_query *query);`

  Ask for a new solution.
- `void ciao_query_end(ciao_query *query);`

  Ends the query and frees the used resources.

120.5 Examples

120.5.1 Mathematical functions

In this example, the standard mathematical library is accessed to provide the *sin*, *cos*, and *fabs* functions. Note that the library is specified simply as

```
:- use_foreign_library([m]).
```

The foreign interface adds the `-lm` at compile time. Note also how some additional options are added to optimize the compiled code (only glue code, in this case) and mathematics (only in the case of Linux in an Intel processor).

File *math.pl*:

```
:- module(math, [sin/2, cos/2, fabs/2], [foreign_interface]).

:- true pred sin(in(X),go(Y)) :: num * num + (foreign,returns(Y)).
:- true pred cos(in(X),go(Y)) :: num * num + (foreign,returns(Y)).
:- true pred fabs(in(X),go(Y)) :: num * num + (foreign,returns(Y)).

:- extra_compiler_opts(['-O2']).
:- extra_compiler_opts('LINUXi86',['-ffast-math']).
:- use_foreign_library('LINUXi86', m).
```

120.5.2 Addresses and C pointers

The `address` type designates any pointer, and provides a means to deal with C pointers in Prolog without interpreting them whatsoever. The C source file which implements the operations accessed from Prolog is declared with the

```
:- use_foreign_source(objects_c).
```

directive.

File *objects.pl*:

```
:- module(objects, [object/2, show_object/1], [foreign_interface]).

:- true pred object(in(N),go(Object)) ::
        int * address + (foreign,returns(Object)).

:- true pred show_object(in(Object)) ::
        address + foreign.

:- use_foreign_source(objects_c).
:- extra_compiler_opts('-O2').
```

File *objects_c.c*:

```
#include <stdio.h>

struct object {
  char *name;
  char *colour;
};

#define OBJECTS 3

struct object objects[OBJECTS] =
```

```
{ {"ring","golden"},
  {"table","brown"},
  {"bottle","green"} };

struct object *object(int n) {
  return &objects[n % OBJECTS];
}

void show_object(struct object *o) {
  printf("I show you a %s %s\n", o->colour, o->name);
}
```

120.5.3 Lists of bytes and buffers

A list of bytes (c.f., a list of ints) corresponds to a byte buffer in C. The length of the buffer is associated to that of the list using the property `size_of/2`. The returned buffer **is freed by Ciao Prolog** upon its recepction, unless the `do_not_free/1` property is specified (see later). Conversely, a list of natural numbers in the range 0 to 255 can be passed to C as a buffer.

File *byte_lists.pl*:

```
:- module(byte_lists, [obtain_list/3, show_list/2], [foreign_interface]).

:- true pred obtain_list(in(N),go(Length),go(List)) :: int * int * byte_list
        + (foreign,size_of(List,Length)).
:- true pred show_list(in(Length),in(List)) :: int * byte_list
        + (foreign,size_of(List,Length)).

:- use_foreign_source(bytes_op).
```

File *bytes_op.c*:

```
#include <stdlib.h>
#include <stdio.h>

void obtain_list(int n, int *l, char **s) {
  int i;
  int c;
  if (n < 0) n = 0;
  *l = n;
  *s = (char *)malloc(*l);
  for (i = 0; i < *l; i++) {
    (*s)[i] = i;
  }
}

void show_list(int l, char *s) {
  if (s) {
    int n;
    printf("From C:");
    for (n = 0; n < l; n++) {
      printf(" %d", s[n]);
```

```
    }
    printf(".\n");
  } else {
    printf("From C: []\n");
  }
}
```

120.5.4 Lists of integers

File *int_lists.pl*:

```
:- module(int_lists, [obtain_list/3, show_list/2], [foreign_interface]).

:- true pred obtain_list(in(N),go(Length),go(List)) :: int * int * int_list
        + (foreign,size_of(List,Length)).
:- true pred show_list(in(Length),in(List)) :: int * int_list
        + (foreign,size_of(List,Length)).

:- use_foreign_source(ints_op).
```

File *ints_op.c*:

```
#include <stdlib.h>
#include <stdio.h>

void obtain_list(int n, int *l, int **s) {
  int i;
  int c;
  if (n < 0) n = 0;
  *l = n;
  *s = (int *)malloc((*l) * sizeof(int));
  for (i = 0; i < *l; i++) {
    (*s)[i] = i;
  }
}

void show_list(int l, int *s) {
  if (s) {
    int n;
    printf("From C:");
    for (n = 0; n < l; n++) {
      printf(" %d", s[n]);
    }
    printf(".\n");
  } else {
```

```
    printf("From C: []\n");
  }
}
```

120.5.5 Strings and atoms

A C string can be seen as a buffer whose end is denoted by the trailing zero, and therefore stating its length is not needed. Two translations are possible into Ciao Prolog: as a Prolog string (list of bytes, with no trailing zero) and as an atom. These are selected automatically just by choosing the corresponding type (look at the examples below).

Note how the `do_not_free/1` property is specified in the `a_string/1` predicate: the string returned by C is static, and therefore it should not be freed by Prolog.

File *strings_and_atoms.pl*:

```
:- module(strings_and_atoms,
        [ lookup_string/2,
          lookup_atom/2,
          a_string/1,
          show_string/1,
          show_atom/1
        ],
        [foreign_interface]).

:- true pred a_string(go(S)) ::
        string + (foreign(get_static_str),returns(S),do_not_free(S)).

:- true pred lookup_string(in(N),go(S)) ::
        int * string + (foreign(get_str),returns(S)).
:- true pred lookup_atom(in(N),go(S)) ::
        int * atm + (foreign(get_str),returns(S)).

:- true pred show_string(in(S)) :: string + foreign(put_str).
:- true pred show_atom(in(S)) :: atm + foreign(put_str).

:- use_foreign_source(str_op).
```

File *str_op.c*:

```
#include <stdlib.h>
#include <stdio.h>

char *get_static_str() {
  return "this is a string Prolog should not free";
}
```

```
char *get_str(int n) {
  char *s;
  int size;
  int i;
  int c;
  if (n < 0) n = -n;
  size = (n%4) + 5;
  s = (char *)malloc(size+1);
  for (i = 0, c = ((i + n) % ('z' - 'a' + 1)) + 'a'; i < size; i++,c++) {
    if (c > 'z') c = 'a';
    s[i] = c;
  }
  s[i] = 0;
  return s;
}

void put_str(char *s) {
  if (s) {
    printf("From C: \"%s\"\n", s);
  } else {
    printf("From C: null\n");
  }
}
```

120.5.6 Arbitrary Terms

This example shows how data Prolog can be passed untouched to C code, and how it can be manipulated there.

File *any_term.pl*:

```
:- module(any_term,
        [custom_display_term/1,
         custom_create_term/2
        ],
        [foreign_interface]).

:- true pred custom_display_term(in(X)) :: any_term + foreign.
:- true pred custom_create_term(in(L), go(X)) :: int * any_term + (foreign,returns(X

:- use_foreign_source(any_term_c).
:- extra_compiler_opts('-O2').
```

File *any_term_c.c*:

```
#include <stdio.h>
```

```
#include "ciao_prolog.h"

ciao_term custom_create_term(int n) {
  ciao_term t;
  t = ciao_empty_list();
  while (n > 0) {
    t = ciao_list(ciao_integer(n), t);
    n--;
  }
  return t;
}

void custom_display_term(ciao_term term) {
  if (ciao_is_atom(term)) {
    printf("<atom name=\"%s\"/>", ciao_atom_name(term));
  } else if (ciao_is_structure(term)) {
    int i;
    int a;
    a = ciao_structure_arity(term);
    printf("<structure name=\"%s\" arity=\"%d\">", ciao_structure_name(term), a);
    for (i = 1; i <= a; i++) {
      printf("<argument number=\"%d\">", i);
      custom_display_term(ciao_structure_arg(term, i));
      printf("</argument>");
    }
    printf("</structure>");
  } else if (ciao_is_list(term)) {
    printf("<list>");
    printf("<head>");
    custom_display_term(ciao_list_head(term));
    printf("</head>");
    printf("<tail>");
    custom_display_term(ciao_list_tail(term));
    printf("</tail>");
    printf("</list>");
  } else if (ciao_is_empty_list(term)) {
    printf("<empty_list/>");
  } else if (ciao_is_integer(term)) {
    printf("<integer value=\"%d\"/>", ciao_to_integer(term));
  } else if (ciao_is_number(term)) {
    printf("<float value=\"%f\"/>", ciao_to_float(term));
  } else {
    printf("<unknown/>");
  }
}
```

120.5.7 Exceptions

The following example defines a predicate in C that converts a list of codes into a number using `strtol()`. If this conversion fails, then a exception is raised.

File *exceptions_example.pl*:

```
:- module(exceptions_example,
        [codes_to_number_c/2,
         safe_codes_to_number/2
        ],
        [foreign_interface]).

:- use_module(library(format)).

% If the string is not a number raises an exception.
:- true pred codes_to_number_c(in(X), go(Y)) :: string * int + (foreign, returns(Y))

safe_codes_to_number(X, Y) :-
        catch(codes_to_number_c(X, Y), Error, handle_exception(Error)).

handle_exception(Error) :- format("Exception caught ~w~n", [Error]).

:- use_foreign_source(exceptions_c).
:- extra_compiler_opts('-O2').
```

File *exceptions_c.c*:

```
#include <string.h>
#include "ciao_prolog.h"

int codes_to_number_c(char *s) {
  char *endptr;
  int n;
  n = strtol(s, &endptr, 10);
  if (endptr == NULL || *endptr != '\0') {
    ciao_raise_exception(ciao_structure("codes_to_number_exception",
                                        1,
                                        ciao_atom(s)));
  }
  return n;
}
```

120.5.8 Testing number types and using unbound length integers

Unbound length integers (and, in general, any number) can be converted to/from `ciao_terms` by using strings. The following examples show two possibilities: one which tries to be as smart as possible (checking whether numbers fit into a machine int or not), and being lazy and simpler -and probably slower.

File *bigints.pl*:

```
:- module(bigints,
```

```
        [
          make_smart_conversion/3, % Checks and uses convenient format
          force_string_conversion/2  % Passes around using strings
        ],
        [foreign_interface]).

:- true pred make_smart_conversion_c(in(X), go(Y), go(How))::
        any_term * any_term * any_term + foreign #
"Given a number @var{X}, it is unified with @var{Y} by using the most
specific internal representation (short integer, float, or long
integer).  @var{How} returns how the conversion was done.
It behaves unpredictably if @var{X} is not a number.".

:- true pred force_string_conversion_c(in(X), go(Y))::
        any_term * any_term + foreign #
"Given a number @var{X}, it is unified with @var{Y} by using the most
general internal representation (a string of characters). It behaves
unpredictably if @var{X} is not a number.".

:- use_foreign_source(bigints_c).

make_smart_conversion(A, B, C):-
        number(A),                              % Safety test
        make_smart_conversion_c(A, B, C).

force_string_conversion(A, B):-
        number(A),                              % Safety test
        force_string_conversion_c(A, B).
```

File *bigints_c.c*:

```
#include "ciao_prolog.h"

void make_smart_conversion_c(ciao_term  number_in,
                             ciao_term *number_out,
                             ciao_term *how_converted) {
  int    inter_int;
  double inter_float;
  char * inter_str;

  if (ciao_fits_in_int(number_in)) {/* Includes the case of being a float */
    inter_int = ciao_to_integer(number_in);
    *number_out = ciao_integer(inter_int);
    *how_converted = ciao_atom("machine_integer");
  } else
    if (ciao_is_integer(number_in)) { /* Big number */
      inter_str   = ciao_get_number_chars(number_in);
      *number_out = ciao_put_number_chars(inter_str);
      ciao_free(inter_str);
      *how_converted = ciao_atom("string");
    } else { /* Must be a float */
      inter_float = ciao_to_float(number_in);
```

```
      *number_out = ciao_float(inter_float);
      *how_converted = ciao_atom("float");
    }
}

void force_string_conversion_c(ciao_term  number_in,
                               ciao_term *number_out) {
  char *inter_str;
  inter_str  = ciao_get_number_chars(number_in);
  *number_out = ciao_put_number_chars(inter_str);
  ciao_free(inter_str);
}
```

120.6 Usage and interface (`foreign_interface_doc`)

- **Library usage:**
  The foreign interface is used by including `foreign_interface` in the include list of a module, or by means of an explicit `:- use_package(foreign_interface)`.

121 Foreign Language Interface Properties

Author(s): Jose F. Morales, Manuel Carro.

The foreign language interface uses some properties to specify linking regimes, foreign files to be compiled, types of data available, memory allocation policies, etc.

121.1 Usage and interface (foreign_interface_properties)

- **Library usage:**
  `:- use_module(library(foreign_interface_properties)).`
- **Exports:**
  - *Properties:*
    `foreign_low/1`, `foreign_low/2`, `size_of/3`, `foreign/1`, `foreign/2`, `returns/2`, `do_not_free/2`, `needs_state/1`, `ttr/3`.
  - *Regular Types:*
    `int_list/1`, `double_list/1`, `byte_list/1`, `byte/1`, `null/1`, `address/1`, `any_term/1`.

121.2 Documentation on exports (foreign_interface_properties)

int_list/1: REGTYPE

Usage: `int_list(List)`

- *Description:* `List` is a list of integers.

double_list/1: REGTYPE

Usage: `double_list(List)`

- *Description:* `List` is a list of numbers.

byte_list/1: REGTYPE

Usage: `byte_list(List)`

- *Description:* `List` is a list of bytes.

byte/1: REGTYPE

Usage: `byte(B)`

- *Description:* `Byte` is a byte.

null/1: REGTYPE

Usage: `null(Address)`

- *Description:* `Address` is a null adress.

address/1: REGTYPE

Usage: `address(Address)`

– *Description:* `Address` is a memory address.

any_term/1: REGTYPE

Usage: `any_term(X)`

– *Description:* `X` is any term. The foreign interface passes it to C functions as a general term.

foreign_low/1: PROPERTY

Usage: `foreign_low(Name)`

– *Description:* The Prolog predicate `Name` is implemented using the function `Name`. The implementation is not a common C one, but it accesses directly the internal Ciao Prolog data structures and functions, and therefore no glue code is generated for it.

foreign_low/2: PROPERTY

Usage: `foreign_low(PrologName,ForeignName)`

– *Description:* The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied.

size_of/3: PROPERTY

Usage: `size_of(Name,ListVar,SizeVar)`

– *Description:* For predicate `Name`, the size of the argument of type `byte_list/1`, `ListVar`, is given by the argument of type integer `SizeVar`.

foreign/1: PROPERTY

Usage: `foreign(Name)`

– *Description:* The Prolog predicate `Name` is implemented using the foreign function `Name`.

foreign/2: PROPERTY

Usage: `foreign(PrologName,ForeignName)`

– *Description:* The Prolog predicate `PrologName` is implemented using the foreign function `ForeignName`.

returns/2: PROPERTY

Usage: `returns(Name,Var)`

– *Description:* The result of the foreign function that implements the Prolog predicate `Name` is unified with the Prolog variable `Var`. Cannot be used without `foreign/1` or `foreign/2`.

do_not_free/2: PROPERTY

Usage: `do_not_free(Name,Var)`

– *Description:* For predicate `Name`, the C argument passed to (returned from) the foreign function will not be freed after calling the foreign function.

needs_state/1: PROPERTY

Usage: `needs_state(Name)`

– *Description:* The foreign function which implementes the predicate `Name` needs a `ciao_state` as its first argument.

ttr/3: PROPERTY

Usage: `ttr(Name,Var,TTr)`

– *Description:* For predicate `Name`, the C argument will be translated ussing `TTr` as term translator.

121.3 Documentation on internals (`foreign_interface_properties`)

use_foreign_source/1: DECLARATION

Usage: `:- use_foreign_source(Files).`

– *Description:* `Files` is the (list of) foreign file(s) that will be linked with the glue-code file. If the file(s) do(es) not have extension, then the '.c' extension will be automatically added

– *The following properties hold at call time:*

`Files` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

use_foreign_source/2: DECLARATION

Usage: `:- use_foreign_source(OsArch,Files).`

– *Description:* `Files` are the OS and architecture dependant foreign files. This allows compiling and linking different files depending on the O.S. and architecture.

– *The following properties hold at call time:*

`OsArch` is an atom. (basic_props:atm/1)

`Files` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

use_foreign_library/1: DECLARATION

Usage: `:- use_foreign_library(Libs).`

– *Description:* `Libs` is the (list of) external library(es) needed to link the C files. Only the short name of the library (i.e., what would follow the `-l` in the linker is needed.

– *The following properties hold at call time:*

`Libs` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

use_foreign_library/2: DECLARATION

Usage: :- `use_foreign_library(OsArch,Libs).`

- *Description:* `Libs` are the OS and architecture dependant libraries.
- *The following properties hold at call time:*

  `OsArch` is an atom. (basic_props:atm/1)

  `Libs` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

extra_compiler_opts/1: DECLARATION

Usage: :- `extra_compiler_opts(Opts).`

- *Description:* `Opts` is the list of additional compiler options (e.g., optimization options) that will be used during the compilation.
- *The following properties hold at call time:*

  `Opts` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

extra_compiler_opts/2: DECLARATION

Usage: :- `extra_compiler_opts(OsArch,Opts).`

- *Description:* `Opts` are the OS and architecture dependant additional compiler options.
- *The following properties hold at call time:*

  `OsArch` is an atom. (basic_props:atm/1)

  `Opts` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

use_compiler/1: DECLARATION

Usage: :- `use_compiler(Compiler).`

- *Description:* `Compiler` is the compiler to use in this file. When this option is used, the default (Ciao-provided) compiler options are not used; those specified in `extra_compiler_options` are used instead.
- *The following properties hold at call time:*

  `Compiler` is an atom. (basic_props:atm/1)

use_compiler/2: DECLARATION

Usage: :- `use_compiler(OsArch,Compiler).`

- *Description:* `Compiler` is the compiler to use in this file when compiling for the architecture `OsArch`. The option management is the same as in `use_compiler/2`.
- *The following properties hold at call time:*

  `OsArch` is an atom. (basic_props:atm/1)

  `Compiler` is an atom. (basic_props:atm/1)

extra_linker_opts/1: DECLARATION

Usage: :- `extra_linker_opts(Opts).`

- *Description:* `Opts` is the list of additional linker options that will be used during the linkage.
- *The following properties hold at call time:*

  `Opts` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

extra_linker_opts/2: DECLARATION

Usage: :- `extra_linker_opts(OsArch,Opts)`.

– *Description:* `Opts` are the OS and architecture dependant additional linker options.

– *The following properties hold at call time:*

`OsArch` is an atom. (basic_props:atm/1)

`Opts` is an atom or a list of atoms. (basic_props:atm_or_atm_list/1)

use_linker/1: DECLARATION

Usage: :- `use_linker(Linker)`.

– *Description:* `Linker` is the linker to use in this file. When this option is used, the default (Ciao-provided) linker options are not used; those specified in `extra_linker_options/1` are used instead.

– *The following properties hold at call time:*

`Linker` is an atom. (basic_props:atm/1)

use_linker/2: DECLARATION

Usage: :- `use_linker(OsArch,Linker)`.

– *Description:* `Compiler` is the linker to use in this file when compiling for the architecture `OsArch`. The option management is the same as in `use_compiler/2`.

– *The following properties hold at call time:*

`OsArch` is an atom. (basic_props:atm/1)

`Linker` is an atom. (basic_props:atm/1)

foreign_inline/2: DECLARATION

Usage: :- `foreign_inline(Term,Text)`.

– *Description:* `Term` is a predicate name. `Text` is a source C code that define the predicate `Term`. `Term` is present for future use with the analyzers. Example of this can be viewed in the hrtimer library.

– *The following properties hold at call time:*

`Term` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

`Text` is a string (a list of character codes). (basic_props:string/1)

121.4 Known bugs and planned improvements (`foreign_interface_properties`)

- The `size_of/3` property has an empty definition
- The `byte/1` property has an empty definition. A possible right definition is commented.

122 Utilities for on-demand compilation of foreign files

Author(s): Manuel Carro, Jose F. Morales.

This module provides two predicates which give the user information regarding how to compile external (C) files in order to link them with the Ciao Prolog engine at runtime.

These predicates are not intended to be called directly by the end-user. Instead, a tool or module whose aim is generating dynamically loadable files from source files should use the predicates in this file in order to find out what are the proper compiler and linker to use, and which options must be passed to them in the current architecture.

122.1 Usage and interface (`foreign_compilation`)

- **Library usage:**
  `:- use_module(library(foreign_compilation)).`
- **Exports:**
  - *Predicates:*
    `compiler_and_opts/2`, `linker_and_opts/2`.

122.2 Documentation on exports (`foreign_compilation`)

compiler_and_opts/2: PREDICATE

Usage: `compiler_and_opts(Compiler,Opts)`

- *Description:* If you want to compile a foreign language file for dynamic linking in the current operating system and architecture, you have to use the compiler `Compiler` and give it the options `Opts`. A variable in `Opts` means that no special option is needed.
- *Call and exit should be compatible with:*
  `Compiler` is an atom. (basic_props:atm/1)
  `Opts` is a list of `atm`s. (basic_props:list/2)

linker_and_opts/2: PREDICATE

Usage: `linker_and_opts(Linker,Options)`

- *Description:* If you want to link a foreign language file for dynamic linking in the current operating system and architecture, you have to use the linker `Compiler` and gite it the options `Opts`. A variable in `Opts` means that no special option is needed.
- *Call and exit should be compatible with:*
  `Linker` is an atom. (basic_props:atm/1)
  `Options` is a list of `atm`s. (basic_props:list/2)

123 Foreign Language Interface Builder

Author(s): Jose F. Morales, Manuel Carro.

Low-level utilities for building foreign interfaces. End-users should not need to use them, as the Ciao Prolog Compiler reads the user assertions and calls appropriately the predicates in this module.

123.1 Usage and interface (`build_foreign_interface`)

- **Library usage:**
  `:- use_module(library(build_foreign_interface)).`
- **Exports:**
  - *Predicates:*
    `build_foreign_interface/1`, `rebuild_foreign_interface/1`, `build_foreign_interface_explicit_decls/2`, `rebuild_foreign_interface_explicit_decls/2`, `build_foreign_interface_object/1`, `rebuild_foreign_interface_object/1`, `do_interface/1`.
- **Other modules used:**
  - *System library modules:*
    `write_c/write_c`, `streams`, `terms`, `lists`, `llists`, `aggregates`, `system`, `messages`, `assertions/assrt_lib`, `foreign_compilation`, `compiler/c_itf`, `compiler/engine_path`, `ctrlcclean`, `errhandle`, `filenames`.

123.2 Documentation on exports (`build_foreign_interface`)

build_foreign_interface/1: PREDICATE

Usage: `build_foreign_interface(File)`

- *Description:* Reads assertions from `File`, generates the gluecode for the Ciao Prolog interface, compiles the foreign files and the gluecode file, and links everything in a shared object. Checks modification times to determine automatically which files must be generated/compiled/linked.
- *Call and exit should be compatible with:*
  `File` is a source name. (streams_basic:sourcename/1)
- *The following properties should hold at call time:*
  `File` is currently ground (it contains no variables). (term_typing:ground/1)
- *The following properties should hold upon exit:*
  `File` is currently ground (it contains no variables). (term_typing:ground/1)

rebuild_foreign_interface/1: PREDICATE

Usage: `rebuild_foreign_interface(File)`

- *Description:* Like `build_foreign_interface/1`, but it does not check the modification time of any file.
- *Call and exit should be compatible with:*
  `File` is a source name. (streams_basic:sourcename/1)

– *The following properties should hold at call time:*
`File` is currently ground (it contains no variables). (term_typing:ground/1)
– *The following properties should hold upon exit:*
`File` is currently ground (it contains no variables). (term_typing:ground/1)

build_foreign_interface_explicit_decls/2: PREDICATE

Usage: `build_foreign_interface_explicit_decls(File,Decls)`

– *Description:* Like `build_foreign_interface/1`, but use declarations in `Decls` instead of reading the declarations from `File`.
– *Call and exit should be compatible with:*
`File` is a source name. (streams_basic:sourcename/1)
`Decls` is a list of `terms`. (basic_props:list/2)
– *The following properties should hold at call time:*
`File` is currently ground (it contains no variables). (term_typing:ground/1)
`Decls` is currently ground (it contains no variables). (term_typing:ground/1)
– *The following properties should hold upon exit:*
`File` is currently ground (it contains no variables). (term_typing:ground/1)
`Decls` is currently ground (it contains no variables). (term_typing:ground/1)

rebuild_foreign_interface_explicit_decls/2: PREDICATE

Usage: `rebuild_foreign_interface_explicit_decls(File,Decls)`

– *Description:* Like `build_foreign_interface_explicit_decls/1`, but it does not check the modification time of any file.
– *Call and exit should be compatible with:*
`File` is a source name. (streams_basic:sourcename/1)
`Decls` is a list of `terms`. (basic_props:list/2)
– *The following properties should hold at call time:*
`File` is currently ground (it contains no variables). (term_typing:ground/1)
`Decls` is currently ground (it contains no variables). (term_typing:ground/1)
– *The following properties should hold upon exit:*
`File` is currently ground (it contains no variables). (term_typing:ground/1)
`Decls` is currently ground (it contains no variables). (term_typing:ground/1)

build_foreign_interface_object/1: PREDICATE

Usage: `build_foreign_interface_object(File)`

– *Description:* Compiles the gluecode file with the foreign source files producing an unique object file.
– *Call and exit should be compatible with:*
`File` is a source name. (streams_basic:sourcename/1)
– *The following properties should hold at call time:*
`File` is currently ground (it contains no variables). (term_typing:ground/1)
– *The following properties should hold upon exit:*
`File` is currently ground (it contains no variables). (term_typing:ground/1)

rebuild_foreign_interface_object/1: PREDICATE

Usage: `rebuild_foreign_interface_object(File)`

- *Description:* Compiles (again) the gluecode file with the foreign source files producing an unique object file.
- *Call and exit should be compatible with:*

  `File` is a source name. (streams_basic:sourcename/1)
- *The following properties should hold at call time:*

  `File` is currently ground (it contains no variables). (term_typing:ground/1)
- *The following properties should hold upon exit:*

  `File` is currently ground (it contains no variables). (term_typing:ground/1)

do_interface/1: PREDICATE

Usage: `do_interface(Decls)`

- *Description:* Given the declarations in `Decls`, this predicate succeeds if these declarations involve the creation of the foreign interface
- *Call and exit should be compatible with:*

  `Decls` is a list of `terms`. (basic_props:list/2)
- *The following properties should hold at call time:*

  `Decls` is currently ground (it contains no variables). (term_typing:ground/1)
- *The following properties should hold upon exit:*

  `Decls` is currently ground (it contains no variables). (term_typing:ground/1)

124 Interactive Menus

Author(s): The CLIP Group.
This library package allows definition interactive menus

124.1 Usage and interface (menu_doc)

- **Library usage:**
  `:- use_package(menu).`
  or
  `:- module(...,...,[menu]).`
- **New operators defined:**
  `::/2` [970,xfx], `<-/2` [971,xfx], `guard/1` [900,fy], `$/2` [150,xfx], `=>/2` [950,xfx], `argnames/1` [1150,fx].
- **Other modules used:**
  - *System library modules:*
    `menu/menu_generator`, `menu/menu_rt`.

124.2 Documentation on multifiles (menu_doc)

menu_default/3: PREDICATE
No further documentation available for this predicate.
The predicate is *multifile*.

menu_opt/6: PREDICATE
No further documentation available for this predicate.
The predicate is *multifile*.

hook_menu_flag_values/3: PREDICATE
No further documentation available for this predicate.
The predicate is *multifile*.

hook_menu_check_flag_value/3: PREDICATE
No further documentation available for this predicate.
The predicate is *multifile*.

hook_menu_flag_help/3: PREDICATE
No further documentation available for this predicate.
The predicate is *multifile*.

hook_menu_default_option/3: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

125 menu_generator (library)

125.1 Usage and interface (menu_generator)

- **Library usage:**
  `:- use_module(library(menu_generator)).`
- **Exports:**
  - *Predicates:*
    menu/1, menu/2, menu/3, menu/4, get_menu_flag/3, set_menu_flag/3, space/1, get_menu_configs/1, save_menu_config/1, remove_menu_config/1, restore_menu_config/1, show_menu_configs/0, show_menu_config/1, get_menu_options/2, get_menu_flags/1, restore_menu_flags_list/1, get_menu_flags/2, restore_menu_flags/2, generate_js_menu/1, eq/3, neq/3, uni_type/2, vmember/2.
  - *Regular Types:*
    menu_flag_values/1.
  - *Multifiles:*
    $is_persistent/2, persistent_dir/2, persistent_dir/4, menu_default/3, menu_opt/6, hook_menu_flag_values/3, hook_menu_check_flag_value/3, hook_menu_flag_help/3, hook_menu_default_option/3.
- **Other modules used:**
  - *System library modules:*
    persdb/persdbrt, aggregates, write, messages, prompt, lists.

125.2 Documentation on exports (menu_generator)

menu/1: PREDICATE

Usage: `menu(M)`

- *Description:* Like menu(M , true).

menu/2: PREDICATE

Usage: `menu(M,Bool)`

- *Description:* Like `menu/4` with no selected options, taking the menu level from the term `M` (example: ana(1) is expert, ana is naive), and using `Bool` to decide whether print help message or not.

menu/3: PREDICATE

Usage: `menu(M,Level,Bool)`

- *Description:* Like `menu/4` with no selected options.

menu/4: PREDICATE

Usage: `menu(M,Level,Bool,AlreadySelectedOpts)`

- *Description:* Execute the menu `X`. `Level` specifies the menu level. `Bool` decides whether print the help message. `AlreadySelectedOpts` is a list with the selected options.

get_menu_flag/3: PREDICATE

Usage: `get_menu_flag(M,F,V)`

- *Description:* Returns the value in `V` of the flag `F` in the menu (-branch) `M`.
- *The following properties should hold at call time:*

  `M` is currently instantiated to an atom. (term_typing:atom/1)

  `F` is currently instantiated to an atom. (term_typing:atom/1)

  `V` is a free variable. (term_typing:var/1)

set_menu_flag/3: PREDICATE

Usage: `set_menu_flag(M,F,V)`

- *Description:* Set the value `V` of the flag `F` in the menu (-branch) `M`.
- *The following properties should hold at call time:*

  `M` is currently instantiated to an atom. (term_typing:atom/1)

  `F` is currently instantiated to an atom. (term_typing:atom/1)

  `V` is a free variable. (term_typing:var/1)

space/1: PREDICATE

Usage: `space(N)`

- *Description:* prints `N` spaces.
- *The following properties should hold at call time:*

  `N` is a number. (basic_props:num/1)

get_menu_configs/1: PREDICATE

Usage: `get_menu_configs(X)`

- *Description:* Returns a list of atoms in `X` with the name of stored configurations.
- *The following properties should hold at call time:*

  `X` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `X` is a list of `atoms`. (basic_props:list/2)

save_menu_config/1: PREDICATE

Usage: `save_menu_config(Name)`

- *Description:* Save the current flags configuration under the `Name` key.
- *The following properties should hold at call time:*

  `Name` is an atom. (basic_props:atm/1)

remove_menu_config/1: PREDICATE

Usage: `remove_menu_config(Name)`

- *Description:* Remove the configuration stored with the `Name` key (the same provided in `save_menu_config/1`).
- *The following properties should hold at call time:*

  `Name` is an atom. (basic_props:atm/1)

restore_menu_config/1: PREDICATE

Usage: `restore_menu_config(Name)`

- *Description:* Restore the configuration saved with the `Name` key (the same provided in `save_menu_config/1`).
- *The following properties should hold at call time:*

  `Name` is an atom. (basic_props:atm/1)

show_menu_configs/0: PREDICATE

Usage:

- *Description:* Show all stored configurations.

show_menu_config/1: PREDICATE

Usage: `show_menu_config(C)`

- *Description:* Show specific configuration values pointed by `C` key (the same provided in `save_menu_config/1`).
- *The following properties should hold at call time:*

  `C` is an atom. (basic_props:atm/1)

get_menu_options/2: PREDICATE

Usage: `get_menu_options(Flag,V)`

- *Description:* Returns possilbe options in `V` by fail for the flag `Flag`.
- *The following properties should hold at call time:*

  `F` is currently instantiated to an atom. (term_typing:atom/1)

get_menu_flags/1: PREDICATE

Usage: `get_menu_flags(L)`

- *Description:* Return a list `L` of all current menu flags, composed by terms with the form (M,F,V), where M is the menu, F the flag, and V the value. This list can be used as argument of `restore_flags_list/1`
- *The following properties should hold at call time:*

  `L` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `L` is a list. (basic_props:list/1)

restore_menu_flags_list/1: PREDICATE

Usage: `restore_menu_flags_list(L)`

- *Description:* Restores menu flags. `L` is a list of tuple (M,F,V) where M is the menu, F is the flag, and V is the value of the flag F in the menu M.
- *The following properties should hold at call time:*

  `L` is a list. (basic_props:list/1)

get_menu_flags/2: PREDICATE

Usage: `get_menu_flags(M,L)`

- *Description:* Return a list `L` of the current menu `M` composed by terms with the form (F=V), F the flag, and V the value. This list can be used as argument of `restore_menu_flags/2`
- *The following properties should hold at call time:*

  `M` is any term. (basic_props:term/1)

  `L` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `L` is a list. (basic_props:list/1)

restore_menu_flags/2: PREDICATE

Usage: `restore_menu_flags(M,F)`

- *Description:* Restore the flag of the menu `M`. `F` is a list of terms F=V, which indicate the flag (F) and the value (V). `M` is the target menu to which those flags "belong". Additionally, `F` can contains terms like `changed_to_menu(NM)` that will put NM as the new target menu.
- *The following properties should hold at call time:*

  `M` is currently instantiated to an atom. (term_typing:atom/1)

  `F` is a list. (basic_props:list/1)

generate_js_menu/1: PREDICATE

Internal Info. Short description and general ideas about how the JS menu is generated.

The current model for the JS menu is an array of `menuq` (object in JS).

```
var assert_rtcheck = menus.length ;
var v_assert_rtcheck ;
menus[ menus.length ] = new menuq(
"assert_rtcheck",
        "Perform Run-Time Checks",
        "none,pred,pp_assrt,pp_code",
        "none",
        '((v_menu_level == "expert") &&
          (v_inter_all == "check_assertions"))' ) ;
```

A variable with the same name as the *flag name* is created with the value of the index of the menu in the array. Another variable with 'v_' (v = value) indicates the value (of the flag) choosed by the user in the combo-boxes that appear on the webpage (note you should not read this if you have not seen the webpage working). The object `menuq` holds

several things: the flag name (to find out the index in the array in some JS functions), the title, the options (notice there is no space in the options, this is important!), default option and the guard.

All the problem here is to generate the (JS) guard, because the rest of information is the same as in `menu_opt/6`. What code does is to execute the guard in prolog, and obtain a list of the form [flag=value,flag2=value2...]. Aditionally an element of the list can be another list, which indicates that the join operator (&& or ||) is swaped. For example: [a=1,[b=2,c=3],d=4] will be translated in JS like ((a==1)&&((b==2)||(c==3))&&(d==4)).

Prolog Guards (the ones in menu_opt) have been rewritten in order to do not generate free variables, i.e., they are finite guards now. So calling them with a variable in its first argument, we get the list like the named in the previous paragraph.

% Unfortunately, the current CiaoPP menu does not have all information % itself to concatenate several menus, i.e., when asking which kind of % action the user desire, depending on the answer one path or another % one is taken. Who decide which path? 'auto_inteface' does. We do have % to take this into account, because generating the assertions of a % "subpath" will produce the activation of it without permision of the % father (the menu which launch it).

Also, we have to keep in mind that menu has several submenus (or branches) defined and ones connect with others. For example, the menu

```
all, 'Select Menu Level'   # menu_level - naive.
all, 'Select Action Group' # inter_all  - analyze :: all_menu_branch.

check(1), 'Perform Compile-Time Checks' # assert_ctcheck - on.
...

ana     , 'Select Aliasing-Mode Analysis' # modes - shfr <- true.
```

defines 3 menus: `all`, `check(1)`, and `ana`. It usually happends that one menu invoques (connect or continue) with another menu (then it is a submenu or a branch). When generating the guards we have to add additional restrictions to the guards in order to make submenus do not appear in the incorrect moment. For example, `check(1)` menu will be only active if `menu_level = expert` and `inter_all=check_assertions` (more on this come later). How are several menus connected between each other? The process of connecting the menus is post-processing the selected flags (options) via post hook (the one defined after :: field). The post-processing hook only have to add the element `ask_menu(Branch,Level)` or `ask_menu(Branch)` to the selected flag list (the argument of the hook). So let us say that when calling all_menu_branch(X , Y) we get:

```
?- all_menu_branch(A,B).

A = [inter_all=optimize,menu_level=naive|_A],
B = [ask_menu(opt,0),inter_all=optimize,menu_level=naive|_A] ? ;

A = [inter_all=optimize,menu_level=expert|_A],
B = [ask_menu(opt,1),inter_all=optimize,menu_level=expert|_A] ? ;

A = [inter_all=analyze,menu_level=naive|_A],
B = [ask_menu(ana,0),inter_all=analyze,menu_level=naive|_A] ? ;

A = [inter_all=analyze,menu_level=expert|_A],
B = [ask_menu(ana,1),inter_all=analyze,menu_level=expert|_A] ? ;
```

```
A = [inter_all=check_assertions,menu_level=naive|_A],
B = [ask_menu(check,0),inter_all=check_assertions,menu_level=naive|_A] ? ;

A = [inter_all=check_assertions,menu_level=expert|_A],
B = [ask_menu(check,1),inter_all=check_assertions,menu_level=expert|_A] ? ;

A = [inter_all=check_certificate,menu_level=_B|_A],
B = [inter_all=check_certificate,menu_level=_B|_A] ? ;

A = [inter_all=optimize,_A,menu_level=naive|_B],
B = [ask_menu(opt,0),inter_all=optimize,_A,menu_level=naive|_B] ?
```

Notice that the last option contains free variables in the list (not taking the tail into account). That is the indicator for us to stop searching for more solutions. Additionally, we can have more complex things like:

```
?- opt_menu_branch(A,B).

A = [menu_level=naive,inter_optimize=_A|_B],
B = [ask_menu(_A,0),menu_level=naive,inter_optimize=_A|_B] ? ;

A = [menu_level=expert,inter_optimize=_A|_B],
B = [ask_menu(_A,1),menu_level=expert,inter_optimize=_A|_B] ? ;

A = [menu_level=naive,_B,inter_optimize=_A|_C],
B = [ask_menu(_A,0),menu_level=naive,_B,inter_optimize=_A|_C] ?
```

In this situation, the menu that will be asked will depend on the value of the flag `inter_optimize`, so we will have to generate as many ask_menu as possible values the flag has. The predicate `generate_menu_path/2` solves all this problem: for a given flag, it looks up to find out the guard composed by flags that will activate the flag. % This predicate also consider the problem of menu aliasing, % i.e., the option optimize in inter_ana menu launch opt menu, so % optimize is an alias for opt or vice-versa. For example, for the given flag `ass_not_stat_eval`, the path is: [v_menu_level=expert, v_inter_all=check_assertions], that means that `menu_level` flag has to have the value "expert" and the `inter_all` flag has to have the value "check_assertions" (note that menu_level and inter_all defines two menu branches). If we would execute only the precondition we would get: [v_assert_ctcheck=on].

There are % two one limitations imposed to the JS menu. % The menu level indicated by `menu_level` flag, is hirewired. The % other limitation is more serious. All flags values in the JS menu are mapped into one set of flags. In other words, changing a value of a shared flag by two menu branch will be reflected on the other branch. For example, changing type analysis in `analyze` menu branch, will modify the value of the same flag in `check assertions` branch.

The last point to name is about generated JS guards. This world is not fair, and sometimes happends things you just do not expect. Here is one of those things. When calling the Prolog guards with the list of current selected values, the cases that can occur are much less than when seeing all the possible combinations. Something like (a=true||a=1)&&(b=2), in Prolog guard execution (with instantiated things) will mean: the selected options are not nil, and a=1 and b=2, or in other words: (a==1)&&(b==2). But in JS, unfortunately means: b=2. Nowadays, this problem is solved by `clean_imperative_guard/2` which tries to remove all stupid `true` conditions, but I am sure Murphy is listening to me now and he started to create an user to make the call `clean_imperative_guard/2` generates wrong answer.

Usage: `generate_js_menu(DoNotIncludeList)`

– *Description:* Reads all multifile `menu_opt/6` predicates and writes in default output a JavaScript Menu.
– *The following properties should hold at call time:*
`DoNotIncludeList` is a list. (basic_props:list/1)

eq/3: PREDICATE

Usage: `eq(Type,A,B)`

– *Description:* `Type` is the value returned by the 2nd arg of `uni_type`. `A` and `B` are whatever terms. This predicate success if they are equal (like A=B).

neq/3: PREDICATE

Usage: `neq(Type,A,B)`

– *Description:* `Type` is the value returned by the 2nd arg of `uni_type`. `A` and `B` are whatever terms. The semantic is similar to A == B.

uni_type/2: PREDICATE

Usage: `uni_type(Var,Type)`

– *Description:* `Var` should be the argument passed to the menu guard. `Type` is an abstract type that decides how unifications should be done in `eq/3` and `neq/3`.

vmember/2: PREDICATE

Usage: `vmember(Var,List)`

– *Description:* It is `member` equivalent predicate to be used in guards.

menu_flag_values/1: REGTYPE

Usage: `menu_flag_values(X)`

– *Description:* Flag values

125.3 Documentation on multifiles (`menu_generator`)

$is_persistent/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *data*.

persistent_dir/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *data*.

persistent_dir/4: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *data*.

menu_default/3: PREDICATE

The predicate is *multifile*.

Usage 1: `menu_default(Menu,Flag,DefaultValue)`

- *Description:* `Menu` is a term that has to correspond with the 1st argument of `Menu`. `Flag` is the desired flag to have a default value. `DefaultValue` is the default value of `Flag`.
- *The following properties should hold at call time:*

  `Menu` is any term. (basic_props:term/1)

  `Flag` is an atom. (basic_props:atm/1)

  `DefaultValue` is an atom. (basic_props:atm/1)

Usage 2: `menu_default(Menu,Flag,DefaultValue)`

- *The following properties hold upon exit:*

  `Menu` is an atom. (basic_props:atm/1)

  `Flag` is an atom. (basic_props:atm/1)

  `DefaultValue` is an atom. (basic_props:atm/1)

Usage 3: `menu_default(Menu,Flag,DefaultValue)`

- *Description:* This call mode can be used to ask which flags and its values has a menu `menu`
- *The following properties should hold at call time:*

  `Menu` is an atom. (basic_props:atm/1)

  `Flag` is a free variable. (term_typing:var/1)

  `DefaultValue` is a free variable. (term_typing:var/1)

Usage 4: `menu_default(Menu,Flag,DefaultValue)`

- *Description:* This call mode can be used to ask which value have the flag `Flag` in the menu `menu`
- *The following properties should hold at call time:*

  `Menu` is an atom. (basic_props:atm/1)

  `Flag` is an atom. (basic_props:atm/1)

  `DefaultValue` is a free variable. (term_typing:var/1)

menu_opt/6: PREDICATE

The predicate is *multifile*.

Usage 1: `menu_opt(Menu,Flag,Text,Guard,BeforePrinting,SelectedHook)`

- *Description:* `Menu` is a term that specifies the menu name. It can be an atom or just a predicate of arity 1, where the 1st argument indicates the menu level (i.e., ana(1) is the level 1 of 'ana' menu). `Flag` is the flag that will be asked.

  `Text` is the test that will be printed when asking the `Flag`.

`Guard` is a predicate of arity 1 that is invoked to see if the flag should be asked. The argument is the selected menu options till moment in the way: [flag1=value1, flag2=value2, ...].

`BeforePrinting` is a predicate of arity 0, that is invoked whenever the menu option has been selected the validator menu options chooser.

`SelectedHook` is a predicate of arity 2, that is invoked whenever the flag has been selected by the user. The 1st argument are the current selected values, including the current flag, and in the 2nd argument the possible modified list is expected.

In summary, if `Guard` holds, then `BeforePrinting` is executed (no action is taken whether it fails or not), and after the user has types the option `SelectedHook` is invoked.

– *The following properties should hold at call time:*

`Menu` is any term. (basic_props:term/1)

`Flag` is an atom. (basic_props:atm/1)

`Text` is an atom. (basic_props:atm/1)

`Guard` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`BeforePrinting` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`SelectedHook` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 2: `menu_opt(Menu,Flag,Text,Guard,BeforePrinting,SelectedHook)`

– *The following properties should hold at call time:*

`Menu` is any term. (basic_props:term/1)

`Flag` is any term. (basic_props:term/1)

`Text` is any term. (basic_props:term/1)

`Guard` is any term. (basic_props:term/1)

`BeforePrinting` is any term. (basic_props:term/1)

`SelectedHook` is any term. (basic_props:term/1)

hook_menu_flag_values/3: PREDICATE

The predicate is *multifile*.

Usage: `hook_menu_flag_values(Menu,Flag,Values)`

– *Description:* It is a hook. It is invoked whenever a menu question is printed. `Values` is a term which specifies the possible values. If `Values` is alist(List) -atom list-, then menu will check if the typed value by user belongs to List. If `Values` is a term ask(T,Flag), the menu will invoke `hook_menu_check_flag_value/3` hook to check if introduced value is valid.

– *The following properties should hold at call time:*

`Menu` is currently instantiated to an atom. (term_typing:atom/1)

`Flag` is currently instantiated to an atom. (term_typing:atom/1)

`Values` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

Flag values (menu_generator:menu_flag_values/1)

hook_menu_check_flag_value/3: PREDICATE

The predicate is *multifile*.

Usage: `hook_menu_check_flag_value(M,F,V)`

– *Description:* It is a hook. It is invoked whenever the menu needs to check whether the answer introduced for the menu `M` is correct. This happens when `hook_menu_flag_values/3` returns in its second argument something different than alist(_).

hook_menu_flag_help/3: PREDICATE

The predicate is *multifile*.

Usage: `hook_menu_flag_help(M,F,H)`

– *Description:* It is a hook. It is invoked whenever the user ask for a help description, `H`, of the flag `F` in the menu `M`.

hook_menu_default_option/3: PREDICATE

The predicate is *multifile*.

Usage: `hook_menu_default_option(M,F,D)`

– *Description:* It is a hook. It is invoked whenever the menu needs to offer a default option to the user in the menu `M` and it has not been neither introduced before nor specified by `menu_default/3`.

125.4 Known bugs and planned improvements (menu_generator)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

126 Interface to daVinci

Author(s): Francisco Bueno.

This library allows connecting a Ciao Prolog application with daVinci V2.X.

The communication is based on a two-way channel: after daVinci is started, messages are sent in to it and read in from it on demand by different Prolog predicates. Messages are sent via writing the term as text; messages are received by reading text and returning an atom. Commands sent and answers received are treated as terms from the Prolog side, since for daVinci they are text but have term syntax; the only difficulty lies in strings, for which special Prolog syntax is provided.

See accompanying file `library(davinci(commands))` for examples on the use of this library.

daVinci is developed by U. of Bremen, Germany.

126.1 Usage and interface (`davinci`)

- **Library usage:**
  `:- use_module(library(davinci)).`
- **Exports:**
  - *Predicates:*
    `davinci/0`, `topd/0`, `davinci_get/1`, `davinci_get_all/1`, `davinci_put/1`, `davinci_quit/0`, `davinci_ugraph/1`, `davinci_lgraph/1`, `ugraph2term/2`, `formatting/2`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `prompt`, `format`, `read`, `graphs/ugraphs`, `write`, `system`.

126.2 Documentation on exports (`davinci`)

davinci/0: PREDICATE

Start up a daVinci process.

topd/0: PREDICATE

A toplevel to send to daVinci commands from standard input.

davinci_get/1: PREDICATE

Usage: `davinci_get(Term)`

- *Description:* Get a message from daVinci. `Term` is a term corresponding to daVinci's message.

davinci_get_all/1: PREDICATE

Usage: `davinci_get_all(List)`

- *Description:* Get all pending messages. `List` is a list of terms as in `davinci_get/1`.

– *The following properties should hold upon exit:*
`List` is a list. (basic_props:list/1)

davinci_put/1: PREDICATE

Usage: `davinci_put(Term)`

– *Description:* Send a command to daVinci.
– *The following properties should hold at call time:*
davinci:davinci_command(Term) (davinci:davinci_command/1)

davinci_quit/0: PREDICATE

Exit daVinci process. All pending answers are lost!

davinci_ugraph/1: PREDICATE

Usage: `davinci_ugraph(Graph)`

– *Description:* Send a graph to daVinci.
– *The following properties should hold at call time:*
davinci:ugraph(Graph) (davinci:ugraph/1)

davinci_lgraph/1: PREDICATE

Usage: `davinci_lgraph(Graph)`

– *Description:* Send a labeled graph to daVinci.
– *The following properties should hold at call time:*
davinci:lgraph(Graph) (davinci:lgraph/1)

ugraph2term/2: PREDICATE

No further documentation available for this predicate.

formatting/2: PREDICATE

No further documentation available for this predicate.

126.3 Documentation on internals (`davinci`)

davinci_command/1: PROPERTY

Syntactically, a command is a term. Semantically, it has to correspond to a command understood by daVinci. Two terms are interpreted in a special way: `string/1` and `text/1`: `string(Term)` is given to daVinci as `"Term"`; `text(List)` is given as `"Term1 Term2 ...Term "` for each `Term` in `List`. If your term has functors `string/1` and `text/1` that you don't want to be interpreted this way, use it twice, i.e., `string(string(Term))` is given to daVinci as `string(Term')` where `Term'` is the interpretation of `Term`.

ugraph/1: PROPERTY

`ugraph(Graph)`

`Graph` is a term which denotes an ugraph as in `library(ugraphs)`. Vertices of the form `node/2` are interpreted in a special way: `node(Term,List)` is interpreted as a vertex `Term` with attributes `List`. `List` is a list of terms conforming the syntax of `davinci_put/1` and corresponding to daVinci's graph nodes attributes. If your vertex has functor `node/2` and you don't want it to be interpreted this way, use it twice, i.e., `node(node(T1,T2),[])` is given to daVinci as vertex `node(T1,T2)`. A vertex is used both as label and name of daVinci's graph node. daVinci's graph edges have label `V1-V2` where `V1` is the source and `V2` the sink of the edge. There is no support for multiple edges between the same two vertices.

lgraph/1: PROPERTY

`lgraph(Graph)`

`Graph` is a term which denotes a wgraph as in `library(wgraphs)`, except that the weights are labels, i.e., they do not need to be integers. Vertices of the form `node/2` are interpreted in a special way. Edge labels are converted into special intermediate vertices. Duplicated labels are solved by adding dummy atoms `''`. There is no support for multiple edges between the same two vertices.

127 The Tcl/Tk interface

Author(s): Montse Iglesias Urraca, The CLIP Group, `http://www.clip.dia.fi.upm.es/`, Facultad de Informática, Universidad Politécnica de Madrid.

The `tcltk` library package is a bidirectional interface to the *Tcl* language and the *Tk* toolkit. Tcl is an interpreted scripting language with many extension packages, particularly the graphical interface toolkit, Tk. The interaction between both languages is expressed in terms of an interface between the Tcl/Tk process and the Prolog process. This approach allows the development of mixed applications where both sides, Tcl/Tk and Prolog, can be combined in order to exploit their respective capabilities.

This library uses two sockets to connect both the Tcl and the Prolog processes: *event_socket* and *term_socket*. There are also two Tcl global variables: *prolog_variables* and *terms*. The value of any of the bound variables in a goal will be stored in the array `prolog_variables` with the variable name as index. *Terms* is the string which contains the printed representation of prolog *terms*.

Prolog to Tcl

The Tcl/Tk side waits for requests from the Prolog side, and executes the Tcl/Tk code received. Also, the Tcl/Tk side handles the events and exceptions which may be raised on its side, passing on control to the Prolog side in case it is necessary.

To use Tcl, you must create a *Tcl interpreter* object and send commands to it. A *Tcl* command is specified as follows:

```
Command         --> Atom  { other than [] }
                  | Number
                  | chars(PrologString)
                  | write(Term)
                  | format(Fmt,Args)
                  | dq(Command)
                  | br(Command)
                  | sqb(Command)
                  | min(Command)
                  | ListOfCommands
ListOfCommands  --> []
                  |[Command|ListOfCommands]
```

where:

`Atom` denotes the printed representation of the atom.

`Number` denotes their printed representations.

`chars(PrologString)`
denotes the string represented by *PrologString* (a list of character codes).

`write(Term)`
denotes the string that is printed by the corresponding built-in predicate.

`format(Term)`
denotes the string that is printed by the corresponding built-in predicate.

`dq(Command)`
denotes the string specified by *Command*, enclosed in double quotes.

`br(Command)`
denotes the string specified by *Command*, enclosed in braces.

`sqb(Command)`
denotes the string specified by *Command*, enclosed in square brackets.

`min(Command)`
: denotes the string specified by *Command*, immediately preceded by a hyphen.

`ListOfCommands`
: denotes the strings denoted by each element, separated by spaces.

The predicates to use Tcl from Prolog are `tcl_new/1`, `tcl_delete/1`, `tcl_eval/3`, and `tcl_event/3`.

An example of use with Prolog as master and Tcl as slave, consisting of a GUI to a program which calculates the factorial of a number:

```
:- use_module(library(tcltk)).

go :-
        tcl_new(X),
        tcl_eval(X,[button,'.b',min(text),dq('Compute!')],_),
        tcl_eval(X,[button,'.c','-text',dq('Quit')],_),
        tcl_eval(X,[entry,'.e1',min(textvariable),'inputval'],_),
        tcl_eval(X,[label,'.l1',min(text),dq('The factorial of ')],_),
        tcl_eval(X,[pack, '.l1','.e1'],_),
        tcl_eval(X,[entry,'.e2',min(textvariable),'outputval'],_),
        tcl_eval(X,[label,'.l2',min(text),dq('is  ')],_),
        tcl_eval(X,[pack, '.l2','.e2'],_),
        tcl_eval(X,[pack,'.b','.c',min(side),'left'],_),
        tcl_eval(X,[bind,'.b','<ButtonPress-1>',
                br([set,'inputval','$inputval','\n',
                prolog_one_event,
                dq(write(execute(tk_test_aux:factorial('$inputval', 'Outputval')))),
                '\n',
                set, 'outputval','$prolog_variables(Outputval)'])],
                _),
        tcl_eval(X,[bind,'.c','<ButtonPress-1>',
                br([prolog_one_event,
                dq(write(execute(exit_tk_event_loop)))])],
                _),
        tk_event_loop(X).
```

Tcl to Prolog

This is the usual way to build a GUI application. The slave, Prolog, behaves as a server that fulfills eventual requests from the master side, Tcl. At some point, during the user interaction with the GUI, an action may take place that triggers the execution of some procedure on the slave side (a form submit, for example). Thus, the slave is invoked, performs a service, and returns the result to the GUI through the socket connection.

This library includes two main specific Tcl commands:

`prolog` *Goal*
: *Goal* is a string containing the printed representation of a Prolog goal. The goal will be called in the user module unless it is prefixed with another module name. The call is always deterministic and its can be either of the following:

  1, in case of success
  : The value of any of the variables in the goal that is bound to a term will be returned to Tcl in the array prolog_variables with the variable name as index.

0, if the execution fails
The Prolog exception Tcl exception is raised. The error message will be "Prolog Exception: " appended with a string representation of such exception.

`prolog_event` *Term*
Adds the new *term* to the *terms* queue. These can be later retrieved through predicates `tcl_event/3` and `tk_next_event/2`.

Additionally, seven extra Tcl commands are defined.

`prolog_delete_event`
Deletes the first *term* of the *terms* queue.

`prolog_list_events`
Sends all the *terms* of the *terms* queue through the *event_socket*. The last element is *end_of_event_list*.

`prolog_cmd` *Command*
Receives as an argument the Tcl/Tk code, evaluates it and returns through the *term_socket* the term *tcl_error* in case of error or the term *tcl_result* with the result of the command executed. If the command is *prolog*, upon return, the goal run on the prolog side is received. In order to get the value of the variables, predicates are compared using the *unify_term* command. Returns 0 when the sript runs without errors, and 1 if there is an error.

`prolog_one_event` *Term*
Receives as an argument the *term* associated to one of the Tk events. Sends the *term* through the *event_socket* and waits for its unification. Then *unify_term* command is called to update the *prolog_variables* array.

`prolog_thread_event` *Term*
Receives as an argument the *term* associated to one of the Tk events. Sends the *term* through the *event_socket* and waits for its unification. Then *unify_term* command is called to update the *prolog_variables* array. In this case the *term_socket* is non blocking.

`convert_variables` *String*
Its argument is a string containing symbols that can not be sent through the sockets. This procedure deletes them from the input string and returns the new string.

`unify_term` *Term1 Term2*
Unifies *Term1* and *Term2* and updates the the *prolog_variables* array.

The predicates to use Prolog from Tcl are `tk_event_loop/1`, `tk_main_loop/1`, `tk_new/2`, and `tk_next_event/2`.

An example of use with Tcl as master and Prolog as slave, implementing the well known "Hello, world!" dummy program (more can be seen in directory examples):

Prolog side:

```
:- use_module(library(tcltk)).
:- use_package(classic).

hello('Hello, world!').

go :-
        tk_new([name('Simple')], Tcl),
        tcl_eval(Tcl, 'source simple.tcl', _),
        tk_main_loop(Tcl),
```

```
        tcl_delete(Tcl).
```

Tcl side (simple.tcl):

```
label .l -textvariable tvar
button .b -text "Go!" -command {run}
pack .l .b -side top

proc run {} {

    global prolog_variables
    global tvar

    prolog hello(X)
    set tvar $prolog_variables(X)
}
```

127.1 Usage and interface (tcltk)

- **Library usage:**
  `:- use_module(library(tcltk)).`
- **Exports:**
  - *Predicates:*
    `tcl_new/1`, `tcl_eval/3`, `tcl_delete/1`, `tcl_event/3`, `tk_event_loop/1`, `tk_main_loop/1`, `tk_new/2`, `tk_next_event/2`.
  - *Regular Types:*
    `tclInterpreter/1`, `tclCommand/1`.
- **Other modules used:**
  - *System library modules:*
    `tcltk/tcltk_low_level`, `write`.

127.2 Documentation on exports (tcltk)

tcl_new/1: PREDICATE

Usage: `tcl_new(TclInterpreter)`

- *Description:* Creates a new interpreter, initializes it, and returns a handle to it in `TclInterpreter`.
- *Call and exit should be compatible with:*
  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk:tclInterpreter/1)
- *The following properties should hold at call time:*
  `TclInterpreter` is a free variable. (term_typing:var/1)

tcl_eval/3: PREDICATE

Meta-predicate with arguments: `tcl_eval(?,?,addmodule(?))`.

Usage: `tcl_eval(TclInterpreter,Command,Result)`

- *Description:* Evaluates the commands given in `Command` in the Tcl interpreter `TclInterpreter`. The result will be stored as a string in `Result`. If there is an error in *Command* an exception is raised. The error messages will be *Tcl Exception:* if the error is in the syntax of the Tcl/Tk code or *Prolog Exception:*, if the error is in the prolog term.
- *Call and exit should be compatible with:*

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk:tclInterpreter/1)

  `Command` is a *Tcl* command. (tcltk:tclCommand/1)

  `Result` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Command` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Result` is a free variable. (term_typing:var/1)

tcl_delete/1: PREDICATE

Usage: `tcl_delete(TclInterpreter)`

- *Description:* Given a handle to a Tcl interpreter in variable `TclInterpreter`, it deletes the interpreter from the system.
- *Call and exit should be compatible with:*

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk:tclInterpreter/1)
- *The following properties should hold at call time:*

  `TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

tcl_event/3: PREDICATE

Usage: `tcl_event(TclInterpreter,Command,Events)`

- *Description:* Evaluates the commands given in `Command` in the Tcl interpreter whose handle is provided in `TclInterpreter`. `Events` is a list of terms stored from Tcl by *prolog_event*. Blocks until there is something on the event queue
- *Call and exit should be compatible with:*

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk:tclInterpreter/1)

  `Command` is a *Tcl* command. (tcltk:tclCommand/1)

  `Events` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Command` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Events` is a free variable. (term_typing:var/1)

tclInterpreter/1: REGTYPE

Usage: `tclInterpreter(I)`

– *Description:* `I` is a reference to a *Tcl* interpreter.

tclCommand/1: REGTYPE

Usage: `tclCommand(C)`

– *Description:* `C` is a *Tcl* command.

tk_event_loop/1: PREDICATE

Usage: `tk_event_loop(TclInterpreter)`

– *Description:* Waits for an event and executes the goal associated to it. Events are stored from Tcl with the *prolog* command. The unified term is sent to the Tcl interpreter in order to obtain the value of the tcl array of *prolog_variables*. If the term received does not have the form `execute(Goal)`, the predicate silently exits. If the execution of `Goal` raises a Prolog error, the interpreter is deleted and an error message is given.

– *Call and exit should be compatible with:*

`TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk:tclInterpreter/1)

– *The following properties should hold at call time:*

`TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

tk_main_loop/1: PREDICATE

Usage: `tk_main_loop(TclInterpreter)`

– *Description:* Passes control to Tk until all windows are gone.

– *Call and exit should be compatible with:*

`TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk:tclInterpreter/1)

– *The following properties should hold at call time:*

`TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

tk_new/2: PREDICATE

Usage: `tk_new(Options,TclInterpreter)`

– *Description:* Performs basic Tcl and Tk initialization and creates the main window of a Tk application.`Options` is a list of optional elements according to:

`name(+ApplicationName)`
: Sets the Tk main window title to `ApplicationName`. It is also used for communicating between Tcl/Tk applications via the Tcl *send* command. Default name is an empty string.

`display(+Display)`
: Gives the name of the screen on which to create the main window. Default is normally determined by the `DISPLAY` environment variable.

`file` Opens the sript `file`. Commands will not be read from standard input and the execution returns back to Prolog only after all windows (and the interpreter) have been deleted.

– *Call and exit should be compatible with:*

`Options` is a list. (basic_props:list/1)

`TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk:tclInterpreter/1)

– *The following properties should hold at call time:*

`Options` is currently a term which is not a free variable. (term_typing:nonvar/1)

`TclInterpreter` is a free variable. (term_typing:var/1)

tk_next_event/2: PREDICATE

Usage: `tk_next_event(TclInterpreter,Event)`

– *Description:* Processes events until there is at least one Prolog event associated with `TclInterpreter`. `Event` is the term correspondig to the head of a queue of events stored from Tcl with the *prolog_event* command.

– *Call and exit should be compatible with:*

`TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk:tclInterpreter/1)

`Event` is a string (a list of character codes). (basic_props:string/1)

– *The following properties should hold at call time:*

`TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Event` is a free variable. (term_typing:var/1)

128 Low level interface library to Tcl/Tk

Author(s): Montse Iglesias Urraca.

The `tcltk_low_level` library defines the low level interface used by the `tcltk` library. Essentially it includes all the code related directly to the handling of sockets and processes. This library should normally not be used directly by user programs, which use `tcltk` instead. On the other hand in some cases it may be useful to undertand how this library works in order to understand possible problems in programs that use the `tcltk` library.

128.1 Usage and interface (`tcltk_low_level`)

- **Library usage:**
  `:- use_module(library(tcltk_low_level)).`
- **Exports:**
  - *Predicates:*
    `new_interp/1`, `new_interp/2`, `new_interp_file/2`, `tcltk/2`, `tcltk_raw_code/2`, `receive_result/2`, `send_term/2`, `receive_event/2`, `receive_list/2`, `receive_confirm/2`, `delete/1`.
- **Other modules used:**
  - *System library modules:*
    `terms`, `sockets/sockets`, `system`, `write`, `read`, `strings`, `format`.

128.2 Documentation on exports (`tcltk_low_level`)

new_interp/1: PREDICATE

Usage: `new_interp(TclInterpreter)`

- *Description:* Creates two sockets to connect to the *wish* process, the term socket and the event socket, and opens a pipe to process *wish* in a new shell.
- *Call and exit should be compatible with:*
  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)
- *The following properties should hold at call time:*
  `TclInterpreter` is a free variable. (term_typing:var/1)

new_interp/2: PREDICATE

Usage: `new_interp(TclInterpreter,Options)`

- *Description:* Creates two sockets, the term socket and the event socket, and opens a pipe to process *wish* in a new shell invoked with the `Options`.
- *Call and exit should be compatible with:*
  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)
  `Options` is currently instantiated to an atom. (term_typing:atom/1)
- *The following properties should hold at call time:*
  `TclInterpreter` is a free variable. (term_typing:var/1)
  `Options` is currently a term which is not a free variable. (term_typing:nonvar/1)

new_interp_file/2: PREDICATE

Usage: `new_interp_file(FileName,TclInterpreter)`

- *Description:* Creates two sockets, the term socket and the event socket, and opens a pipe to process *wish* in a new shell invoked with a `FileName`. `FileName` is treated as a name of a sript file
- *Call and exit should be compatible with:*

  `FileName` is a string (a list of character codes). (basic_props:string/1)

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `TclInterpreter` is a free variable. (term_typing:var/1)

tcltk/2: PREDICATE

Usage: `tcltk(Code,TclInterpreter)`

- *Description:* Sends the `Code` converted to string to the `TclInterpreter`
- *Call and exit should be compatible with:*

  `Code` is a *Tcl* command. (tcltk_low_level:tclCommand/1)

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)
- *The following properties should hold at call time:*

  `Code` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

tcltk_raw_code/2: PREDICATE

Usage: `tcltk_raw_code(String,TclInterpreter)`

- *Description:* Sends the tcltk code items of the `Stream` to the `TclInterpreter`
- *Call and exit should be compatible with:*

  `String` is a string (a list of character codes). (basic_props:string/1)

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)
- *The following properties should hold at call time:*

  `String` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

receive_result/2: PREDICATE

Usage: `receive_result(Result,TclInterpreter)`

- *Description:* Receives the `Result` of the last *TclCommand* into the `TclInterpreter`. If the *TclCommand* is not correct the *wish* process is terminated and a message appears showing the error
- *Call and exit should be compatible with:*

  `Result` is a string (a list of character codes). (basic_props:string/1)

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)

– *The following properties should hold at call time:*

`Result` is a free variable. (term_typing:var/1)

`TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

send_term/2: PREDICATE

Usage: `send_term(String,TclInterpreter)`

– *Description:* Sends the goal executed to the `TclInterpreter`. `String` has the predicate with unified variables

– *Call and exit should be compatible with:*

`String` is a string (a list of character codes). (basic_props:string/1)

`TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)

– *The following properties should hold at call time:*

`String` is currently a term which is not a free variable. (term_typing:nonvar/1)

`TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

receive_event/2: PREDICATE

Usage: `receive_event(Event,TclInterpreter)`

– *Description:* Receives the `Event` from the event socket of the `TclInterpreter`.

– *Call and exit should be compatible with:*

`Event` is a list. (basic_props:list/1)

`TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)

– *The following properties should hold at call time:*

`Event` is a free variable. (term_typing:var/1)

`TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

receive_list/2: PREDICATE

Usage: `receive_list(List,TclInterpreter)`

– *Description:* Receives the `List` from the event socket of the `TclInterpreter`.The `List` has all the predicates that have been inserted from Tcl/Tk with the command prolog_event. It is a list of terms.

– *Call and exit should be compatible with:*

`List` is a list. (basic_props:list/1)

`TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)

– *The following properties should hold at call time:*

`List` is a free variable. (term_typing:var/1)

`TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

receive_confirm/2: PREDICATE

Usage: `receive_confirm(String,TclInterpreter)`

- *Description:* Receives the `String` from the event socket of the `TclInterpreter` when a term inserted into the event queue is managed.
- *Call and exit should be compatible with:*

  `String` is a string (a list of character codes). (basic_props:string/1)

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)
- *The following properties should hold at call time:*

  `String` is a free variable. (term_typing:var/1)

  `TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

delete/1: PREDICATE

Usage: `delete(TclInterpreter)`

- *Description:* Terminates the *wish* process and closes the pipe, term socket and event socket. Deletes the interpreter `TclInterpreter` from the system
- *Call and exit should be compatible with:*

  `TclInterpreter` is a reference to a *Tcl* interpreter. (tcltk_low_level:tclInterpreter/1)
- *The following properties should hold at call time:*

  `TclInterpreter` is currently a term which is not a free variable. (term_typing:nonvar/1)

128.3 Documentation on internals (`tcltk_low_level`)

core/1: PREDICATE

Usage: `core(String)`

- *Description:* `core/1` is a set of facts which contain `String`s to be sent to the Tcl/Tk interpreter on startup. They implement miscelaneous Tcl/Tk procedures which are used by the Tcl/Tk interface.
- *Call and exit should be compatible with:*

  `String` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `String` is a free variable. (term_typing:var/1)

129 The PiLLoW Web programming library

Author(s): Daniel Cabeza, Manuel Hermenegildo, , The Computational logic, Languages, , Implementation, and Parallelism (CLIP) Lab, `http://www.cliplab.org/`, `webmaster@clip.dia.fi.upm.es`, School of CS, T. U. of Madrid (UPM), IMDEA Software Institute.

This package implements the PiLLoW library [CHV96a]. The following three chapters document, respectively, the predicates for HTML/XML/CGI programming, the predicate for HTTP conectivity, and the types used in the definition of the predicates (key for fully understanding the other predicates). You can find a paper and some additional information in the `library/pillow/doc` directory of the distribution, and in the WWW at `http://clip.dia.fi.upm.es/Software/pillow/pillow.html`. There is also a *PiLLoW on-line tutorial* (slides) at `http://clip.dia.fi.upm.es/logalg/slides/C_pillow/C_pillow.html` which illustrates the basic features and provides a number of examples of PiLLoW use.

129.1 Installing PiLLoW

To correctly install PiLLoW, first, make sure you downloaded the right version of PiLLoW (there are different versions for different LP/CLP systems; the version that comes with Ciao is of course the right one for Ciao). Then, please follow these steps:

1. Copy the files in the `images` directory to a WWW accessible directory in your server.
2. Edit the file `icon_address.pl` and change the fact to point to the URL to be used to access the images above.
3. In the Ciao system the files are in the correct place, in other systems copy the files `pillow.pl` and `icon_address.pl` to a suitable directory so that your Prolog system will find them.

129.2 Usage and interface (`pillow_doc`)

- **Library usage:**
  `:- use_package(pillow).`
  or
  `:- module(...,...,[pillow]).`
- **New operators defined:**
  `$/2` [150,xfx], `$/1` [150,fx].
- **Other modules used:**
  - *System library modules:*
    `pillow/http`, `pillow/html`.

130 HTML/XML/CGI programming

Author(s): Daniel Cabeza, Manuel Hermenegildo, Sacha Varma.

This module implements the predicates of the PiLLoW package related to HTML/ XML generation and parsing, CGI and form handlers programming, and in general all the predicates which do not imply the use of the HTTP protocol.

130.1 Usage and interface (`html`)

- **Library usage:**
  `:- use_module(library(html)).`
- **Exports:**
  - *Predicates:*
    `output_html/1`, `html2terms/2`, `xml2terms/2`, `html_template/3`, `html_report_error/1`, `get_form_input/1`, `get_form_value/3`, `form_empty_value/1`, `form_default/3`, `set_cookie/2`, `get_cookies/1`, `url_query/2`, `url_query_amp/2`, `url_query_values/2`, `my_url/1`, `url_info/2`, `url_info_relative/3`, `form_request_method/1`, `icon_address/2`, `html_protect/1`, `http_lines/3`.
  - *Multifiles:*
    `define_flag/3`, `html_expansion/2`.
- **Other modules used:**
  - *System library modules:*
    `strings`, `lists`, `system`, `read`, `pillow/pillow_aux`, `pillow/pillow_types`, `format`, `streams`, `file_utils`.

130.2 Documentation on exports (`html`)

output_html/1: PREDICATE

`output_html(HTMLTerm)`

Outputs `HTMLTerm`, interpreted as an `html_term/1`, to current output stream.

Usage:

- *The following properties should hold at call time:*
  `HTMLTerm` is a term representing HTML code. (pillow_types:html_term/1)

html2terms/2: PREDICATE

`html2terms(String,Terms)`

`String` is a character list containing HTML code and `Terms` is its prolog structured representation.

Usage 1:

- *Description:* Translates an HTML-term into the HTML code it represents.
- *The following properties should hold at call time:*
  `String` is a free variable. (term_typing:var/1)
  `Terms` is a term representing HTML code. (pillow_types:html_term/1)

– *The following properties hold upon exit:*

`String` is a string (a list of character codes). (basic_props:string/1)

Usage 2:

– *Description:* Translates HTML code into a structured HTML-term.

– *Calls should, and exit will be compatible with:*

`Terms` is a term representing HTML code in canonical form. (pillow_types:canonic_html_term/1)

– *The following properties should hold at call time:*

`String` is a string (a list of character codes). (basic_props:string/1)

– *The following properties hold upon exit:*

`Terms` is a term representing HTML code in canonical form. (pillow_types:canonic_html_term/1)

xml2terms/2: PREDICATE

`xml2terms(String,Terms)`

`String` is a character list containing XML code and `Terms` is its prolog structured representation.

Usage 1:

– *Description:* Translates a XML-term into the XML code it represents.

– *The following properties should hold at call time:*

`String` is a free variable. (term_typing:var/1)

`Terms` is a term representing HTML code. (pillow_types:html_term/1)

– *The following properties hold upon exit:*

`String` is a string (a list of character codes). (basic_props:string/1)

Usage 2:

– *Description:* Translates XML code into a structured XML-term.

– *Calls should, and exit will be compatible with:*

`Terms` is a term representing XML code in canonical form. (pillow_types:canonic_xml_term/1)

– *The following properties should hold at call time:*

`String` is a string (a list of character codes). (basic_props:string/1)

– *The following properties hold upon exit:*

`Terms` is a term representing XML code in canonical form. (pillow_types:canonic_xml_term/1)

html_template/3: PREDICATE

`html_template(Chars,Terms,Dict)`

Interprets `Chars` as an HTML template returning in `Terms` the corresponding structured HTML-term, which includes variables, and unifying `Dict` with a dictionary of those variables (an incomplete list of *name*=*Var* pairs). An HTML template is standard HTML code, but in which "slots" can be defined and given an identifier. These slots represent parts of the HTML code in which other HTML code can be inserted, and are represented in the HTML-term as free variables. There are two kinds of variables in templates:

- Variables representing page contents. A variable with name *name* is defined with the special tag `<V>`*name*`</V>`.
- Variables representing tag attributes. They occur as an attribute or an attribute value starting with `_`, followed by its name, which must be formed by alphabetic characters.

As an example, suposse the following HTML template:

```
<html>
<body bgcolor=_bgcolor>
<v>content</v>
</body>
</html>
```

The following query in the Ciao toplevel shows how the template is parsed, and the dictionary returned:

```
?- file_to_string('template.html',_S), html_template(_S,Terms,Dict).

Dict = [bgcolor=_A,content=_B|_],
Terms = [env(html,[],["
",env(body,[bgcolor=_A],["
",_B,"
"]),"
"]),"
"] ?

yes
```

If a dictionary with values is supplied at call time, then variables are unified accordingly inside the template:

```
?- file_to_string('template.html',_S),
   html_template(_S,Terms,[content=b("hello world!"),bgcolor="white"]).

Terms = [env(html,[],["
",env(body,[bgcolor="white"],["
",b("hello world!"),"
"]),"
"]),"
"] ?

yes
```

Usage:

– *Calls should, and exit will be compatible with:*

`Terms` is a term representing HTML code in canonical form. (pillow_types:canonic_html_term/1)

`Dict` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Chars` is a string (a list of character codes). (basic_props:string/1)

– *The following properties hold upon exit:*

`Terms` is a term representing HTML code in canonical form. (pillow_types:canonic_html_term/1)

`Dict` is a list. (basic_props:list/1)

html_report_error/1: PREDICATE

Usage: `html_report_error(Error)`

– *Description:* Outputs error `Error` as a standard HTML page.

get_form_input/1: PREDICATE

`get_form_input(Dict)`

Translates input from the form (with either the POST or GET methods, and even with CONTENT_TYPE multipart/form-data) to a dictionary `Dict` of *attribute=value* pairs. If the flag `raw_form_values` is `off` (which is the default state), it translates empty values (which indicate only the presence of an attribute) to the atom `'$empty'`, values with more than one line (from text areas or files) to a list of lines as strings, the rest to atoms or numbers (using `name/2`). If the flag `on`, it gives all values as atoms, without translations.

Usage:

– *The following properties should hold at call time:*

`Dict` is a free variable. (term_typing:var/1)

– *The following properties hold upon exit:*

`Dict` is a dictionary of values of the attributes of a form. It is a list of `form_assignment` (pillow_types:form_dict/1)

get_form_value/3: PREDICATE

`get_form_value(Dict,Var,Val)`

Unifies `Val` with the value for attribute `Var` in dictionary `Dict`. Does not fail: value is `''` if not found (this simplifies the programming of form handlers when they can be accessed directly).

Usage:

– *Calls should, and exit will be compatible with:*

`Val` is a value of an attribute of a form. (pillow_types:form_value/1)

– *The following properties should hold at call time:*

`Dict` is a dictionary of values of the attributes of a form. It is a list of `form_assignment` (pillow_types:form_dict/1)

`Var` is an atom. (basic_props:atm/1)

– *The following properties hold upon exit:*

`Val` is a value of an attribute of a form. (pillow_types:form_value/1)

form_empty_value/1: PREDICATE

Usage: `form_empty_value(Term)`

– *Description:* Checks that `Term`, a value comming from a text area is empty (can have spaces, newlines and linefeeds).

form_default/3: PREDICATE

Usage: `form_default(Val,Default,NewVal)`

– *Description:* Useful when a form is only partially filled, or when the executable can be invoked either by a link or by a form, to set form defaults. If the value of `Val` is empty then `NewVal=Default`, else `NewVal=Val`.
– *The following properties should hold at call time:*

`Val` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Default` is currently a term which is not a free variable. (term_typing:nonvar/1)

`NewVal` is a free variable. (term_typing:var/1)

set_cookie/2: PREDICATE

`set_cookie(Name,Value)`

Sets a cookie of name `Name` and value `Value`. Must be invoked before outputting any data, including the `cgi_reply` html-term.

Usage:

– *The following properties should hold at call time:*

`Name` is an atom. (basic_props:atm/1)

`Value` is an atomic term (an atom or a number). (basic_props:constant/1)

get_cookies/1: PREDICATE

`get_cookies(Cookies)`

Unifies `Cookies` with a dictionary of *attribute=value* pairs of the active cookies for this URL. If the flag `raw_form_values` is `on`, *value*s are always atoms even if they could be interpreted as numbers.

Usage:

– *The following properties should hold at call time:*

`Cookies` is a free variable. (term_typing:var/1)

– *The following properties hold upon exit:*

`Cookies` is a dictionary of values. It is a list of pairs *atom=constant*. (pillow_types:value_dict/1)

url_query/2: PREDICATE

`url_query(Dict,URLArgs)`

(Deprecated, see `url_query_values/2`) Translates a dictionary `Dict` of parameter values into a string `URLArgs` for appending to a URL pointing to a form handler.

Usage:

– *The following properties should hold at call time:*

`Dict` is a dictionary of values. It is a list of pairs *atom=constant*. (pillow_types:value_dict/1)

`URLArgs` is a free variable. (term_typing:var/1)

– *The following properties hold upon exit:*

`URLArgs` is a string (a list of character codes). (basic_props:string/1)

url_query_amp/2: PREDICATE

`url_query_amp(Dict,URLArgs)`

Translates a dictionary `Dict` of parameter values into a string `URLArgs` for appending to a URL pointing to a form handler to be used in the href of a link (uses & instead of &).

Usage:

- *The following properties should hold at call time:*

  `Dict` is a dictionary of values. It is a list of pairs *atom=constant*. (pillow_types:value_dict/1)

  `URLArgs` is a free variable. (term_typing:var/1)

- *The following properties hold upon exit:*

  `URLArgs` is a string (a list of character codes). (basic_props:string/1)

url_query_values/2: PREDICATE

`url_query_values(Dict,URLArgs)`

`Dict` is a dictionary of parameter values and `URLArgs` is the URL-encoded string of those assignments, which may appear after an URL pointing to a CGI script preceded by a '?'. `Dict` is computed according to the `raw_form_values` flag. The use of this predicate is reversible.

Usage 1:

- *The following properties should hold at call time:*

  `Dict` is a dictionary of values. It is a list of pairs *atom=constant*. (pillow_types:value_dict/1)

  `URLArgs` is a free variable. (term_typing:var/1)

- *The following properties hold upon exit:*

  `URLArgs` is a string (a list of character codes). (basic_props:string/1)

Usage 2:

- *The following properties should hold at call time:*

  `Dict` is a free variable. (term_typing:var/1)

  `URLArgs` is a string (a list of character codes). (basic_props:string/1)

- *The following properties hold upon exit:*

  `Dict` is a dictionary of values. It is a list of pairs *atom=constant*. (pillow_types:value_dict/1)

my_url/1: PREDICATE

`my_url(URL)`

Unifies `URL` with the Uniform Resource Locator (WWW address) of this cgi executable.

Usage:

- *Calls should, and exit will be compatible with:*

  `URL` is a string (a list of character codes). (basic_props:string/1)

- *The following properties hold upon exit:*

  `URL` is a string (a list of character codes). (basic_props:string/1)

url_info/2: PREDICATE

`url_info(URL,URLTerm)`

Translates a URL `URL` to a Prolog structure `URLTerm` which details its various components, and vice-versa. For now non-HTTP URLs make the predicate fail.

Usage 1:

- *Calls should, and exit will be compatible with:*
  `URLTerm` specifies a URL. (pillow_types:url_term/1)
- *The following properties should hold at call time:*
  `URL` is an atom. (basic_props:atm/1)
- *The following properties hold upon exit:*
  `URLTerm` specifies a URL. (pillow_types:url_term/1)

Usage 2:

- *Calls should, and exit will be compatible with:*
  `URLTerm` specifies a URL. (pillow_types:url_term/1)
- *The following properties should hold at call time:*
  `URL` is a string (a list of character codes). (basic_props:string/1)
- *The following properties hold upon exit:*
  `URLTerm` specifies a URL. (pillow_types:url_term/1)

Usage 3:

- *The following properties should hold at call time:*
  `URL` is a free variable. (term_typing:var/1)
  `URLTerm` specifies a URL. (pillow_types:url_term/1)
- *The following properties hold upon exit:*
  `URL` is a string (a list of character codes). (basic_props:string/1)

url_info_relative/3: PREDICATE

`url_info_relative(URL,BaseURLTerm,URLTerm)`

Translates a relative URL `URL` which appears in the HTML page refered to by `BaseURLTerm` into `URLTerm`, a Prolog structure containing its absolute parameters. Absolute URLs are translated as with `url_info/2`. E.g.

```
url_info_relative("dadu.html",
                  http('www.foo.com',80,"/bar/scoob.html"), Info)
```

gives `Info = http('www.foo.com',80,"/bar/dadu.html")`.

Usage 1:

- *Calls should, and exit will be compatible with:*
  `URLTerm` specifies a URL. (pillow_types:url_term/1)
- *The following properties should hold at call time:*
  `URL` is an atom. (basic_props:atm/1)
  `BaseURLTerm` specifies a URL. (pillow_types:url_term/1)
- *The following properties hold upon exit:*
  `URLTerm` specifies a URL. (pillow_types:url_term/1)

Usage 2:

– *Calls should, and exit will be compatible with:*
`URLTerm` specifies a URL. (pillow_types:url_term/1)
– *The following properties should hold at call time:*
`URL` is a string (a list of character codes). (basic_props:string/1)
`BaseURLTerm` specifies a URL. (pillow_types:url_term/1)
– *The following properties hold upon exit:*
`URLTerm` specifies a URL. (pillow_types:url_term/1)

form_request_method/1: PREDICATE

Usage: `form_request_method(Method)`

– *Description:* Unifies `Method` with the method of invocation of the form handler (`GET` or `POST`).
– *The following properties hold upon exit:*
`Method` is an atom. (basic_props:atm/1)

icon_address/2: PREDICATE

`icon_address(Img,IAddress)`

The PiLLoW image `Img` has URL `IAddress`.

Usage:

– *Calls should, and exit will be compatible with:*
`Img` is an atom. (basic_props:atm/1)
`IAddress` is an atom. (basic_props:atm/1)
– *The following properties hold upon exit:*
`Img` is an atom. (basic_props:atm/1)
`IAddress` is an atom. (basic_props:atm/1)

html_protect/1: PREDICATE

`html_protect(Goal)`

Calls `Goal`. If an error occurs during its execution, or it fails, an HTML page is output informing about the incident. Normaly the whole execution of a CGI is protected thus.

Meta-predicate with arguments: `html_protect(goal)`.

Usage:

– *The following properties should hold at call time:*
`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

http_lines/3: PREDICATE

Usage: `http_lines(Lines,String,Tail)`

– *Description:* `Lines` is a list of the lines with occur in `String` until `Tail`. The lines may end UNIX-style or DOS-style in `String`, in `Lines` they have not end of line characters. Suitable to be used in DCGs.

– *Calls should, and exit will be compatible with:*
`Lines` is a list of `strings`. (basic_props:list/2)
`String` is a string (a list of character codes). (basic_props:string/1)
`Tail` is a string (a list of character codes). (basic_props:string/1)

130.3 Documentation on multifiles (`html`)

define_flag/3: PREDICATE

Defines a flag as follows:

```
define_flag(raw_form_values,[on,off],off).
```

(See Chapter 24 [Changing system behaviour and various flags], page 181).

If flag is `on`, values returned by `get_form_input/1` are always atoms, unchanged from its original value.

The predicate is *multifile*.

Usage: `define_flag(Flag,FlagValues,Default)`

– *The following properties hold upon exit:*
`Flag` is an atom. (basic_props:atm/1)
Define the valid flag values (basic_props:flag_values/1)

html_expansion/2: PREDICATE

The predicate is *multifile*.

Usage: `html_expansion(Term,Expansion)`

– *Description:* Hook predicate to define macros. Expand occurrences of `Term` into `Expansion`, in `output_html/1`. Take care to not transform something into itself!

130.4 Other information (`html`)

The code uses input from from L. Naish's forms and Francisco Bueno's previous Chat interface. Other people who have contributed are (please inform us if we leave out anybody): Markus Fromherz, Samir Genaim.

131 HTTP conectivity

Author(s): Daniel Cabeza.

This module implements the HTTP protocol, which allows retrieving data from HTTP servers.

131.1 Usage and interface (`http`)

- **Library usage:**
  `:- use_module(library(http)).`
- **Exports:**
  - *Predicates:*
    `fetch_url/3`.
- **Other modules used:**
  - *System library modules:*
    `strings`, `lists`, `pillow/pillow_aux`, `pillow/pillow_types`, `pillow/http_ll`.

131.2 Documentation on exports (`http`)

fetch_url/3: PREDICATE

`fetch_url(URL,Request,Response)`

Fetches the document pointed to by `URL` from Internet, using request parameters `Request`, and unifies `Response` with the parameters of the response. Fails on timeout. Note that redirections are not handled automatically, that is, if `Response` contains terms of the form `status(redirection,301,_)` and `location(NewURL)`, the program should in most cases access location `NewURL`.

Usage: `fetch_url(URL,Request,Response)`

- *The following properties should hold at call time:*
  `URL` specifies a URL. (pillow_types:url_term/1)
  `Request` is a list of `http_request_param`s. (basic_props:list/2)
- *The following properties hold upon exit:*
  `Response` is a list of `http_response_param`s. (basic_props:list/2)

132 PiLLoW types

Author(s): Daniel Cabeza.

Here are defined the regular types used in the documentation of the predicates of the PiLLoW package.

132.1 Usage and interface (pillow_types)

- **Library usage:**
  `:- use_module(library(pillow_types)).`
- **Exports:**
  - *Regular Types:*
    `canonic_html_term/1`, `canonic_xml_term/1`, `html_term/1`, `form_dict/1`, `form_assignment/1`, `form_value/1`, `value_dict/1`, `url_term/1`, `http_request_param/1`, `http_response_param/1`, `http_date/1`, `weekday/1`, `month/1`, `hms_time/1`.

132.2 Documentation on exports (pillow_types)

canonic_html_term/1: REGTYPE

A term representing HTML code in canonical, structured way. It is a list of terms defined by the following predicate:

```
canonic_html_item(comment(S)) :-
        string(S).
canonic_html_item(declare(S)) :-
        string(S).
canonic_html_item(env(Tag,Atts,Terms)) :-
        atm(Tag),
        list(Atts,tag_attrib),
        canonic_html_term(Terms).
canonic_html_item(Tag$Atts) :-
        atm(Tag),
        list(Atts,tag_attrib).
canonic_html_item(S) :-
        string(S).
tag_attrib(Att) :-
        atm(Att).
tag_attrib(Att=Val) :-
        atm(Att),
        string(Val).
```

Each structure represents one HTML construction:

env(*tag*,*attribs*,*terms*)
: An HTML environment, with name *tag*, list of attributes *attribs* and contents *terms*.

$(*tag*,*attribs*)
: An HTML element of name *tag* and list of attributes *attribs*. `($)/2` is defined by the pillow package as an infix, binary operator.

comment(*string***)**
An HTML comment (translates to/from `<!--`*string*`-->`).

declare(*string***)**
An HTML declaration, they are used only in the header (translates to/from `<!`*string*`>`).

string Normal text is represented as a list of character codes.

For example, the term

```
env(a,[href="www.therainforestsite.com"],
      ["Visit ",img$[src="TRFS.gif"]])
```

is output to (or parsed from):

```
<a href="www.therainforestsite.com">Visit <img src="TRFS.gif"></a>
```

Usage: `canonic_html_term(HTMLTerm)`

– *Description:* `HTMLTerm` is a term representing HTML code in canonical form.

canonic_xml_term/1: REGTYPE

A term representing XML code in canonical, structured way. It is a list of terms defined by the following predicate (see `tag_attrib/1` definition in `canonic_html_term/1`):

```
canonic_xml_item(Term) :-
        canonic_html_item(Term).
canonic_xml_item(xmldecl(Atts)) :-
        list(Atts,tag_attrib).
canonic_xml_item(env(Tag,Atts,Terms)) :-
        atm(Tag),
        list(Atts,tag_attrib),
        canonic_xml_term(Terms).
canonic_xml_item(elem(Tag,Atts)) :-
        atm(Tag),
        list(Atts,tag_attrib).
```

In addition to the structures defined by `canonic_html_term/1` (the `($)/2` structure appears only in malformed XML code), the following structures can be used:

elem(*tag***,***atts***)**
Specifies an XML empty element of name *tag* and list of attributes *atts*. For example, the term

```
elem(arc,[weigh="3",begin="n1",end="n2"])
```

is output to (or parsed from):

```
<arc weigh="3" begin="n1" end="n2"/>
```

xmldecl(*atts***)**
Specifies an XML declaration with attributes *atts* (translates to/from `<?xml` *atts*`?>`)

Usage: `canonic_xml_term(XMLTerm)`

– *Description:* `XMLTerm` is a term representing XML code in canonical form.

html_term/1: REGTYPE

A term which represents HTML or XML code in a structured way. In addition to the structures defined by `canonic_html_term/1` or `canonic_xml_term/1`, the following structures can be used:

begin(*tag*,*atts*)
: It translates to the start of an HTML environment of name *tag* and attributes *atts*. There exists also a **begin**(*tag*) structure. Useful, in conjunction with the next structure, when including in a document output generated by an existing piece of code (e.g. *tag* = `pre`). Its use is otherwise discouraged.

end(*tag*) Translates to the end of an HTML environment of name *tag*.

start Used at the beginning of a document (translates to `<html>`).

end Used at the end of a document (translates to `</html>`).

`--` Produces a horizontal rule (translates to `<hr>`).

`\\` Produces a line break (translates to `<br>`).

$ Produces a paragraph break (translates to `<p>`).

image(*address*)
: Used to include an image of address (URL) *address* (equivalent to `img$[src=`*address*`]`).

image(*address*,*atts*)
: As above with the list of attributes *atts*.

ref(*address*,*text*)
: Produces a hypertext link, *address* is the URL of the referenced resource, *text* is the text of the reference (equivalent to `a([href=`*address*`],`*text*`)`).

label(*name*,*text*)
: Labels *text* as a target destination with label *name* (equivalent to `a([name=`*name*`],`*text*`)`).

heading(*n*,*text*)
: Produces a heading of level *n* (between 1 and 6), *text* is the text to be used as heading. Useful when one wants a heading level relative to another heading (equivalent to `h`*n*`(`*text*`)`).

itemize(*items*)
: Produces a list of bulleted items, *items* is a list of corresponding HTML terms (translates to a `<ul>` environment).

enumerate(*items*)
: Produces a list of numbered items, *items* is a list of corresponding HTML terms (translates to a `<ol>` environment).

description(*defs*)
: Produces a list of defined items, *defs* is a list whose elements are definitions, each of them being a Prolog sequence (composed by `','/2` operators). The last element of the sequence is the definition, the other (if any) are the defined terms (translates to a `<dl>` environment).

nice_itemize(*img*,*items*)
: Produces a list of bulleted items, using the image *img* as bullet. The predicate `icon_address/2` provides a colored bullet.

preformatted(*text*)
Used to include preformatted text, *text* is a list of HTML terms, each element of the list being a line of the resulting document (translates to a `<pre>` environment).

verbatim(*text*)
Used to include text verbatim, special HTML characters (`<,>,&,"` and space) are translated into its quoted HTML equivalent.

prolog_term(*term*)
Includes any prolog term *term*, represented in functional notation. Variables are output as `_`.

nl Used to include a newline in the HTML source (just to improve human readability).

entity(*name*)
Includes the entity of name *name* (ISO-8859-1 special character).

start_form(*addr*,*atts*)
Specifies the beginning of a form. *addr* is the address (URL) of the program that will handle the form, and *atts* other attributes of the form, as the method used to invoke it. If *atts* is not present (there is only one argument) the method defaults to POST.

start_form Specifies the beginning of a form without assigning address to the handler, so that the form handler will be the cgi-bin executable producing the form.

end_form Specifies the end of a form.

checkbox(*name*,*state*)
Specifies an input of type `checkbox` with name *name*, *state* is `on` if the checkbox is initially checked.

radio(*name*,*value*,*selected*)
Specifies an input of type `radio` with name *name* (several radio buttons which are interlocked must share their name), *value* is the the value returned by the button, if *selected*=*value* the button is initially checked.

input(*type*,*atts*)
Specifies an input of type *type* with a list of attributes *atts*. Possible values of *type* are `text`, `hidden`, `submit`, `reset`, ldots

textinput(*name*,*atts*,*text*)
Specifies an input text area of name *name*. *text* provides the default text to be shown in the area, *atts* a list of attributes.

option(*name*,*val*,*options*)
Specifies a simple option selector of name *name*, *options* is the list of available options and *val* is the initial selected option (if *val* is not in *options* the first item is selected by default) (translates to a `<select>` environment).

menu(*name*,*atts*,*items*)
Specifies a menu of name *name*, list of attributes *atts* and list of options *items*. The elements of the list *items* are marked with the prefix operator `$` to indicate that they are selected (translates to a `<select>` environment).

form_reply

cgi_reply This two are equivalent, they do not generate HTML, rather, the CGI protocol requires this content descriptor to be used at the beginning by CGI executables (including form handlers) when replying (translates to `Content-type: text/html`).

pr Includes in the page a graphical logo with the message "Developed using the PiLLoW Web programming library", which points to the manual and library source.

name(*text*)
A term with functor *name*/1, different from the special functors defined herein, represents an HTML environment of name *name* and included text *text*. For example, the term

```
address('clip@clip.dia.fi.upm.es')
```

is translated into the HTML source

```
<address>clip@clip.dia.fi.upm.es</address>
```

name(*atts*,*text*)
A term with functor *name*/2, different from the special functors defined herein, represents an HTML environment of name *name*, attributes *atts* and included text *text*. For example, the term

```
a([href='http://www.clip.dia.fi.upm.es/'],"Clip home")
```

represents the HTML source

```
<a href="http://www.clip.dia.fi.upm.es/">Clip home</a>
```

Usage: `html_term(HTMLTerm)`
– *Description:* `HTMLTerm` is a term representing HTML code.

form_dict/1: REGTYPE

Usage: `form_dict(Dict)`
– *Description:* `Dict` is a dictionary of values of the attributes of a form. It is a list of `form_assignment`

form_assignment/1: REGTYPE

Usage: `form_assignment(Eq)`
– *Description:* `Eq` is an assignment of value of an attribute of a form. It is defined by:

```
form_assignment(A=V) :-
        atm(A),
        form_value(V).
form_value(A) :-
        atm(A).
form_value(N) :-
        num(N).
form_value(L) :-
        list(L,string).
```

form_value/1: REGTYPE

Usage: `form_value(V)`
– *Description:* `V` is a value of an attribute of a form.

value_dict/1: REGTYPE

Usage: `value_dict(Dict)`

– *Description:* `Dict` is a dictionary of values. It is a list of pairs *atom=constant*.

url_term/1: REGTYPE

A term specifying an Internet Uniform Resource Locator. Currently only HTTP URLs are supported. Example: `http('www.clip.dia.fi.upm.es',80,"/Software/Ciao/")`. Defined as

```
url_term(http(Host,Port,Document)) :-
        atm(Host),
        int(Port),
        string(Document).
```

Usage: `url_term(URL)`

– *Description:* `URL` specifies a URL.

http_request_param/1: REGTYPE

A parameter of an HTTP request:

- **head:** Specify that the document content is not wanted.
- **timeout(*T*):** *T* specifies the time in seconds to wait for the response. Default is 300 seconds.
- **if_modified_since(*Date*):** Get document only if newer than *Date*. *Date* has the format defined by `http_date/1`.
- **user_agent(*Agent*):** Provides a user-agent field, *Agent* is an atom. The string `"PiLLoW/1.1"` (or whatever version of PiLLoW is used) is appended.
- **authorization(*Scheme*,*Params*):** To provide credentials. See RFC 1945 for details.
- *option*(*Value*)**:** Any unary term, being *Value* an atom, can be used to provide another valid option (e.g. `from('user@machine')`).

Usage: `http_request_param(Request)`

– *Description:* `Request` is a parameter of an HTTP request.

http_response_param/1: REGTYPE

A parameter of an HTTP response:

- **content(*String*):** *String* is the document content (list of bytes). If the `head` parameter of the HTTP request is used, an empty list is get here.
- **status(*Type,Code,Reason*):** *Type* is an atom denoting the response type, *Code* is the status code (an integer), and *Reason* is a string holding the reason phrase.
- **message_date(*Date*):** *Date* is the date of the response, with format defined by `http_date/1`.
- **location(*Loc*):** This parameter appears when the document has moved, *Loc* is an atom holding the new location.
- **http_server(*Server*):** *Server* is the server responding, as a string.
- **authenticate(*Params*):** Returned if document is protected, *Params* is a list of chagenges. See RFC 1945 for details.
- **allow(*Methods*):** *Methods* are the methods allowed by the server, as a list of atoms.

- **content_encoding(***Encoding***):** *Encoding* is an atom defining the encoding.
- **content_length(***Length***):** *Length* is the length of the document (an integer).
- **content_type(***Type,Subtype,Params***):** Specifies the document content type, *Type* and *Subtype* are atoms, *Params* a list of parameters (e.g. `content_type(text,html,[])`).
- **expires(***Date***):** *Date* is the date after which the entity should be considered stale. Format defined by `http_date/1`.
- **last_modified(***Date***):** *Date* is the date at which the sender believes the resource was last modified. Format defined by `http_date/1`.
- **pragma(***String***):** Miscellaneous data.
- *header***(***String***):** Any other functor *header*/1 is an extension header.

Usage: `http_response_param(Response)`

– *Description:* `Response` is a parameter of an HTTP response.

http_date/1: REGTYPE

`http_date(Date)`

`Date` is a term defined as

```
http_date(date(WeekDay,Day,Month,Year,Time)) :-
        weekday(WeekDay),
        int(Day),
        month(Month),
        int(Year),
        hms_time(Time).
```

.

Usage: `http_date(Date)`

– *Description:* `Date` is a term denoting a date.

weekday/1: REGTYPE

Usage: `weekday(WeekDay)`

– *Description:* `WeekDay` is a term denoting a weekday.

month/1: REGTYPE

Usage: `month(Month)`

– *Description:* `Month` is a term denoting a month.

hms_time/1: REGTYPE

Usage: `hms_time(Time)`

– *Description:* `Time` is an atom of the form `hh:mm:ss`

133 Persistent predicate database

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133.1 Introduction to persistent predicates

This library implements a *generic persistent predicate database*. The basic notion implemented by the library is that of a persistent predicate. The persistent predicate concept provides a simple, yet powerful generic persistent data access method [CHGT98,Par97]. A persistent predicate is a special kind of dynamic, data predicate that "resides" in some persistent medium (such as a set of files, a database, etc.) that is typically external to the program using such predicates. The main effect is that any changes made to a persistent predicate from a program "survive" across executions. I.e., if the program is halted and restarted the predicate that the new process sees is in precisely the same state as it was when the old process was halted (provided no change was made in the meantime to the storage by other processes or the user).

Persistent predicates appear to a program as ordinary predicates, and calls to these predicates can appear in clause bodies in the usual way. However, the definitions of these predicates do not appear in the program. Instead, the library maintains automatically the definitions of predicates which have been declared as persistent in the persistent storage.

Updates to persistent predicates can be made using enhanced versions of `asserta_fact/1`, `assertz_fact/1` and `retract_fact/1`. The library makes sure that each update is a transactional update, in the sense that if the update terminates, then the permanent storage has definitely been modified. For example, if the program making the updates is halted just after the update and then restarted, then the updated state of the predicate will be seen. This provides security against possible data loss due to, for example, a system crash. Also, due to the atomicity of the transactions, persistent predicates allow concurrent updates from several programs.

133.2 Persistent predicates, files, and relational databases

The concept of persistent predicates provided by this library essentially implements a lightweight, simple, and at the same time powerful form of relational database (a deductive database), and which is standalone, in the sense that it does not require external support, other than the file management capabilities provided by the operating system. This is due to the fact that the persistent predicates are in fact stored in one or more auxiliary files below a given directory.

This type of database is specially useful when building small to medium-sized standalone applications in Prolog which require persistent storage. In many cases it provides a much easier way of implementing such storage than using files under direct program control. For example, interactive applications can use persistent predicates to represent their internal state in a way that is close to the application. The persistence of such predicates then allows automatically restoring the state to that at the end of a previous session. Using persistent predicates amounts to simply declaring some predicates as such and eliminates having to worry about opening files, closing them, recovering from system crashes, etc.

In other cases, however, it may be convenient to use a relational database as persistent storage. This may be the case, for example, when the data already resides in such a database (where it is perhaps accessed also by other applications) or the volume of data is very large. `persdb_sql` [CCG98] is a companion library which implements the same notion of persistent predicates used herein, but keeping the storage in a relational database. This provides a very natural and transparent way to access SQL database relations from a Prolog program. In that library, facilities are also provided for reflecting more complex *views* of the database relations

as predicates. Such views can be constructed as conjunctions, disjunctions, projections, etc. of database relations, and may include SQL-like aggregation operations.

A nice characteristic of the notion of persistent predicates used in both of these libraries is that it abstracts away how the predicate is actually stored. Thus, a program can use persistent predicates stored in files or in external relational databases interchangeably, and the type of storage used for a given predicate can be changed without having to modify the program (except for replacing the corresponding `persistent/2` declarations).

An example application of the `persdb` and `persdb_sql` libraries (and also the `pillow` library [CH97]), is `WebDB` [GCH98]. `WebDB` is a generic, highly customizable *deductive database engine* with an *html interface*. `WebDB` allows creating and maintaining Prolog-based databases as well as relational databases (residing in conventional relational database engines) using any standard WWW browser.

133.3 Using file-based persistent predicates

Persistent predicates can be declared statically, using `persistent/2` declarations (which is the preferred method, when possible), or dynamically via calls to `make_persistent/2`. Currently, persistent predicates may only contain facts, i.e., they are *dynamic* predicates of type `data/1`.

Predicates declared as persistent are linked to directory, and the persistent state of the predicate will be kept in several files below that directory. The files in which the persistent predicates are stored are in readable, plain ASCII format, and in Prolog syntax. One advantage of this approach is that such files can also be created or edited by hand, in a text editor, or even by other applications.

An example definition of a persistent predicate implemented by files follows:

```
:- persistent(p/3,dbdir).

persistent_dir(dbdir, '/home/clip/public_html/db').
```

The first line declares the predicate `p/3` persistent. The argument `dbdir` is a key used to index into a fact of the relation `persistent_dir/2-4`, which specifies the directory where the corresponding files will be kept. The effect of the declaration, together with the `persistent_dir/2-4` fact, is that, although the predicate is handled in the same way as a normal data predicate, in addition the system will create and maintain efficiently a persistent version of `p/3` via files in the directory `/home/clip/public_html/db`.

The level of indirection provided by the `dbdir` argument makes it easy to place the storage of several persistent predicates in a common directory, by specifying the same key for all of them. It also allows changing the directory for several such persistent predicates by modifying only one fact in the program. Furthermore, the `persistent_dir/2-4` predicate can even be dynamic and specified at run-time.

133.4 Implementation Issues

We outline the current implementation approach. This implementation attempts to provide at the same time efficiency and security. To this end, up to three files are used for each predicate (the persistence set): the data file, the operations file, and the backup file. In the updated state the facts (tuples) that define the predicate are stored in the data file and the operations file is empty (the backup file, which contains a security copy of the data file, may or may not exist).

While a program using a persistent predicate is running, any insertion (assert) or deletion (retract) operations on the predicate are performed on both the program memory and on the persistence set. However, in order to incurr only a small overhead in the execution, rather than changing the data file directly, a record of each of the insertion and deletion operations is

appended to the operations file. The predicate is then in a transient state, in that the contents of the data file do not reflect exactly the current state of the corresponding predicate. However, the complete persistence set does.

When a program starts, all pending operations in the operations file are performed on the data file. A backup of the data file is created first to prevent data loss if the system crashes during this operation. The order in which this updating of files is done ensures that, if at any point the process dies, on restart the data will be completely recovered. This process of updating the persistence set can also be triggered at any point in the execution of the program (for example, when halting) by calling `update_files`.

133.5 Defining an initial database

It is possible to define an initial database by simply including in the program code facts of persistent predicates. They will be included in the persistent database when it is created. They are ignored in successive executions.

133.6 Using persistent predicates from the top level

Special care must be taken when loading into the top level modules or user files which use persistent predicates. Beforehand, a goal `use_module(library(persdb(persdbrt)))` must be issued. Furthermore, since persistent predicates defined by the loaded files are in this way defined dynamically, a call to `initialize_db/0` is commonly needed after loading and before calling predicates of these files.

133.7 Usage and interface (`persdbrt`)

- **Library usage:**
  There are two packages which implement persistence: `persdb` and `'persdb/ll'` (for low level). In the first, the standard builtins `asserta_fact/1`, `assertz_fact/1`, and `retract_fact/1` are replaced by new versions which handle persistent data predicates, behaving as usual for normal data predicates. In the second package, predicates with names starting with `p` are defined, so that there is no overhead in calling the standard builtins. In any case, each package is used as usual: including it in the package list of the module, or using the `use_package/1` declaration.
- **Exports:**
  - *Predicates:*
    `passerta_fact/1`, `passertz_fact/1`, `pretract_fact/1`, `pretractall_fact/1`, `asserta_fact/1`, `assertz_fact/1`, `retract_fact/1`, `retractall_fact/1`, `initialize_db/0`, `make_persistent/2`, `update_files/0`, `update_files/1`, `create/2`.
  - *Regular Types:*
    `meta_predname/1`, `directoryname/1`.
  - *Multifiles:*
    `$is_persistent/2`, `persistent_dir/2`, `persistent_dir/4`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `read`, `aggregates`, `system`, `file_locks/file_locks`, `persdb/persdbcache`.

133.8 Documentation on exports (persdbrt)

passerta_fact/1: PREDICATE

Meta-predicate with arguments: `passerta_fact(fact)`.

Usage: `passerta_fact(Fact)`

- *Description:* Persistent version of `asserta_fact/1`: the current instance of `Fact` is interpreted as a fact (i.e., a relation tuple) and is added at the beginning of the definition of the corresponding predicate. The predicate concerned must be declared `persistent`. Any uninstantiated variables in the `Fact` will be replaced by new, private variables. Defined in the `'persdb/ll'` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

passertz_fact/1: PREDICATE

Meta-predicate with arguments: `passertz_fact(fact)`.

Usage: `passertz_fact(Fact)`

- *Description:* Persistent version of `assertz_fact/1`: the current instance of `Fact` is interpreted as a fact (i.e., a relation tuple) and is added at the end of the definition of the corresponding predicate. The predicate concerned must be declared `persistent`. Any uninstantiated variables in the `Fact` will be replaced by new, private variables. Defined in the `'persdb/ll'` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

pretract_fact/1: PREDICATE

`pretract_fact(P)`

Retracts a predicate in both, the dynamic and the persistent databases.

Meta-predicate with arguments: `pretract_fact(fact)`.

Usage: `pretract_fact(Fact)`

- *Description:* Persistent version of `retract_fact/1`: deletes on backtracking all the facts which unify with `Fact`. The predicate concerned must be declared `persistent`. Defined in the `'persdb/ll'` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

pretractall_fact/1: PREDICATE

`pretractall_fact(P)`

Retracts all the instances of a predicate in both, the dynamic and the persistent databases.

Meta-predicate with arguments: `pretractall_fact(fact)`.

asserta_fact/1: PREDICATE

Meta-predicate with arguments: `asserta_fact(fact)`.

Usage: `asserta_fact(Fact)`

- *Description:* Same as `passerta_fact/1`, but if the predicate concerned is not persistent then behaves as the builtin of the same name. Defined in the `persdb` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

assertz_fact/1: PREDICATE

Meta-predicate with arguments: `assertz_fact(fact)`.

Usage: `assertz_fact(Fact)`

- *Description:* Same as `passertz_fact/1`, but if the predicate concerned is not persistent then behaves as the builtin of the same name. Defined in the `persdb` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

retract_fact/1: PREDICATE

Meta-predicate with arguments: `retract_fact(fact)`.

Usage: `retract_fact(Fact)`

- *Description:* Same as `pretract_fact/1`, but if the predicate concerned is not persistent then behaves as the builtin of the same name. Defined in the `persdb` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

retractall_fact/1: PREDICATE

Meta-predicate with arguments: `retractall_fact(fact)`.

Usage: `retractall_fact(Fact)`

- *Description:* Same as `pretractall_fact/1`, but if the predicate concerned is not persistent then behaves as the builtin of the same name. Defined in the `persdb` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

initialize_db/0: PREDICATE

Usage:

- *Description:* Initializes the whole database, updating the state of the declared persistent predicates. Must be called explicitly after dynamically defining clauses for `persistent_dir/2`.

make_persistent/2: PREDICATE

Meta-predicate with arguments: `make_persistent(spec,?)`.

Usage: `make_persistent(PredDesc,Keyword)`

- *Description:* Dynamic version of the `persistent` declaration.
- *The following properties should hold at call time:*

  persdbrt:meta_predname(PredDesc) (persdbrt:meta_predname/1)

  `Keyword` is an atom corresponding to a directory identifier. (persdbcache:keyword/1)

update_files/0: PREDICATE

Usage:

- *Description:* Updates the files comprising the persistence set of all persistent predicates defined in the application.

update_files/1: PREDICATE

Meta-predicate with arguments: `update_files(list(spec))`.

Usage: `update_files(PredSpecList)`

- *Description:* Updates the files comprising the persistence set of the persistent predicates in `PredSpecList`.
- *Call and exit should be compatible with:*

  `PredSpecList` is a list of `prednames`. (basic_props:list/2)

create/2: PREDICATE

No further documentation available for this predicate.

meta_predname/1: REGTYPE

A regular type, defined as follows:

```
meta_predname($:(P)) :-
        predname(P).
```

directoryname/1: REGTYPE

Usage: `directoryname(X)`

- *Description:* `X` is an atom, the name of a directory.

133.9 Documentation on multifiles (persdbrt)

$is_persistent/2: PREDICATE

`$is_persistent(Spec,Key)`

Predicate `Spec` persists within database `Key`. Programmers should not define this predicate directly in the program.

The predicate is *multifile*.

The predicate is of type *data*.

persistent_dir/2: PREDICATE

The predicate is *multifile*.

The predicate is of type *data*.

Usage: `persistent_dir(Keyword,Location_Path)`

- *Description:* Relates identifiers of locations (the `Keywords`) with descriptions of such locations (`Location_Paths`). `Location_Path` is **a directory** and it means that the definition for the persistent predicates associated with `Keyword` is kept in files below that directory (which must previously exist). These files, in the updated state, contain the actual definition of the predicate in Prolog syntax (but with module names resolved).
- *Call and exit should be compatible with:*

  `Keyword` is an atom corresponding to a directory identifier. (persdbcache:keyword/1)

  `Location_Path` is an atom, the name of a directory. (persdbrt:directoryname/1)

persistent_dir/4: PREDICATE

The predicate is *multifile*.

The predicate is of type *data*.

Usage: `persistent_dir(Keyword,Location_Path,DirPerms,FilePerms)`

- *Description:* The same as `persistent_dir/2`, but including also the permission modes for persistent directories and files.
- *Call and exit should be compatible with:*

  `Keyword` is an atom corresponding to a directory identifier. (persdbcache:keyword/1)

  `Location_Path` is an atom, the name of a directory. (persdbrt:directoryname/1)

  `DirPerms` is an integer. (basic_props:int/1)

  `FilePerms` is an integer. (basic_props:int/1)

133.10 Documentation on internals (persdbrt)

persistent/2: DECLARATION

Usage: `:- persistent(PredDesc,Keyword).`

- *Description:* Declares the predicate `PredDesc` as persistent. `Keyword` is the identifier of a location where the persistent storage for the predicate is kept. The location `Keyword` is described in the `persistent_dir` predicate, which must contain a fact in which the first argument unifies with `Keyword`.

– *The following properties should hold upon exit:*
`PredDesc` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(basic_props:predname/1)

`Keyword` is an atom corresponding to a directory identifier. (persdbcache:keyword/1)

keyword/1: PREDICATE

An atom which identifies a fact of the `persistent_dir/2` relation. This fact relates this atom to a directory in which the persistent storage for one or more persistent predicates is kept. Storage is expected under a subdirectory by the name of the module and in a file by the name of the predicate.

133.11 Known bugs and planned improvements (`persdbrt`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.
- To load in the toplevel a file which uses this package, module `library(persdb(persdbrt))` has to be previously loaded.

134 Using the persdb library

Author(s): The CLIP Group.

Through the following examples we will try to illustrate the two mains ways of declaring and using persistent predicates: statically (the preferred method) and dynamically (necessary when the new persistent predicates have to be defined at run-time). The final example is a small application implementing a simple persistent queue.

134.1 An example of persistent predicates (static version)

134.2 An example of persistent predicates (dynamic version)

134.3 A simple application / a persistent queue

135 Filed predicates

Author(s): Francisco Bueno.

This package allows using files as a " cache" for predicates defined by facts. This is useful for huge tables of facts that may push the memory limits of the system too far. Goals of a filed predicate are executed simply by reading from the corresponding file.

Anything in the DB file used for the predicate that is different from a fact for the corresponding predicate is ignored. Each call to a filed predicate forces opening the file, so the use of this package is subject to the limit on the number of open files that the system can support.

Dynamic modification of the filed predicates is also allowed during execution of the program. Thus filed predicates are regarded as dynamic, data predicates residing in a file. However, dynamic modifications to the predicates do not affect the file, unless the predicate is also declared persistent.

The package is compatible with `persdb` in the sense that a predicate can be made both filed and persistent. In this way, the predicate can be used in programs, but it will not be loaded (saving memory), can also be modified during execution, and modifications will persist in the file. Thus, the user interface to both packages is the same (so the DB file must be one for both filing and persistency).

135.1 Usage and interface (`factsdb_doc`)

- **Library usage:**
  This facility is used as a package, thus either including `factsdb` in the package list of the module, or by using the `use_package/1` declaration. The facility predicates are defined in library module `factsdb_rt`.
- **Other modules used:**
  - *System library modules:*
    `factsdb/factsdb_rt`.

135.2 Documentation on multifiles (`factsdb_doc`)

$factsdb$cached_goal/3: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

135.3 Known bugs and planned improvements (`factsdb_doc`)

- The DB files for persistent predicates have to be used as such from the beginning. Using a DB file for a filed predicate first, and then using it also when making the predicate persistent won't work. Nor the other way around: using a DB file for a persistent predicate first, and then using it also when making the predicate filed.

136 Filed predicates (runtime)

Author(s): Francisco Bueno.
Runtime module for the `factsdb` package.

136.1 Usage and interface (`factsdb_rt`)

- **Library usage:**
  `:- use_module(library(factsdb_rt)).`
- **Exports:**
  - *Predicates:*
    `asserta_fact/1`, `assertz_fact/1`, `call/1`, `current_fact/1`, `retract_fact/1`.
  - *Multifiles:*
    `$factsdb$cached_goal/3`, `persistent_dir/2`, `file_alias/2`.
- **Other modules used:**
  - *System library modules:*
    `counters`, `read`, `persdb/persdbcache`.

136.2 Documentation on exports (`factsdb_rt`)

asserta_fact/1: PREDICATE

Meta-predicate with arguments: `asserta_fact(fact)`.

Usage: `asserta_fact(Fact)`

- *Description:* Version of `data_facts:asserta_fact/1` for filed predicates. The current instance of `Fact` is interpreted as a fact and is added at the beginning of the definition of the corresponding predicate. Therefore, before all the facts filed in the DB file for the predicate. The predicate concerned must be declared as `facts`; if it is not, then `data_facts:asserta_fact/1` is used.
- *The following properties should hold at call time:*
  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

assertz_fact/1: PREDICATE

Meta-predicate with arguments: `assertz_fact(fact)`.

Usage: `assertz_fact(Fact)`

- *Description:* Version of `data_facts:assertz_fact/1` for filed predicates. The current instance of `Fact` is interpreted as a fact and is added at the end of the definition of the corresponding predicate. Therefore, after all the facts filed in the DB file for the predicate. The predicate concerned must be declared as `facts`; if it is not, then `data_facts:assertz_fact/1` is used.
- *The following properties should hold at call time:*
  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

call/1: PREDICATE

Meta-predicate with arguments: `call(fact)`.

Usage: `call(Fact)`

- *Description:* Same as `current_fact/1` if the predicate concerned is declared as `facts`. If it is not, an exception is raised.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

current_fact/1: PREDICATE

Meta-predicate with arguments: `current_fact(fact)`.

Usage: `current_fact(Fact)`

- *Description:* Version of `data_facts:current_fact/1` for filed predicates. The current instance of `Fact` is interpreted as a fact and is unified with an actual fact in the current definition of the corresponding predicate. Therefore, with a fact previously asserted or filed in the DB file for the predicate, if it has not been retracted. The predicate concerned must be declared as `facts`; if it is not, then `data_facts:current_fact/1` is used.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

retract_fact/1: PREDICATE

Meta-predicate with arguments: `retract_fact(fact)`.

Usage: `retract_fact(Fact)`

- *Description:* Version of `data_facts:retract_fact/1` for filed predicates. The current instance of `Fact` is interpreted as a fact and is unified with an actual fact in the current definition of the corresponding predicate; such a fact is deleted from the predicate definition. This is true even for the facts filed in the DB file for the predicate; but these are NOT deleted from the file (unless the predicate is persistent). The predicate concerned must be declared as `facts`; if it is not, then `data_facts:retract_fact/1` is used.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

136.3 Documentation on multifiles (`factsdb_rt`)

$factsdb$cached_goal/3: PREDICATE

`$factsdb$cached_goal(Spec,Spec,Key)`

Predicate `Spec` is filed within database `Key`. Programmers should not define this predicate directly in the program.

The predicate is *multifile*.

persistent_dir/2: PREDICATE

See `persdb`.

The predicate is *multifile*.

The predicate is of type *data*.

file_alias/2: PREDICATE

See `symfnames`. This predicate is used only if `persistent_dir/2` fails.

The predicate is *multifile*.

The predicate is of type *data*.

136.4 Documentation on internals (`factsdb_rt`)

facts/2: DECLARATION

Usage: `:- facts(PredDesc,Keyword).`

- *Description:* Declares the predicate `PredDesc` as filed. `Keyword` is the identifier of a location where the file DB for the predicate is kept. The location `Keyword` is described in the `file_alias` predicate, which must contain a fact in which the first argument unifies with `Keyword`.
- *The following properties should hold upon exit:*

  `PredDesc` is a Name/Arity structure denoting a predicate name:

  ```
  predname(P/A) :-
          atm(P),
          nnegint(A).
  ```

  (basic_props:predname/1)

  `Keyword` is an atom corresponding to a directory identifier. (persdbcache:keyword/1)

keyword/1: PREDICATE

See `persdbrt`. The same conventions for location of DB files apply in both packages.

137 sqltypes (library)

137.1 Usage and interface (sqltypes)

- **Library usage:**
  `:- use_module(library(sqltypes)).`
- **Exports:**
  - *Predicates:*
    `accepted_type/2`, `get_type/2`, `type_compatible/2`, `type_union/3`, `sybase2sqltypes_list/2`, `sybase2sqltype/2`, `postgres2sqltypes_list/2`, `postgres2sqltype/2`.
  - *Regular Types:*
    `sqltype/1`, `sybasetype/1`, `postgrestype/1`.

137.2 Documentation on exports (sqltypes)

sqltype/1: REGTYPE

```
sqltype(int).
sqltype(flt).
sqltype(num).
sqltype(string).
sqltype(date).
sqltype(time).
sqltype(datetime).
```

These types have the same meaning as the corresponding standard types in the `basictypes` library.

Usage: `sqltype(Type)`

- *Description:* `Type` is an SQL data type supported by the translator.

accepted_type/2: PREDICATE

Usage: `accepted_type(SystemType,NativeType)`

- *Description:* For the moment, tests wether the `SystemType` received is a sybase or a postgres type (in the future other systems should be supported) and obtains its equivalent `NativeType` sqltype.
- *Call and exit should be compatible with:*
  `SystemType` is an SQL data type supported by Sybase. (sqltypes:sybasetype/1)
  `NativeType` is an SQL data type supported by the translator. (sqltypes:sqltype/1)

get_type/2: PREDICATE

Usage: `get_type(Constant,Type)`

- *Description:* Prolog implementation-specific definition of type retrievals. CIAO Prolog version given here (ISO).

– *Call and exit should be compatible with:*
`Constant` is any term. (basic_props:term/1)
`Type` is an SQL data type supported by the translator. (sqltypes:sqltype/1)
– *The following properties should hold at call time:*
`Constant` is currently a term which is not a free variable. (term_typing:nonvar/1)

type_compatible/2: PREDICATE

Usage: `type_compatible(TypeA,TypeB)`

– *Description:* Checks if `TypeA` and `TypeB` are compatible types, i.e., they are the same or one is a subtype of the other.
– *Call and exit should be compatible with:*
`TypeA` is an SQL data type supported by the translator. (sqltypes:sqltype/1)
`TypeB` is an SQL data type supported by the translator. (sqltypes:sqltype/1)

type_union/3: PREDICATE

Usage: `type_union(TypeA,TypeB,Union)`

– *Description:* `Union` is the union type of `TypeA` and `TypeB`.
– *Call and exit should be compatible with:*
`TypeA` is an SQL data type supported by the translator. (sqltypes:sqltype/1)
`TypeB` is an SQL data type supported by the translator. (sqltypes:sqltype/1)
`Union` is an SQL data type supported by the translator. (sqltypes:sqltype/1)

sybasetype/1: REGTYPE

SQL datatypes supported by Sybase for which a translation is defined:

```
sybasetype(integer).
sybasetype(numeric).
sybasetype(float).
sybasetype(double).
sybasetype(date).
sybasetype(char).
sybasetype(varchar).
sybasetype('long varchar').
sybasetype(binary).
sybasetype('long binary').
sybasetype(timestamp).
sybasetype(time).
sybasetype(tinyint).
```

Usage: `sybasetype(Type)`

– *Description:* `Type` is an SQL data type supported by Sybase.

sybase2sqltypes_list/2: PREDICATE

Usage: `sybase2sqltypes_list(SybaseTypesList,SQLTypesList)`

– *Description:* `SybaseTypesList` is a list of Sybase SQL types. `PrologTypesList` contains their equivalent SQL-type names in CIAO.
– *The following properties should hold upon exit:*
`SybaseTypesList` is a list. (basic_props:list/1)
`SQLTypesList` is a list. (basic_props:list/1)

sybase2sqltype/2: PREDICATE

Usage: `sybase2sqltype(SybaseType,SQLType)`

– *Description:* `SybaseType` is a Sybase SQL type name, and `SQLType` is its equivalent SQL-type name in CIAO.
– *The following properties should hold upon exit:*
`SybaseType` is an SQL data type supported by Sybase. (sqltypes:sybasetype/1)
`SQLType` is an SQL data type supported by the translator. (sqltypes:sqltype/1)

postgrestype/1: REGTYPE

SQL datatypes supported by postgreSQL for which a translation is defined:

```
postgrestype(int2).
postgrestype(int4).
postgrestype(int8).
postgrestype(float4).
postgrestype(float8).
postgrestype(date).
postgrestype(timestamp).
postgrestype(time).
postgrestype(char).
postgrestype(varchar).
postgrestype(text).
postgrestype(bool).
```

Usage: `postgrestype(Type)`

– *Description:* `Type` is an SQL data type supported by postgres.

postgres2sqltypes_list/2: PREDICATE

Usage: `postgres2sqltypes_list(PostgresTypesList,SQLTypesList)`

– *Description:* `PostgresTypesList` is a list of postgres SQL types. `PrologTypesList` contains their equivalent SQL-type names in CIAO.
– *The following properties should hold upon exit:*
`PostgresTypesList` is a list. (basic_props:list/1)
`SQLTypesList` is a list. (basic_props:list/1)

postgres2sqltype/2: PREDICATE

Usage: `postgres2sqltype(PostgresType,SQLType)`

– *Description:* `PostgresType` is a postgres SQL type name, and `SQLType` is its equivalent SQL-type name in CIAO.

– *The following properties should hold upon exit:*
`PostgresType` is an SQL data type supported by postgres. (sqltypes:postgrestype/1)
`SQLType` is an SQL data type supported by the translator. (sqltypes:sqltype/1)

138 persdbtr_sql (library)

138.1 Usage and interface (persdbtr_sql)

- **Library usage:**
  `:- use_module(library(persdbtr_sql)).`
- **Exports:**
  - *Predicates:*
    `sql_persistent_tr/2`, `sql_goal_tr/2`, `dbId/2`.

138.2 Documentation on exports (persdbtr_sql)

sql_persistent_tr/2: PREDICATE

No further documentation available for this predicate.

sql_goal_tr/2: PREDICATE

No further documentation available for this predicate.

dbId/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *data*.

139 pl2sqlinsert (library)

139.1 Usage and interface (pl2sqlinsert)

- **Library usage:**
  `:- use_module(library(pl2sqlinsert)).`
- **Exports:**
  - *Predicates:*
    `pl2sqlInsert/2`.
  - *Multifiles:*
    `sql__relation/3`, `sql__attribute/4`.
- **Other modules used:**
  - *System library modules:*
    `operators`, `default_predicates`, `lists`.

139.2 Documentation on exports (pl2sqlinsert)

pl2sqlInsert/2: PREDICATE

No further documentation available for this predicate.

139.3 Documentation on multifiles (pl2sqlinsert)

sql__relation/3: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *data*.

sql__attribute/4: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *data*.

140 Prolog to Java interface

Author(s): Jesús Correas.

This module defines the Ciao Prolog to Java interface. This interface allows a Prolog program to start a Java process, create Java objects, invoke methods, set/get attributes (fields), and handle Java events.

This interface only works with JDK version 1.2 or higher.

Although the Java side interface is explained in Javadoc format (it is available at `library/javall/javadoc/` in your Ciao installation), the general interface structure is detailed here.

140.1 Prolog to Java Interface Structure

This interface is made up of two parts: a Prolog part and a Java part, running in separate processes. The Prolog part receives requests from a Prolog program and sends them to the Java part through a socket. The Java part receives requests from the socket and performs the actions included in the requests.

If an event is thrown in the Java side, an asynchronous message must be sent away to the Prolog side, in order to launch a Prolog goal to handle the event. This asynchronous communication is performed using a separate socket. The nature of this communication needs the use of threads both in Java and Prolog: to deal with the 'sequential program flow,' and other threads for event handling.

In both sides the threads are automatically created by the context of the objects we use. The user must be aware that different requests to the other side of the interface could run concurrently.

140.1.1 Prolog side of the Java interface

The Prolog side receives the actions to do in the Java side from the user program, and sends them to the Java process through the socket connection. When the action is done in the Java side, the result is returned to the user Prolog program, or the action fails if there is any problem in the Java side.

Prolog data representation of Java elements is very simple in this interface. Java primitive types such as integers and characters are translated into the Prolog corresponding terms, and even some Java objects are translated in the same way (e. g. Java strings). Java objects are represented in Prolog as compound terms with a reference id to identify the corresponding Java object. Data conversion is made automatically when the interface is used, so the Prolog user programs do not have to deal with the complexity of these tasks.

140.1.2 Java side

The Java side of this layer is more complex than the Prolog side. The tasks this part has to deal with are the following:

- Wait for requests from the Prolog side.
- Translate the Prolog terms received in the Prolog 'serialized' form to a more useful Java representation (see the Java interface documentation available at `library/javall/javadoc/` in your Ciao installation for details regarding Java representation of Prolog terms).
- Interpret the requests received from the Prolog side, and execute them.
- Handle the set of objects created by or derived from the requests received from the prolog side.

- Handle the events raised in the Java side, and launch the listeners added in the prolog side.
- Handle the exceptions raised in the Java side, and send them to the Prolog side.

In the implementation of the Java side, two items must be carefully designed: the handling of Java objects, and the representation of prolog data structures. The last item is specially important because all the interactions between Prolog and Java are made using Prolog structures, an easy way to standardize the different data management in both sides. Even the requests themselves are encapsulated using Prolog structures. The overload of this encapsulation is not significant in terms of socket traffic, due to the optimal implementation of the prolog serialized term.

The java side must handle the objects created from the Prolog side dinamically, and these objects must be accessed as fast as possible from the set of objects. The Java API provides a powerful implementation of Hash tables that achieves all the requirements of our implementation.

On the other hand, the java representation of prolog terms is made using the inheritance of java classes. In the java side there exists a representation of a generic prolog term, implemented as an abstract class in java. Variables, atoms, compound terms, lists, and numeric terms are classes in the java side which inherit from the term class. Java objects can be seen also under the prolog representation as compound terms, where the single argument corresponds to the Hash key of the actual java object in the Hash table referred to before. This behaviour makes the handling of mixed java and prolog elements easy. Prolog goals are represented in the java side as objects which contain a prolog compound term with the term representing the goal. This case will be seen more in depth in next chapter, where the java to prolog interface is explained.

140.2 Java event handling from Prolog

Java event handling is based on a delegation model since version 1.1.x. This approach to event handling is very powerful and elegant, but a user program cannot handle all the events that can arise on a given object: for each kind of event, a listener must be implemented and added specifically. However, the Java 2 API includes a special listener (`AWTEventListener`) that can manage the internal java event queue.

The prolog to java interface has been designed to emulate the java event handler, and is also based on event objects and listeners. The prolog to java interface implements its own event manager, to handle those events that have prolog listeners associated to the object that raises the event. From the prolog side can be added listeners to objects for specific events. The java side includes a list of goals to launch from the object and event type.

Due to the events nature, the event handler must work in a separate thread to manage the events asynchronously. The java side has its own mechanisms to work this way. The prolog side must be implemented specially for event handling using threads. The communication between java and prolog is also asynchronous, and an additional socket stream is used to avoid interferences with the main socket stream. The event stream will work in this implementation only in one way: from java to prolog. If an event handler needs to send back requests to java, it will use the main socket stream, just like the requests sent directly from a prolog program.

The internal process of register a Prolog event handler to a Java event is shown in the next figure:

When an event raises, the Prolog to Java interface has to send to the Prolog user program the goal to evaluate. Graphically, the complete process takes the tasks involved in the following figure:

140.3 Java exception handling from Prolog

Java exception handling is very similar to the peer prolog handling: it includes some specific statements to trap exceptions from user code. In the java side, the exceptions can be originated from an incorrect request, or can be originated in the code called from the request. Both exception types will be sent to prolog using the main socket stream, allowing the prolog program manage the exception. However, the first kind of exceptions are prefixed, so the user program can distinguish them from the second type of exceptions.

In order to handle exceptions properly using the prolog to java and java to prolog interfaces simultaneously, in both sides of the interface those exceptions coming from their own side will be filtered: this avoids an endless loop of exceptions bouncing from one side to another.

140.4 Usage and interface (`javart`)

- **Library usage:**
  `:- use_module(library(javart)).`
- **Exports:**
  - *Predicates:*
    `java_start/0`, `java_start/1`, `java_start/2`, `java_stop/0`, `java_connect/2`, `java_disconnect/0`, `java_use_module/1`, `java_create_object/2`, `java_delete_object/1`, `java_invoke_method/2`, `java_get_value/2`, `java_set_value/2`, `java_add_listener/3`, `java_remove_listener/3`.
  - *Regular Types:*
    `machine_name/1`, `java_constructor/1`, `java_object/1`, `java_event/1`, `prolog_goal/1`, `java_field/1`, `java_method/1`.
- **Other modules used:**
  - *System library modules:*
    `concurrency/concurrency`, `iso_byte_char`, `lists`, `read`, `write`, `javall/javasock`, `system`.

140.5 Documentation on exports (`javart`)

java_start/0: PREDICATE

Usage:

- *Description:* Starts the Java server on the local machine, connects to it, and starts the event handling thread.

java_start/1: PREDICATE

Usage: `java_start(Classpath)`

- *Description:* Starts the Java server on the local machine, connects to it, and starts the event handling thread. The Java server is started using the classpath received as argument.
- *Call and exit should be compatible with:*
  `Classpath` is a string (a list of character codes). (basic_props:string/1)

– *The following properties should hold at call time:*

`Classpath` is currently a term which is not a free variable. (term_typing:nonvar/1)

java_start/2: PREDICATE

Usage: `java_start(Machine_name,Classpath)`

– *Description:* Starts the Java server in `machine_name` (using rsh!), connects to it, and starts the event handling thread. The Java server is started using the `Classpath` received as argument.

– *Call and exit should be compatible with:*

`Machine_name` is the network name of a machine. (javart:machine_name/1)

`Classpath` is a string (a list of character codes). (basic_props:string/1)

– *The following properties should hold at call time:*

`Machine_name` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Classpath` is currently a term which is not a free variable. (term_typing:nonvar/1)

java_stop/0: PREDICATE

Usage:

– *Description:* Stops the interface terminating the threads that handle the socket connection, and finishing the Java interface server if it was started using java_start/n.

java_connect/2: PREDICATE

Usage: `java_connect(Machine_name,Port_number)`

– *Description:* Connects to an existing Java interface server running in `Machine_name` and listening at port `port_number`. To connect to a Java server located in the local machine, use 'localhost' as machine_name.

– *Call and exit should be compatible with:*

`Machine_name` is the network name of a machine. (javart:machine_name/1)

`Port_number` is an integer. (basic_props:int/1)

– *The following properties should hold at call time:*

`Machine_name` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Port_number` is currently a term which is not a free variable. (term_typing:nonvar/1)

java_disconnect/0: PREDICATE

Usage:

– *Description:* Closes the connection with the java process, terminating the threads that handle the connection to Java. This predicate does not terminate the Java process (this is the disconnection procedure for Java servers not started from Prolog). This predicate should be used when the communication is established with java_connect/2.

machine_name/1: REGTYPE

Usage: `machine_name(X)`

– *Description:* `X` is the network name of a machine.

java_constructor/1: REGTYPE

Usage: `java_constructor(X)`

- *Description:* `X` is a java constructor (structure with functor as constructor full name, and arguments as constructor arguments).

java_object/1: REGTYPE

Usage: `java_object(X)`

- *Description:* `X` is a java object (a structure with functor '$java_object', and argument an integer given by the java side).

java_event/1: REGTYPE

Usage: `java_event(X)`

- *Description:* `X` is a java event represented as an atom with the full event constructor name (e.g., 'java.awt.event.ActionListener').

prolog_goal/1: REGTYPE

Usage: `prolog_goal(X)`

- *Description:* `X` is a prolog predicate. Prolog term that represents the goal that must be invoked when the event raises on the object. The predicate arguments can be java objects, or even the result of java methods. These java objects will be evaluated when the event raises (instead of when the listener is added). The arguments that represent java objects must be instantiated to already created objects. The variables will be kept uninstantiated when the event raises and the predicate is called.

java_field/1: REGTYPE

Usage: `java_field(X)`

- *Description:* `X` is a java field (structure on which the functor name is the field name, and the single argument is the field value).

java_use_module/1: PREDICATE

Usage: `java_use_module(Module)`

- *Description:* Loads a module and makes it available from Java.
- *Call and exit should be compatible with:*

  `Module` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `Module` is currently a term which is not a free variable. (term_typing:nonvar/1)

java_create_object/2: PREDICATE

Usage:

- *Description:* New java object creation. The constructor must be a compound term as defined by its type, with the full class name as functor (e.g., 'java.lang.String'), and the parameters passed to the constructor as arguments of the structure.

- *Call and exit should be compatible with:*

  `Arg1` is a java constructor (structure with functor as constructor full name, and arguments as constructor arguments). (javart:java_constructor/1)

  `Arg2` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)
- *The following properties should hold at call time:*

  `Arg1` is a java constructor (structure with functor as constructor full name, and arguments as constructor arguments). (javart:java_constructor/1)

  `Arg2` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Arg2` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

java_delete_object/1: PREDICATE

Usage:

- *Description:* Java object deletion. It removes the object given as argument from the Java object table.
- *Call and exit should be compatible with:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)
- *The following properties should hold at call time:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

java_invoke_method/2: PREDICATE

Usage:

- *Description:* Invokes a java method on an object. Given a Java object reference, invokes the method represented with the second argument.
- *Call and exit should be compatible with:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

  `Arg2` is a java method (structure with functor as method name, and arguments as method ones, plus a result argument. This result argument is unified with the atom 'Yes' if the java method returns void). (javart:java_method/1)
- *The following properties should hold at call time:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

  `Arg2` is a java method (structure with functor as method name, and arguments as method ones, plus a result argument. This result argument is unified with the atom 'Yes' if the java method returns void). (javart:java_method/1)

java_method/1: REGTYPE

Usage: `java_method(X)`

- *Description:* `X` is a java method (structure with functor as method name, and arguments as method ones, plus a result argument. This result argument is unified with the atom 'Yes' if the java method returns void).

java_get_value/2: PREDICATE

Usage:

- *Description:* Gets the value of a field. Given a Java object as first argument, it instantiates the variable given as second argument. This field must be uninstantiated in the java_field functor, or this predicate will fail.
- *Call and exit should be compatible with:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

  `Arg2` is a java field (structure on which the functor name is the field name, and the single argument is the field value). (javart:java_field/1)
- *The following properties should hold at call time:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

  `Arg2` is a java field (structure on which the functor name is the field name, and the single argument is the field value). (javart:java_field/1)

java_set_value/2: PREDICATE

Usage:

- *Description:* Sets the value of a Java object field. Given a Java object reference, it assigns the value included in the java_field compound term. The field value in the java_field structure must be instantiated.
- *Call and exit should be compatible with:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

  `Arg2` is a java field (structure on which the functor name is the field name, and the single argument is the field value). (javart:java_field/1)
- *The following properties should hold at call time:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

  `Arg2` is a java field (structure on which the functor name is the field name, and the single argument is the field value). (javart:java_field/1)

java_add_listener/3: PREDICATE

Meta-predicate with arguments: `java_add_listener(?,?,goal)`.

Usage:

- *Description:* Adds a listener to an event on an object. Given a Java object reference, it registers the goal received as third argument to be launched when the Java event raises.
- *Call and exit should be compatible with:*

  `Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

  `Arg2` is a java event represented as an atom with the full event constructor name (e.g., 'java.awt.event.ActionListener'). (javart:java_event/1)

  `Arg3` is a prolog predicate. Prolog term that represents the goal that must be invoked when the event raises on the object. The predicate arguments can be java

objects, or even the result of java methods. These java objects will be evaluated when the event raises (instead of when the listener is added). The arguments that represent java objects must be instantiated to already created objects. The variables will be kept uninstantiated when the event raises and the predicate is called. (javart:prolog_goal/1)

– *The following properties should hold at call time:*

`Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

`Arg2` is a java event represented as an atom with the full event constructor name (e.g., 'java.awt.event.ActionListener'). (javart:java_event/1)

`Arg3` is a prolog predicate. Prolog term that represents the goal that must be invoked when the event raises on the object. The predicate arguments can be java objects, or even the result of java methods. These java objects will be evaluated when the event raises (instead of when the listener is added). The arguments that represent java objects must be instantiated to already created objects. The variables will be kept uninstantiated when the event raises and the predicate is called. (javart:prolog_goal/1)

java_remove_listener/3: PREDICATE

Usage:

– *Description:* It removes a listener from an object event queue. Given a Java object reference, goal registered for the given event is removed.

– *Call and exit should be compatible with:*

`Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

`Arg2` is a java event represented as an atom with the full event constructor name (e.g., 'java.awt.event.ActionListener'). (javart:java_event/1)

`Arg3` is a prolog predicate. Prolog term that represents the goal that must be invoked when the event raises on the object. The predicate arguments can be java objects, or even the result of java methods. These java objects will be evaluated when the event raises (instead of when the listener is added). The arguments that represent java objects must be instantiated to already created objects. The variables will be kept uninstantiated when the event raises and the predicate is called. (javart:prolog_goal/1)

– *The following properties should hold at call time:*

`Arg1` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (javart:java_object/1)

`Arg2` is a java event represented as an atom with the full event constructor name (e.g., 'java.awt.event.ActionListener'). (javart:java_event/1)

`Arg3` is a prolog predicate. Prolog term that represents the goal that must be invoked when the event raises on the object. The predicate arguments can be java objects, or even the result of java methods. These java objects will be evaluated when the event raises (instead of when the listener is added). The arguments that represent java objects must be instantiated to already created objects. The variables will be kept uninstantiated when the event raises and the predicate is called. (javart:prolog_goal/1)

141 Java to Prolog interface

Author(s): Jesús Correas.

This module defines the Prolog side of the Java to Prolog interface. This side of the interface only has one public predicate: a server that listens at the socket connection with Java, and executes the commands received from the Java side.

In order to evaluate the goals received from the Java side, this module can work in two ways: executing them in the same engine, or starting a thread for each goal. The easiest way is to launch them in the same engine, but the goals must be evaluated sequentially: once a goal provides the first solution, all the subsequent goals must be finished before this goal can backtrack to provide another solution. The Prolog side of this interface works as a top-level, and the goals partially evaluated are not independent.

The solution of this goal dependence is to evaluate the goals in a different prolog engine. Although Ciao includes a mechanism to evaluate goals in different engines, the approach used in this interface is to launch each goal in a different thread.

The decision of what kind of goal evaluation is selected is done by the Java side. Each evaluation type has its own command terms, so the Java side can choose the type it needs.

A Prolog server starts by calling the `prolog_server/0` predicate, or by calling `prolog_server/1` predicate and providing the port number as argument. The user predicates and libraries to be called from Java must be included in the executable file, or be accesible using the built-in predicates dealing with code loading.

141.1 Usage and interface (`jtopl`)

- **Library usage:**
  `:- use_module(library(jtopl)).`
- **Exports:**
  - *Predicates:*
    `prolog_server/0`, `prolog_server/1`, `prolog_server/2`, `shell_s/0`, `query_solutions/2`, `query_requests/2`, `running_queries/2`.
- **Other modules used:**
  - *System library modules:*
    `concurrency/concurrency`, `system`, `read`, `compiler/compiler`, `javall/javasock`.

141.2 Documentation on exports (`jtopl`)

prolog_server/0: PREDICATE

Usage:

- *Description:* Prolog server entry point. Reads from the standard input the node name and port number where the java client resides, and starts the prolog server listening at the jp socket. This predicate acts as a server: it includes an endless read-process loop until the `prolog_halt` command is received.

  However, from the low-level communication point of view, this Prolog server actually works as a client of the Java side. This means that Java side waits at the given port to a Prolog server trying to create a socket; Prolog side connects to that port, and then waits for Java requests (acting as a 'logical' server). To use this Prolog server as a real server waiting for connections at a given port, use `prolog_server/1`.

prolog_server/1: PREDICATE

Usage:

- *Description:* Waits for incoming Java connections to act as a Prolog goal server for Java requests.This is the only `prolog_server/*` predicate that works as a true server: given a port number, waits for a connection from Java and then serves Java requests. When a termination request is received, finishes the connection to Java and waits next Java connection request. This behaviour is different with respect to previous versions of this library. To work as before, use `prolog_server/2`.

  Although it currently does not support simultaneous Java connections, some work is being done in that direction.
- *Call and exit should be compatible with:*

  `Arg1` is an atom. (basic_props:atm/1)

prolog_server/2: PREDICATE

Usage:

- *Description:* Prolog server entry point. Given a network `node` and a `port` number, starts the prolog server trying to connect to Java side at that `node:port` address, and then waits for Java requests. This predicate acts as a server: it includes an endless read-process loop until the `prolog_halt` command is received.

  However, from the low-level communication point of view, this Prolog server actually works as a client of the Java side. This means that Java side waits at the given port to a Prolog server trying to create a socket; Prolog side connects to that port, and then waits for Java requests (acting as a 'logical' server). To use this Prolog server as a real server waiting for connections at a given port, use `prolog_server/1`.
- *Call and exit should be compatible with:*

  `Arg1` is an atom. (basic_props:atm/1)

  `Arg2` is an atom. (basic_props:atm/1)

shell_s/0: PREDICATE

Usage:

- *Description:* Command execution loop. This predicate is called when the connection to Java is established, and performs an endless loop processing the commands received. This predicate is only intended to be used by the Prolog to Java interface and it should not be used by a user program.

query_solutions/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *concurrent*.

query_requests/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *concurrent*.

running_queries/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *concurrent*.

142 Low-level Prolog to Java socket connection

Author(s): Jesús Correas.

This module defines a low-level socket interface, to be used by javart and jtopl. Includes all the code related directly to the handling of sockets. This library should not be used by any user program, because is a very low-level connection to Java. Use `javart` (Prolog to Java interface) or `jtopl` (Java to Prolog interface) libraries instead.

142.1 Usage and interface (`javasock`)

- **Library usage:**
  `:- use_module(library(javasock)).`
- **Exports:**
  - *Predicates:*
    `bind_socket_interface/1`, `start_socket_interface/2`, `stop_socket_interface/0`, `join_socket_interface/0`, `java_query/2`, `java_response/2`, `prolog_query/2`, `prolog_response/2`, `is_connected_to_java/0`, `java_debug/1`, `java_debug_redo/1`, `start_threads/0`.
- **Other modules used:**
  - *System library modules:*
    `fastrw`, `sockets/sockets`, `format`, `concurrency/concurrency`, `javall/jtopl`, `sockets/sockets_io`.

142.2 Documentation on exports (`javasock`)

bind_socket_interface/1: PREDICATE

Usage: `bind_socket_interface(Port)`

- *Description:* Given an port number, waits for a connection request from the Java side, creates the sockets to connect to the java process, and starts the threads needed to handle the connection.
- *Call and exit should be compatible with:*
  `Port` is an integer. (basic_props:int/1)
- *The following properties should hold at call time:*
  `Port` is currently a term which is not a free variable. (term_typing:nonvar/1)

start_socket_interface/2: PREDICATE

Usage: `start_socket_interface(Address,Stream)`

- *Description:* Given an address in format 'node:port', creates the sockets to connect to the java process, and starts the threads needed to handle the connection.
- *Call and exit should be compatible with:*
  `Address` is any term. (basic_props:term/1)
  `Stream` is an open stream. (streams_basic:stream/1)

– *The following properties should hold at call time:*

`Address` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Stream` is currently a term which is not a free variable. (term_typing:nonvar/1)

stop_socket_interface/0: PREDICATE

Usage:

– *Description:* Closes the sockets to disconnect from the java process, and waits until the threads that handle the connection terminate.

join_socket_interface/0: PREDICATE

Usage:

– *Description:* Waits until the threads that handle the connection terminate.

java_query/2: PREDICATE

The predicate is of type *concurrent*.

Usage: `java_query(ThreadId,Query)`

– *Description:* Data predicate containing the queries to be sent to Java. First argument is the Prolog thread Id, and second argument is the query to send to Java.

– *Call and exit should be compatible with:*

`ThreadId` is an atom. (basic_props:atm/1)

`Query` is any term. (basic_props:term/1)

java_response/2: PREDICATE

The predicate is of type *concurrent*.

Usage: `java_response(Id,Response)`

– *Description:* Data predicate that stores the responses to requests received from Java. First argument corresponds to the Prolog thread Id; second argument corresponds to the response itself.

– *Call and exit should be compatible with:*

`Id` is an atom. (basic_props:atm/1)

`Response` is any term. (basic_props:term/1)

prolog_query/2: PREDICATE

The predicate is of type *concurrent*.

Usage: `prolog_query(Id,Query)`

– *Description:* Data predicate that keeps a queue of the queries requested to Prolog side from Java side.

– *Call and exit should be compatible with:*

`Id` is an integer. (basic_props:int/1)

`Query` is any term. (basic_props:term/1)

prolog_response/2: PREDICATE

The predicate is of type *concurrent*.

Usage: `prolog_response(Id,Response)`

- *Description:* Data predicate that keeps a queue of the responses to queries requested to Prolog side from Java side.
- *Call and exit should be compatible with:*

  `Id` is an integer. (basic_props:int/1)

  `Response` is any term. (basic_props:term/1)

is_connected_to_java/0: PREDICATE

Usage:

- *Description:* Checks if the connection to Java is established.

java_debug/1: PREDICATE

No further documentation available for this predicate.

java_debug_redo/1: PREDICATE

No further documentation available for this predicate.

start_threads/0: PREDICATE

Usage:

- *Description:* Starts the threads that will handle the connection to Java. This predicate is declared public for internal purposes, and it is not intended to be used by a user program.

143 Calling emacs from Prolog

Author(s): The CLIP Group.

This library provides a *prolog-emacs interface*. This interface is complementary to (and independent from) the emacs mode, which is used to develop programs from within the `emacs` editor/environment. Instead, this library allows calling `emacs` from a running Prolog program. This facilitates the use of `emacs` as a "user interface" for a Prolog program. Emacs can be made to:

- Visit a file, which can then be edited.
- Execute arbitrary *emacs lisp* code, sent from Prolog.

In order for this library to work correctly, the following is needed:

- You should be running the `emacs` editor on the same machine where the executable calling this library is executing.
- This `emacs` should be running the *emacs server*. This can be done by including the following line in your `.emacs` file:

  ```
  ;; Start a server that emacsclient can connect to.
  (server-start)
  ```

  Or typing `M-x server-start` within `emacs`.

This suffices for using `emacs` to edit files. For running arbitrary code the following also needs to be added to the `.emacs` file:

`(setq enable-local-eval t)`
: Allows executing lisp code without asking.

`(setq enable-local-eval nil)`
: Does not allow executing lisp code without asking.

`(setq enable-local-eval 'maybe)`
: Allows executing lisp code only if user agrees after asking (asks interactively for every invocation).

Examples:

Assuming that a `.pl` file loads this library, then:

`..., emacs_edit('foo'), ...`
: Opens file `foo` for editing in `emacs`.

`..., emacs_eval_nowait("(run-ciao-toplevel)"), ...`
: Starts execution of a Ciao top-level within `emacs`.

143.1 Usage and interface (emacs)

- **Library usage:**
  `:- use_module(library(emacs)).`
- **Exports:**
  - *Predicates:*
    `emacs_edit/1`, `emacs_edit_nowait/1`, `emacs_eval/1`, `emacs_eval_nowait/1`.
  - *Regular Types:*
    `elisp_string/1`.
- **Other modules used:**
  - *System library modules:*
    `terms_check`, `lists`, `terms`, `system`.

143.2 Documentation on exports (emacs)

emacs_edit/1: PREDICATE

Usage:

- *Description:* Opens the given file for editing in `emacs`. Waits for editing to finish before continuing.
- *The following properties should hold at call time:*
  `Arg1` is an atom which is the name of a file. (emacs:filename/1)

emacs_edit_nowait/1: PREDICATE

Usage:

- *Description:* Opens the given file for editing in `emacs` and continues without waiting for editing to finish.
- *The following properties should hold at call time:*
  `Arg1` is an atom which is the name of a file. (emacs:filename/1)

emacs_eval/1: PREDICATE

Usage:

- *Description:* Executes in emacs the lisp code given as argument. Waits for the command to finish before continuing.
- *The following properties should hold at call time:*
  `Arg1` is a string containing `emacs` lisp code. (emacs:elisp_string/1)

emacs_eval_nowait/1: PREDICATE

Usage:

- *Description:* Executes in emacs the lisp code given as argument and continues without waiting for it to finish.

– *The following properties should hold at call time:*
`Arg1` is a string containing `emacs` lisp code. (emacs:elisp_string/1)

elisp_string/1: REGTYPE

Usage: `elisp_string(L)`

– *Description:* `L` is a string containing `emacs` lisp code.

144 linda (library)

This is a SICStus-like linda package. Note that this is essentially quite obsolete, and provided mostly in case it is needed for compatibility, since Ciao now supports all Linda functionality (and more) through the concurrent fact database.

144.1 Usage and interface (`linda`)

- **Library usage:**
  `:- use_module(library(linda)).`
- **Exports:**
  - *Predicates:*
    `linda_client/1`, `close_client/0`, `in/1`, `in/2`, `in_noblock/1`, `out/1`, `rd/1`, `rd/2`, `rd_noblock/1`, `rd_findall/3`, `linda_timeout/2`, `halt_server/0`, `open_client/2`, `in_stream/2`, `out_stream/2`.
- **Other modules used:**
  - *System library modules:*
    `read`, `fastrw`, `sockets/sockets`.

144.2 Documentation on exports (`linda`)

linda_client/1: PREDICATE

No further documentation available for this predicate.

close_client/0: PREDICATE

No further documentation available for this predicate.

in/1: PREDICATE

No further documentation available for this predicate.

in/2: PREDICATE

No further documentation available for this predicate.

in_noblock/1: PREDICATE

No further documentation available for this predicate.

out/1: PREDICATE

No further documentation available for this predicate.

rd/1: PREDICATE

No further documentation available for this predicate.

rd/2: PREDICATE

No further documentation available for this predicate.

rd_noblock/1: PREDICATE

No further documentation available for this predicate.

rd_findall/3: PREDICATE

No further documentation available for this predicate.

linda_timeout/2: PREDICATE

No further documentation available for this predicate.

halt_server/0: PREDICATE

No further documentation available for this predicate.

open_client/2: PREDICATE

No further documentation available for this predicate.

in_stream/2: PREDICATE

No further documentation available for this predicate.

out_stream/2: PREDICATE

No further documentation available for this predicate.

PART IX - Abstract data types

Author(s): The CLIP Group.

This part includes libraries which implement some generic data structures (abstract data types) that are used frequently in programs or in the Ciao system itself.

145 Extendable arrays with logarithmic access time

Author(s): Lena Flood.

This module implements extendable arrays with logarithmic access time. It has been adapted from shared code written by David Warren and Fernando Pereira.

145.1 Usage and interface (arrays)

- **Library usage:**
  `:- use_module(library(arrays)).`
- **Exports:**
  - *Predicates:*
    `new_array/1`, `is_array/1`, `aref/3`, `arefa/3`, `arefl/3`, `aset/4`, `array_to_list/2`.

145.2 Documentation on exports (arrays)

new_array/1: PREDICATE

Usage: `new_array(Array)`

- *Description:* returns an empty new array `Array`.
- *The following properties should hold at call time:*
  `Array` is a free variable. (term_typing:var/1)

is_array/1: PREDICATE

Usage: `is_array(Array)`

- *Description:* `Array` actually is an array.
- *The following properties should hold at call time:*
  `Array` is currently a term which is not a free variable. (term_typing:nonvar/1)

aref/3: PREDICATE

Usage: `aref(Index,Array,Element)`

- *Description:* unifies `Element` to `Array`[`Index`], or fails if `Array`[`Index`] has not been set.
- *The following properties should hold at call time:*
  `Index` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Array` is currently a term which is not a free variable. (term_typing:nonvar/1)

arefa/3: PREDICATE

Usage: `arefa(Index,Array,Element)`

- *Description:* is as `aref/3`, except that it unifies `Element` with a new array if `Array`[`Index`] is undefined. This is useful for multidimensional arrays implemented as arrays of arrays.

– *The following properties should hold at call time:*

`Index` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Array` is currently a term which is not a free variable. (term_typing:nonvar/1)

arefl/3: PREDICATE

Usage: `arefl(Index,Array,Element)`

– *Description:* is as `aref/3`, except that `Element` appears as `[]` for undefined cells. Thus, `arefl(_,_,[])` always succeeds no matter what you give in the first or second args.

– *The following properties should hold at call time:*

`Index` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Array` is currently a term which is not a free variable. (term_typing:nonvar/1)

aset/4: PREDICATE

Usage: `aset(Index,Array,Element,NewArray)`

– *Description:* unifies `NewArray` with the result of setting `Array`[`Index`] to `Element`.

– *The following properties should hold at call time:*

`Index` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Array` is currently a term which is not a free variable. (term_typing:nonvar/1)

`NewArray` is a free variable. (term_typing:var/1)

array_to_list/2: PREDICATE

Usage: `array_to_list(Array,List)`

– *Description:* returns a `List` of pairs Index-Element of all the elements of `Array` that have been set.

– *The following properties should hold at call time:*

`Array` is currently a term which is not a free variable. (term_typing:nonvar/1)

`List` is a free variable. (term_typing:var/1)

146 Association between key and value

Author(s): Pablo Chico, Manuel Carro.

This library implements a table. It takes its name from the classical "association lists". It allows storing a set of values and a key for each value, such that the values can later be accessed through these keys. These keys could not be ground terms, but they could not be instanciated later (so, this implementation unify with '==' instead of '='). The implementation uses a dynamically changing data structure for efficiency. When there are few elements the data structure used is a list of pairs. When the number of elements stored goes beyond some number, an AVL tree is used. There is a certain level of hysteresis so that no repeated data structure conversions occur when the number of elements is close to the threshold.

146.1 Usage and interface (assoc)

- **Library usage:**
  `:- use_module(library(assoc)).`
- **Exports:**
  - *Predicates:*
    `empty_assoc/1`, `assoc_to_list/2`, `is_assoc/1`, `min_assoc/3`, `max_assoc/3`, `gen_assoc/3`, `get_assoc/3`, `get_assoc/5`, `get_next_assoc/4`, `get_prev_assoc/4`, `list_to_assoc/2`, `ord_list_to_assoc/2`, `map_assoc/2`, `map_assoc/3`, `map/3`, `foldl/4`, `put_assoc/4`, `put_assoc/5`, `add_assoc/4`, `update_assoc/5`, `del_assoc/4`, `del_min_assoc/4`, `del_max_assoc/4`.
- **Other modules used:**
  - *System library modules:*
    `hiordlib`, `lists`.

146.2 Documentation on exports (assoc)

empty_assoc/1: PREDICATE

Usage 1: `empty_assoc(Assoc)`

- *Description:* True if `Assoc` is an empty `assoc_table`.
- *The following properties should hold at call time:*
  `Assoc` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Assoc` is a associations beetwen keys and values. (assoc:assoc_table/1)

Usage 2: `empty_assoc(Assoc)`

- *Description:* `Assoc` is an empty `assoc_table`.
- *The following properties should hold at call time:*
  `Assoc` is a free variable. (term_typing:var/1)
  `Assoc` is a associations beetwen keys and values. (assoc:assoc_table/1)

assoc_to_list/2: PREDICATE

Usage: `assoc_to_list(Assoc,L)`

– *Description:* Transforms `Assoc` into `L` where each pair of `L` was a association in `Assoc`.
– *The following properties should hold at call time:*
`Assoc` is currently a term which is not a free variable. (term_typing:nonvar/1)
`L` is a free variable. (term_typing:var/1)
`Assoc` is a associations beetwen keys and values. (assoc:assoc_table/1)
`L` is a ordered list of elements of the form `key-value`. (assoc:ord_pairs/1)

is_assoc/1: PREDICATE

Usage: `is_assoc(Assoc)`

– *Description:* True if `Assoc` is an `assoc_table`.
– *The following properties should hold at call time:*
`Assoc` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Assoc` is a associations beetwen keys and values. (assoc:assoc_table/1)

min_assoc/3: PREDICATE

Usage: `min_assoc(Assoc,Key,Value)`

– *Description:* `Key` and `Value` are `key` and `value` of the element with the smallest `key` in `Assoc`.
– *The following properties should hold at call time:*
`Assoc` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Key` is a free variable. (term_typing:var/1)
`Value` is a free variable. (term_typing:var/1)
`Assoc` is a associations beetwen keys and values. (assoc:assoc_table/1)
`K` is a valid key in a `assoc_table`. (assoc:key/1)
`Value` is a valid value in a `assoc_table`. (assoc:value/1)

max_assoc/3: PREDICATE

Usage: `max_assoc(Assoc,Key,Value)`

– *Description:* `Key` and `Value` are the `key` and `value` of the element with the largest `key` in `Assoc`.
– *The following properties should hold at call time:*
`Assoc` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Key` is a free variable. (term_typing:var/1)
`Value` is a free variable. (term_typing:var/1)
`Assoc` is a associations beetwen keys and values. (assoc:assoc_table/1)
`Key` is a valid key in a `assoc_table`. (assoc:key/1)
`Value` is a valid value in a `assoc_table`. (assoc:value/1)

gen_assoc/3: PREDICATE

Usage 1: `gen_assoc(K,Assoc,V)`

– *Description:* Enumerate matching elements of Assoc in ascending order of their keys via backtracking.
– *The following properties should hold at call time:*

`K` is a free variable.	(term_typing:var/1)
`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`V` is a free variable.	(term_typing:var/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`.	(assoc:value/1)

Usage 2: `gen_assoc(K,Assoc,V)`
– *Description:* Enumerate matching elements of Assoc in ascending order of their keys via backtracking whose value is `V`.
– *The following properties should hold at call time:*

`K` is a free variable.	(term_typing:var/1)
`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`V` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`.	(assoc:value/1)

get_assoc/3: PREDICATE

Usage 1: `get_assoc(K,Assoc,V)`
– *Description:* True if `V` is the value associated to the key `K` in the assoc_table `Assoc`.
– *The following properties should hold at call time:*

`K` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`V` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`.	(assoc:value/1)

Usage 2: `get_assoc(K,Assoc,V)`
– *Description:* `V` is the value associated to the key `K` in the assoc_table `Assoc`.
– *The following properties should hold at call time:*

`K` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`V` is a free variable.	(term_typing:var/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`.	(assoc:value/1)

get_assoc/5: PREDICATE

Usage: `get_assoc(K,Assoc,Old,NewAssoc,New)`

- *Description:* `NewAssoc` is an `assoc_table` identical to `Assoc` except that the value associated with `Key` is `New` instead of `Old`.
- *The following properties should hold at call time:*

`K` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Old` is a free variable.	(term_typing:var/1)
`NewAssoc` is a free variable.	(term_typing:var/1)
`New` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`Old` is a valid value in a `assoc_table`.	(assoc:value/1)
`NewAssoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`New` is a valid value in a `assoc_table`.	(assoc:value/1)

get_next_assoc/4: PREDICATE

Usage: `get_next_assoc(K,Assoc,NextK,NextV)`

- *Description:* `NextK` and `NextV` are the next `key` and associated `value` after `K` in `Assoc`.
- *The following properties should hold at call time:*

`K` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`NextK` is a free variable.	(term_typing:var/1)
`NextV` is a free variable.	(term_typing:var/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`NextK` is a valid key in a `assoc_table`.	(assoc:key/1)
`NextV` is a valid value in a `assoc_table`.	(assoc:value/1)

get_prev_assoc/4: PREDICATE

Usage: `get_prev_assoc(K,Assoc,PrevK,PrevV)`

- *Description:* `PrevK` and `PrevV` are the previous `key` and associated `value` after `K` in `Assoc`.
- *The following properties should hold at call time:*

`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`PrevK` is a valid key in a `assoc_table`.	(assoc:key/1)
`PrevV` is a valid value in a `assoc_table`.	(assoc:value/1)

list_to_assoc/2: PREDICATE

Usage: `list_to_assoc(L,Assoc)`

– *Description:* Transforms `L` into `Assoc` where each pair of `L` will be a association in `Assoc`.
– *The following properties should hold at call time:*

`L` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc` is a free variable.	(term_typing:var/1)
`L` is a list of elements of the form `key-value`.	(assoc:pairs/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)

ord_list_to_assoc/2: PREDICATE

Usage: `ord_list_to_assoc(L,Assoc)`

– *Description:* Transforms `L`, a list of pairs (using the functor `-/2`) sorted by its first element, into the table `Assoc` where each pair of `L` will become a association in `Assoc`.
– *The following properties should hold at call time:*

`L` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc` is a free variable.	(term_typing:var/1)
`L` is a ordered list of elements of the form `key-value`.	(assoc:ord_pairs/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)

map_assoc/2: PREDICATE

Meta-predicate with arguments: `map_assoc((pred 1),?)`.

Usage: `map_assoc(Pred,Assoc)`

– *Description:* `Assoc` is an association tree, and for each `Key`, if `Key` is associated with `Value` in `Assoc`, Pred(Value) is true.
– *The following properties should hold at call time:*

`Pred` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)

map_assoc/3: PREDICATE

Meta-predicate with arguments: `map_assoc((pred 2),?,?)`.

Usage: `map_assoc(Pred,Assoc,NewAssoc)`

– *Description:* `Assoc` and `NewAssoc` are association trees of the same shape, and for each `Key`, if `Key` is associated with `Old` in `Assoc` and with `new` in `NewAssoc`, Pred(Old,New) is true.
– *The following properties should hold at call time:*

`Pred` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`NewAssoc` is a free variable.	(term_typing:var/1)

map/3: PREDICATE

Meta-predicate with arguments: `map(?,(pred 3),?)`.

Usage: `map(Assoc1,Pred,Assoc2)`

– *Description:* Applies `Pred` with arity 3 to each value of the assoc_table `Assoc1` obtaining the new assoc_table `Assoc2` in which only the values can have changed.
– *The following properties should hold at call time:*

`Assoc1` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Pred` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Assoc2` is a free variable. (term_typing:var/1)

foldl/4: PREDICATE

Meta-predicate with arguments: `foldl(?,?,(pred 4),?)`.

Usage: `foldl(Assoc,DS,Pred,NDS)`

– *Description:* Applies `Pred` with arity 4 to each value of the assoc_table `Assoc`. If `Pred` is satisfied, it updates the data-structure DS. Otherwise it fails.
– *The following properties should hold at call time:*

`Assoc` is currently a term which is not a free variable. (term_typing:nonvar/1)
`DS` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Pred` is currently a term which is not a free variable. (term_typing:nonvar/1)
`NDS` is a free variable. (term_typing:var/1)

put_assoc/4: PREDICATE

Usage: `put_assoc(K,Assoc,V,NewAssoc)`

– *Description:* The value `V` is inserted in `Assoc` associated to the key `K` and the result is `NewAssoc`. This can be used to insert and change associations.
– *The following properties should hold at call time:*

`K` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Assoc` is currently a term which is not a free variable. (term_typing:nonvar/1)
`V` is currently a term which is not a free variable. (term_typing:nonvar/1)
`NewAssoc` is a free variable. (term_typing:var/1)
`K` is a valid key in a `assoc_table`. (assoc:key/1)
`Assoc` is a associations beetwen keys and values. (assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`. (assoc:value/1)
`NewAssoc` is a associations beetwen keys and values. (assoc:assoc_table/1)

put_assoc/5: PREDICATE

Usage: `put_assoc(K,Assoc1,V,Assoc2,Member)`

– *Description:* The value `V` is inserted in `Assoc1` associated to the key `K` and the result is `Assoc2`. If the key `K` doesn't belong to the `Assoc1` then `Member` is unified with no. Otherwise, `Assoc2` is the result of substituting the association `K-OldValue` by `K-V` and `Member` is unified with yes(OldValue).
– *The following properties should hold at call time:*

`K` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Assoc1` is currently a term which is not a free variable. (term_typing:nonvar/1)
`V` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Assoc2` is a free variable. (term_typing:var/1)
`Member` is a free variable. (term_typing:var/1)
`K` is a valid key in a `assoc_table`. (assoc:key/1)
`Assoc1` is a associations beetwen keys and values. (assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`. (assoc:value/1)
`Assoc2` is a associations beetwen keys and values. (assoc:assoc_table/1)
`Member` is no or yes(value). (assoc:is_member/1)

add_assoc/4: PREDICATE

Usage: `add_assoc(K,Assoc1,V,Assoc2)`

– *Description:* This is similar to `put_value/5` but `Key` must not appear in `Assoc1` (`Member` in put_value/5 is known to be no). An error is thrown otherwise.
– *The following properties should hold at call time:*

`K` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Assoc1` is currently a term which is not a free variable. (term_typing:nonvar/1)
`V` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Assoc2` is a free variable. (term_typing:var/1)
`K` is a valid key in a `assoc_table`. (assoc:key/1)
`Assoc1` is a associations beetwen keys and values. (assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`. (assoc:value/1)
`Assoc2` is a associations beetwen keys and values. (assoc:assoc_table/1)

update_assoc/5: PREDICATE

Usage: `update_assoc(K,Assoc1,V,Assoc2,OldVar)`

– *Description:* This is similar to `put_assoc/5` but `Key` must not appear in `Assoc1` (`Member` in put_value/5 is known to be no). An error is thrown otherwise.
– *The following properties should hold at call time:*

`K` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Assoc1` is currently a term which is not a free variable. (term_typing:nonvar/1)
`V` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Assoc2` is a free variable. (term_typing:var/1)
`OldVar` is a free variable. (term_typing:var/1)
`K` is a valid key in a `assoc_table`. (assoc:key/1)
`Assoc1` is a associations beetwen keys and values. (assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`. (assoc:value/1)
`Assoc2` is a associations beetwen keys and values. (assoc:assoc_table/1)
`OldVar` is a valid value in a `assoc_table`. (assoc:value/1)

del_assoc/4: PREDICATE

Usage: `del_assoc(K,Assoc1,V,Assoc2)`

– *Description:* Delete in `Assoc1` the key `K` to give `Assoc2`. If the key `K` does not belong to the `Assoc1` then `Member` is unified with no and `Assoc1` and `Assoc2` are unified. Otherwise `Assoc2` is the result of deleting the key `K` and its associated `Value`, and `Member` is unified with yes(Value).

– *The following properties should hold at call time:*

`K` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Assoc1` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`V` is a free variable.	(term_typing:var/1)
`Assoc2` is a free variable.	(term_typing:var/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`Assoc1` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`V` is a valid value in a `assoc_table`.	(assoc:value/1)
`Assoc2` is a associations beetwen keys and values.	(assoc:assoc_table/1)

del_min_assoc/4: PREDICATE

Usage: `del_min_assoc(Assoc,K,V,NewAssoc)`

– *Description:* `Assoc` and `NewAssoc` define the same finite function except that `Assoc` associates `K` with `V` and `NewAssoc` doesn't associate `K` with any value and `K` precedes all other keys in `Assoc`.

– *The following properties should hold at call time:*

`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`K` is a free variable.	(term_typing:var/1)
`V` is a free variable.	(term_typing:var/1)
`NewAssoc` is a free variable.	(term_typing:var/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`V` is a valid value in a `assoc_table`.	(assoc:value/1)
`NewAssoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)

del_max_assoc/4: PREDICATE

Usage: `del_max_assoc(Assoc,K,V,NewAssoc)`

– *Description:* `Assoc` and `NewAssoc` define the same finite function except that `Assoc` associates `K` with `V` and `NewAssoc` doesn't associate `K` with any value and `K` is preceded by all other keys in `Assoc`.

– *The following properties should hold at call time:*

`Assoc` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`K` is a free variable.	(term_typing:var/1)
`V` is a free variable.	(term_typing:var/1)
`NewAssoc` is a free variable.	(term_typing:var/1)
`Assoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)
`K` is a valid key in a `assoc_table`.	(assoc:key/1)
`V` is a valid value in a `assoc_table`.	(assoc:value/1)
`NewAssoc` is a associations beetwen keys and values.	(assoc:assoc_table/1)

147 counters (library)

147.1 Usage and interface (counters)

- **Library usage:**
  `:- use_module(library(counters)).`
- **Exports:**
  - *Predicates:*
    `setcounter/2`, `getcounter/2`, `inccounter/2`.

147.2 Documentation on exports (counters)

setcounter/2: PREDICATE

No further documentation available for this predicate.

getcounter/2: PREDICATE

No further documentation available for this predicate.

inccounter/2: PREDICATE

No further documentation available for this predicate.

148 Identity lists

Author(s): Francisco Bueno.

The operations in this module handle lists by performing equality checks via identity instead of unification.

148.1 Usage and interface (idlists)

- **Library usage:**
  `:- use_module(library(idlists)).`
- **Exports:**
  - *Predicates:*
    `member_0/2`, `memberchk/2`, `list_insert/2`, `add_after/4`, `add_before/4`, `delete/3`, `subtract/3`, `union_idlists/3`.

148.2 Documentation on exports (idlists)

member_0/2: PREDICATE

`member_0(X,Xs)`

True iff memberchk/2 is true.

memberchk/2: PREDICATE

`memberchk(X,Xs)`

Checks that `X` is an element of (list) `Xs`.

list_insert/2: PREDICATE

Usage: `list_insert(List,Term)`

- *Description:* Adds `Term` to the end of (tail-opened) `List` if there is not an element in `List` identical to `Term`.
- *The following properties should hold at call time:*
  `List` is a free variable. (term_typing:var/1)
  `Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

add_after/4: PREDICATE

Usage: `add_after(L0,E0,E,L)`

- *Description:* Adds element `E` after the first element identical to `E0` (or at end) of list `L0`, returning in `L` the new list.
- *The following properties should hold at call time:*
  `L0` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `E0` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `E` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `L` is a free variable. (term_typing:var/1)

add_before/4: PREDICATE

Usage: `add_before(L0,E0,E,L)`

- *Description:* Adds element `E` before the first element identical to `E0` (or at start) of list `L0`, returning in `L` the new list.
- *The following properties should hold at call time:*

  `L0` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `E0` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `E` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `L` is a free variable. (term_typing:var/1)

delete/3: PREDICATE

Usage: `delete(List,Element,Rest)`

- *Description:* `Rest` has the same elements of `List` except for all the occurrences of elements identical to `Element`.
- *The following properties should hold at call time:*

  `List` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Element` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Rest` is a free variable. (term_typing:var/1)

subtract/3: PREDICATE

Usage: `subtract(Set,Set0,Difference)`

- *Description:* `Difference` has the same elements of `Set` except those which have an identical occurrence in `Set0`.
- *The following properties should hold at call time:*

  `Set` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Set0` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Difference` is a free variable. (term_typing:var/1)

union_idlists/3: PREDICATE

Usage: `union_idlists(List1,List2,List)`

- *Description:* `List` has the elements which are in `List1` but are not identical to an element in `List2` followed by the elements in `List2`.
- *The following properties should hold at call time:*

  `List1` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `List2` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `List` is a free variable. (term_typing:var/1)

149 Lists of numbers

Author(s): The CLIP Group.
This module implements some kinds of lists of numbers.

149.1 Usage and interface (numlists)

- **Library usage:**
  `:- use_module(library(numlists)).`
- **Exports:**
  - *Predicates:*
    `get_primes/2`, `sum_list/2`, `sum_list/3`, `sum_list_of_lists/2`, `sum_list_of_lists/3`.
  - *Regular Types:*
    `intlist/1`, `numlist/1`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

149.2 Documentation on exports (numlists)

get_primes/2: PREDICATE

Usage: `get_primes(N,Primes)`

- *Description:* Computes the `N`th first prime numbers in ascending order.
- *The following properties should hold at call time:*
  `N` is an integer. (basic_props:int/1)
- *The following properties should hold upon exit:*
  `Primes` is a list of integers. (numlists:intlist/1)

intlist/1: REGTYPE

Usage: `intlist(X)`

- *Description:* `X` is a list of integers.

numlist/1: REGTYPE

Usage: `numlist(X)`

- *Description:* `X` is a list of numbers.

sum_list/2: PREDICATE

Usage: `sum_list(List,N)`

- *Description:* `N` is the total sum of the elements of `List`.

- *The following properties should hold at call time:*
  `List` is a list of numbers. (numlists:numlist/1)
- *The following properties should hold upon exit:*
  `N` is a number. (basic_props:num/1)

sum_list/3: PREDICATE

Usage: `sum_list(List,N0,N)`

- *Description:* `N` is the total sum of the elements of `List` plus `N0`.
- *The following properties should hold at call time:*
  `List` is a list of numbers. (numlists:numlist/1)
  `N0` is a number. (basic_props:num/1)
- *The following properties should hold upon exit:*
  `N` is a number. (basic_props:num/1)

sum_list_of_lists/2: PREDICATE

Usage: `sum_list_of_lists(Lists,N)`

- *Description:* `N` is the total sum of the elements of the lists of `Lists`.
- *The following properties should hold at call time:*
  `List` is a list of `numlists`. (basic_props:list/2)
- *The following properties should hold upon exit:*
  `N` is a number. (basic_props:num/1)

sum_list_of_lists/3: PREDICATE

Usage: `sum_list_of_lists(Lists,N0,N)`

- *Description:* `N` is the total sum of the elements of the lists of `Lists` plus `N0`.
- *The following properties should hold at call time:*
  `List` is a list of `numlists`. (basic_props:list/2)
  `N0` is a number. (basic_props:num/1)
- *The following properties should hold upon exit:*
  `N` is a number. (basic_props:num/1)

150 Pattern (regular expression) matching - deprecated version

Author(s): The CLIP Group.

(Deprecated - please use the new "regexp" package instead.)

This library provides facilities for matching strings and terms against *patterns* (i.e., *regular expressions*).

150.1 Usage and interface (patterns)

- **Library usage:**
  `:- use_module(library(patterns)).`
- **Exports:**
  - *Predicates:*
    `match_pattern/2`, `match_pattern/3`, `case_insensitive_match/2`, `letter_match/2`, `match_pattern_pred/2`.
  - *Regular Types:*
    `pattern/1`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

150.2 Documentation on exports (patterns)

match_pattern/2: PREDICATE

Usage: `match_pattern(Pattern,String)`

- *Description:* Matches `String` against `Pattern`. For example, `match_pattern("*.pl","foo.pl")` succeeds.
- *The following properties should hold at call time:*

  `Pattern` is a pattern to match against. (patterns:pattern/1)

  `String` is a string (a list of character codes). (basic_props:string/1)

match_pattern/3: PREDICATE

Usage: `match_pattern(Pattern,String,Tail)`

- *Description:* Matches `String` against `Pattern`. `Tail` is the remainder of the string after the match. For example, `match_pattern("??*","foo.pl",Tail)` succeeds, instantiating `Tail` to `"o.pl"`.
- *The following properties should hold at call time:*

  `Pattern` is a pattern to match against. (patterns:pattern/1)

  `String` is a string (a list of character codes). (basic_props:string/1)

  `Tail` is a string (a list of character codes). (basic_props:string/1)

case_insensitive_match/2: PREDICATE

Usage: `case_insensitive_match(Pred1,Pred2)`

– *Description:* Tests if two predicates `Pred1` and `Pred2` match in a case-insensitive way.

letter_match/2: PREDICATE

Usage: `letter_match(X,Y)`

– *Description:* True iff `X` and `Y` represents the same letter

pattern/1: REGTYPE

Special characters for `Pattern` are:

*	Matches any string, including the null string.
?	Matches any single character.
[...]	Matches any one of the enclosed characters. A pair of characters separated by a minus sign denotes a range; any character lexically between those two characters, inclusive, is matched. If the first character following the [is a ^ then any character not enclosed is matched. No other character is special inside this construct. To include a] in a character set, you must make it the first character. To include a '-', you must use it in a context where it cannot possibly indicate a range: that is, as the first character, or immediately after a range.
|	Specifies an alternative. Two patterns A and B with | in between form an expression that matches anything that either A or B will match.
{...}	Groups alternatives inside larger patterns.
\	Quotes a special character (including itself).

Usage: `pattern(P)`

– *Description:* `P` is a pattern to match against.

match_pattern_pred/2: PREDICATE

Usage: `match_pattern_pred(Pred1,Pred2)`

– *Description:* Tests if two predicates `Pred1` and `Pred2` match using regular expressions.

151 Graphs

Author(s): Francisco Bueno.
This module implements utilities for work with graphs

151.1 Usage and interface (graphs)

- **Library usage:**
  `:- use_module(library(graphs)).`
- **Exports:**
  - *Predicates:*
    `dgraph_to_ugraph/2`, `dlgraph_to_lgraph/2`, `edges_to_ugraph/2`, `edges_to_lgraph/2`.
  - *Regular Types:*
    `dgraph/1`, `dlgraph/1`.
- **Other modules used:**
  - *System library modules:*
    `sort`, `graphs/ugraphs`, `graphs/lgraphs`.

151.2 Documentation on exports (graphs)

dgraph/1: REGTYPE

`dgraph(Graph)`

A directed graph is a term `graph(V,E)` where `V` is a list of vertices and `E` is a list of edges (none necessarily sorted). Edges are pairs of vertices which are directed, i.e., `(a,b)` represents `a->b`. Two vertices `a` and `b` are equal only if `a==b`.

Usage: `dgraph(Graph)`

- *Description:* `Graph` is a directed graph.

dlgraph/1: REGTYPE

`dlgraph(Graph)`

A labeled directed graph is a directed graph where edges are triples of the form `(a,l,b)` where `l` is the label of the edge `(a,b)`.

Usage: `dlgraph(Graph)`

- *Description:* `Graph` is a directed labeled graph.

dgraph_to_ugraph/2: PREDICATE

Usage: `dgraph_to_ugraph(Graph,UGraph)`

- *Description:* Converts `Graph` to `UGraph`.

– *The following properties should hold at call time:*
`Graph` is currently a term which is not a free variable. (term_typing:nonvar/1)
`UGraph` is a free variable. (term_typing:var/1)
`Graph` is a directed graph. (graphs:dgraph/1)
`UGraph` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Graph` is a directed graph. (graphs:dgraph/1)
`UGraph` is an ugraph. (ugraphs:ugraph/1)

dlgraph_to_lgraph/2: PREDICATE

Usage: `dlgraph_to_lgraph(Graph,LGraph)`

– *Description:* Converts `Edges` to `LGraph`.
– *The following properties should hold at call time:*
`Graph` is currently a term which is not a free variable. (term_typing:nonvar/1)
`LGraph` is a free variable. (term_typing:var/1)
`Graph` is a directed labeled graph. (graphs:dlgraph/1)
`LGraph` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Graph` is a directed labeled graph. (graphs:dlgraph/1)
`LGraph` is a labeled graph of `term` terms. (lgraphs:lgraph/2)

edges_to_ugraph/2: PREDICATE

Usage: `edges_to_ugraph(Edges,UGraph)`

– *Description:* Converts `Graph` to `UGraph`.
– *The following properties should hold at call time:*
`Edges` is currently a term which is not a free variable. (term_typing:nonvar/1)
`UGraph` is a free variable. (term_typing:var/1)
`Edges` is a list of `pair`s. (basic_props:list/2)
`UGraph` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Edges` is a list of `pair`s. (basic_props:list/2)
`UGraph` is an ugraph. (ugraphs:ugraph/1)

edges_to_lgraph/2: PREDICATE

Usage: `edges_to_lgraph(Edges,LGraph)`

– *Description:* Converts `Edges` to `LGraph`.
– *The following properties should hold at call time:*
`Edges` is currently a term which is not a free variable. (term_typing:nonvar/1)
`LGraph` is a free variable. (term_typing:var/1)
`Edges` is a list of `triple`s. (basic_props:list/2)
`LGraph` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Edges` is a list of `triple`s. (basic_props:list/2)
`LGraph` is a labeled graph of `term` terms. (lgraphs:lgraph/2)

151.3 Documentation on internals (graphs)

pair/1: REGTYPE

Usage: `pair(P)`

– *Description:* `P` is a pair `(_,_)`.

triple/1: REGTYPE

Usage: `triple(P)`

– *Description:* `P` is a triple `(_,_,_)`.

152 Unweighted graph-processing utilities

Author(s): Richard A. O'Keefe (original shared code), Mats Carlsson (adapted from original code), Francisco Bueno (modifications), Manuel Carro (modifications).

An unweighted directed graph (ugraph) is represented as a list of (vertex-neighbors) pairs, where the pairs are in standard order (as produced by keysort with unique keys) and the neighbors of each vertex are also in standard order (as produced by sort), and every neighbor appears as a vertex even if it has no neighbors itself.

An undirected graph is represented as a directed graph where for each edge `(U,V)` there is a symmetric edge `(V,U)`.

An edge `(U,V)` is represented as the term `U-V`.

A vertex can be any term. Two vertices are distinct iff they are not identical (`==/2`).

A path is represented as a list of vertices. No vertex can appear twice in a path.

152.1 Usage and interface (ugraphs)

- **Library usage:**
  `:- use_module(library(ugraphs)).`
- **Exports:**
  - *Predicates:*
    `vertices_edges_to_ugraph/3`, `neighbors/3`, `edges/2`, `del_edges/3`, `add_edges/3`, `vertices/2`, `del_vertices/3`, `add_vertices/3`, `transpose/2`, `rooted_subgraph/3`, `point_to/3`.
  - *Regular Types:*
    `ugraph/1`.
- **Other modules used:**
  - *System library modules:*
    `sets`, `sort`.

152.2 Documentation on exports (ugraphs)

vertices_edges_to_ugraph/3: PREDICATE

No further documentation available for this predicate.

neighbors/3: PREDICATE

Usage: `neighbors(Vertex,Graph,Neighbors)`

- *Description:* Is true if `Vertex` is a vertex in `Graph` and `Neighbors` are its neighbors.
- *The following properties should hold at call time:*

`Vertex` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Graph` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Neighbors` is a free variable.	(term_typing:var/1)

edges/2: PREDICATE

Usage: `edges(Graph,Edges)`

- *Description:* Unifies `Edges` with the edges in `Graph`.
- *The following properties should hold at call time:*

  `Graph` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Edges` is a free variable. (term_typing:var/1)

del_edges/3: PREDICATE

Usage: `del_edges(Graph1,Edges,Graph2)`

- *Description:* Is true if `Graph2` is `Graph1` with `Edges` removed from it.
- *The following properties should hold at call time:*

  `Graph1` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Edges` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Graph2` is a free variable. (term_typing:var/1)

add_edges/3: PREDICATE

Usage: `add_edges(Graph1,Edges,Graph2)`

- *Description:* Is true if `Graph2` is `Graph1` with `Edges` and their 'to' and 'from' vertices added to it.
- *The following properties should hold at call time:*

  `Graph1` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Edges` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Graph2` is a free variable. (term_typing:var/1)

vertices/2: PREDICATE

Usage: `vertices(Graph,Vertices)`

- *Description:* Unifies `Vertices` with the vertices in `Graph`.
- *The following properties should hold at call time:*

  `Graph` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Vertices` is a free variable. (term_typing:var/1)

del_vertices/3: PREDICATE

Usage: `del_vertices(Graph1,Vertices,Graph2)`

- *Description:* Is true if `Graph2` is `Graph1` with `Vertices` and all edges to and from `Vertices` removed from it.
- *The following properties should hold at call time:*

  `Graph1` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Vertices` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Graph2` is a free variable. (term_typing:var/1)

add_vertices/3: PREDICATE

Usage: `add_vertices(Graph1,Vertices,Graph2)`

- *Description:* Is true if `Graph2` is `Graph1` with `Vertices` added to it.
- *The following properties should hold at call time:*

  `Graph1` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Vertices` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Graph2` is a free variable. (term_typing:var/1)

transpose/2: PREDICATE

Usage: `transpose(Graph,Transpose)`

- *Description:* Is true if `Transpose` is the graph computed by replacing each edge `(u,v)` in `Graph` by its symmetric edge `(v,u)`. It can only be used one way around. The cost is O(N^2).
- *The following properties should hold at call time:*

  `Graph` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Transpose` is a free variable. (term_typing:var/1)

rooted_subgraph/3: PREDICATE

Usage: `rooted_subgraph(Graph,Sources,SubGraph)`

- *Description:* `SubGraph` is the subgraph of `Graph` which is reachable from `Sources`.
- *The following properties should hold at call time:*

  `Graph` is an ugraph. (ugraphs:ugraph/1)

  `Sources` is a list. (basic_props:list/1)

  `SubGraph` is a free variable. (term_typing:var/1)
- *The following properties hold upon exit:*

  `SubGraph` is an ugraph. (ugraphs:ugraph/1)

point_to/3: PREDICATE

Usage: `point_to(Vertex,Graph,Point_to)`

- *Description:* Is true if `Point_to` is the list of nodes which go directly to `Vertex` in `Graph`.
- *The following properties should hold at call time:*

  `Vertex` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Graph` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Point_to` is a free variable. (term_typing:var/1)

ugraph/1: REGTYPE

Usage: `ugraph(Graph)`

- *Description:* `Graph` is an ugraph.

153 wgraphs (library)

153.1 Usage and interface (wgraphs)

- **Library usage:**
  `:- use_module(library(wgraphs)).`
- **Exports:**
  - *Predicates:*
    `vertices_edges_to_wgraph/3`.
- **Other modules used:**
  - *System library modules:*
    `sets`, `sort`.

153.2 Documentation on exports (wgraphs)

vertices_edges_to_wgraph/3: PREDICATE

No further documentation available for this predicate.

154 Labeled graph-processing utilities

Author(s): Francisco Bueno.
See the comments for the `ugraphs` library.

154.1 Usage and interface (`lgraphs`)

- **Library usage:**
  `:- use_module(library(lgraphs)).`
- **Exports:**
  - *Predicates:*
    `vertices_edges_to_lgraph/3`.
  - *Regular Types:*
    `lgraph/2`.
- **Other modules used:**
  - *System library modules:*
    `sort`, `sets`.

154.2 Documentation on exports (`lgraphs`)

lgraph/2: REGTYPE

Usage: `lgraph(Graph,Type)`

- *Description:* `Graph` is a labeled graph of `Type` terms.

vertices_edges_to_lgraph/3: PREDICATE

`vertices_edges_to_lgraph(Vertices0,Edges,Graph)`

This one is a copy of the same procedure in library(wgraphs) except for the definition of min/3 (ah! - the polimorphism!).

It would only be needed if there are multi-edges, i.e., several edges between the same two vertices.

155 queues (library)

155.1 Usage and interface (queues)

- **Library usage:**
  `:- use_module(library(queues)).`
- **Exports:**
  - *Predicates:*
    `q_empty/1`, `q_insert/3`, `q_member/2`, `q_delete/3`.

155.2 Documentation on exports (queues)

q_empty/1: PREDICATE

No further documentation available for this predicate.

q_insert/3: PREDICATE

No further documentation available for this predicate.

q_member/2: PREDICATE

No further documentation available for this predicate.

q_delete/3: PREDICATE

No further documentation available for this predicate.

156 Random numbers

Author(s): Daniel Cabeza.
This module provides predicates for generating pseudo-random numbers

156.1 Usage and interface (random)

- **Library usage:**
  `:- use_module(library(random)).`
- **Exports:**
  - *Predicates:*
    `random/1`, `random/3`, `srandom/1`.
- **Other modules used:**
  - *System library modules:*
    `foreign_interface/foreign_interface_properties`.

156.2 Documentation on exports (random)

random/1: PREDICATE

`random(Number)`

`Number` is a (pseudo-) random number in the range [0.0,1.0]

Usage:

- *The following properties should hold at call time:*
  `Number` is a free variable. (term_typing:var/1)
- *The following properties hold upon exit:*
  `Number` is currently instantiated to a float. (term_typing:float/1)
- *The following properties hold globally:*
  The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

random/3: PREDICATE

`random(Low,Up,Number)`

`Number` is a (pseudo-) random number in the range [`Low`, `Up`]

Usage 1:

- *Description:* If `Low` and `Up` are integers, `Number` is an integer.
- *The following properties should hold at call time:*
  `Low` is an integer. (basic_props:int/1)
  `Up` is an integer. (basic_props:int/1)
  `Number` is a free variable. (term_typing:var/1)
- *The following properties hold upon exit:*
  `Number` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

Usage 2:

– *The following properties should hold at call time:*

`Low` is a float. (basic_props:flt/1)

`Up` is a number. (basic_props:num/1)

`Number` is a free variable. (term_typing:var/1)

– *The following properties hold upon exit:*

`Number` is a float. (basic_props:flt/1)

Usage 3:

– *The following properties should hold at call time:*

`Low` is an integer. (basic_props:int/1)

`Up` is a float. (basic_props:flt/1)

`Number` is a free variable. (term_typing:var/1)

– *The following properties hold upon exit:*

`Number` is a float. (basic_props:flt/1)

srandom/1: PREDICATE

`srandom(Seed)`

Changes the sequence of pseudo-random numbers according to `Seed`. The stating sequence of numbers generated can be duplicated by calling the predicate with `Seed` unbound (the sequence depends on the OS).

Usage:

– *Calls should, and exit will be compatible with:*

`Seed` is an integer. (basic_props:int/1)

– *The following properties hold upon exit:*

`Seed` is an integer. (basic_props:int/1)

– *The following properties hold globally:*

The Prolog predicate `PrologName` is implemented using the function `ForeignName`. The same considerations as above example are to be applied. (foreign_interface_properties:foreign_low/2)

157 Set Operations

Author(s): Lena Flood.
This module implements set operations. Sets are just ordered lists.

157.1 Usage and interface (sets)

- **Library usage:**
  `:- use_module(library(sets)).`
- **Exports:**
  - *Predicates:*
    `insert/3`, `ord_delete/3`, `ord_member/2`, `ord_test_member/3`, `ord_subtract/3`, `ord_intersection/3`, `ord_intersection_diff/4`, `ord_intersect/2`, `ord_subset/2`, `ord_subset_diff/3`, `ord_union/3`, `ord_union_diff/4`, `ord_union_symdiff/4`, `ord_union_change/3`, `merge/3`, `ord_disjoint/2`, `setproduct/3`.
- **Other modules used:**
  - *System library modules:*
    `sort`.

157.2 Documentation on exports (sets)

insert/3: PREDICATE

Usage: `insert(Set1,Element,Set2)`

- *Description:* It is true when `Set2` is `Set1` with `Element` inserted in it, preserving the order.
- *The following properties should hold at call time:*
  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Element` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Set2` is a free variable. (term_typing:var/1)

ord_delete/3: PREDICATE

Usage: `ord_delete(Set0,X,Set)`

- *Description:* It succeeds if `Set` is `Set0` without element `X`.
- *The following properties should hold at call time:*
  `Set0` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `X` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Set` is a free variable. (term_typing:var/1)

ord_member/2: PREDICATE

Usage: `ord_member(X,Set)`

- *Description:* It succeeds if `X` is member of `Set`.

– *The following properties should hold at call time:*
`X` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Set` is currently a term which is not a free variable. (term_typing:nonvar/1)

ord_test_member/3: PREDICATE

Usage: `ord_test_member(Set,X,Result)`

– *Description:* If `X` is member of `Set` then `Result=yes`. Otherwise `Result=no`.
– *The following properties should hold at call time:*
`Set` is currently a term which is not a free variable. (term_typing:nonvar/1)
`X` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Result` is a free variable. (term_typing:var/1)

ord_subtract/3: PREDICATE

Usage: `ord_subtract(Set1,Set2,Difference)`

– *Description:* It is true when `Difference` contains all and only the elements of `Set1` which are not also in `Set2`.
– *The following properties should hold at call time:*
`Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)

ord_intersection/3: PREDICATE

Usage: `ord_intersection(Set1,Set2,Intersection)`

– *Description:* It is true when `Intersection` is the ordered representation of `Set1` and `Set2`, provided that `Set1` and `Set2` are ordered lists.
– *The following properties should hold at call time:*
`Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)

ord_intersection_diff/4: PREDICATE

Usage: `ord_intersection_diff(Set1,Set2,Intersect,NotIntersect)`

– *Description:* `Intersect` contains those elements which are both in `Set1` and `Set2`, and `NotIntersect` those which are in `Set1` but not in `Set2`.
– *The following properties should hold at call time:*
`Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Intersect` is a free variable. (term_typing:var/1)
`NotIntersect` is a free variable. (term_typing:var/1)

ord_intersect/2: PREDICATE

Usage: `ord_intersect(Xs,Ys)`

- *Description:* Succeeds when the two ordered lists have at least one element in common.
- *The following properties should hold at call time:*

  `Xs` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Ys` is currently a term which is not a free variable. (term_typing:nonvar/1)

ord_subset/2: PREDICATE

Usage: `ord_subset(Xs,Ys)`

- *Description:* Succeeds when every element of `Xs` appears in `Ys`.
- *The following properties should hold at call time:*

  `Xs` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Ys` is currently a term which is not a free variable. (term_typing:nonvar/1)

ord_subset_diff/3: PREDICATE

Usage: `ord_subset_diff(Set1,Set2,Difference)`

- *Description:* It succeeds when every element of `Set1` appears in `Set2` and `Difference` has the elements of `Set2` which are not in `Set1`.
- *The following properties should hold at call time:*

  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Difference` is a free variable. (term_typing:var/1)

ord_union/3: PREDICATE

Usage: `ord_union(Set1,Set2,Union)`

- *Description:* It is true when `Union` is the union of `Set1` and `Set2`. When some element occurs in both sets, `Union` retains only one copy.
- *The following properties should hold at call time:*

  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)

ord_union_diff/4: PREDICATE

Usage: `ord_union_diff(Set1,Set2,Union,Difference)`

- *Description:* It succeeds when `Union` is the union of `Set1` and `Set2`, and `Difference` is `Set2` set-minus `Set1`.
- *The following properties should hold at call time:*

  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Union` is a free variable. (term_typing:var/1)

  `Difference` is a free variable. (term_typing:var/1)

ord_union_symdiff/4: PREDICATE

Usage: `ord_union_symdiff(Set1,Set2,Union,Diff)`

- *Description:* It is true when Diff is the symmetric difference of Set1 and Set2, and Union is the union of Set1 and Set2.
- *The following properties should hold at call time:*

  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Union` is a free variable. (term_typing:var/1)
  `Diff` is a free variable. (term_typing:var/1)

ord_union_change/3: PREDICATE

Usage: `ord_union_change(Set1,Set2,Union)`

- *Description:* `Union` is the union of `Set1` and `Set2` and `Union` is different from `Set2`.
- *The following properties should hold at call time:*

  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Union` is a free variable. (term_typing:var/1)

merge/3: PREDICATE

Usage: `merge(Set1,Set2,Union)`

- *Description:* See `ord_union/3`.
- *The following properties should hold at call time:*

  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)

ord_disjoint/2: PREDICATE

Usage: `ord_disjoint(Set1,Set2)`

- *Description:* `Set1` and `Set2` have no element in common.
- *The following properties should hold at call time:*

  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)

setproduct/3: PREDICATE

Usage: `setproduct(Set1,Set2,Product)`

- *Description:* `Product` has all two element sets such that one element is in `Set1` and the other in `set2`, except that if the same element belongs to both, then the corresponding one element set is in `Product`.
- *The following properties should hold at call time:*

  `Set1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Set2` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Product` is a free variable. (term_typing:var/1)

158 Variable name dictionaries

Author(s): Francisco Bueno, Edison Mera.

158.1 Usage and interface (vndict)

- **Library usage:**
  `:- use_module(library(vndict)).`
- **Exports:**
  - *Predicates:*
    `create_dict/2`, `create_pretty_dict/2`, `complete_dict/3`, `complete_vars_dict/3`, `prune_dict/3`, `sort_dict/2`, `dict2varnamesl/2`, `varnamesl2dict/2`, `find_name/4`, `prettyvars/2`, `rename/2`, `vars_names_dict/3`.
  - *Regular Types:*
    `null_dict/1`, `varnamedict/1`.
- **Other modules used:**
  - *System library modules:*
    `varnames/dict_types`, `idlists`, `terms_vars`, `sets`, `sort`.

158.2 Documentation on exports (vndict)

null_dict/1: REGTYPE

Usage: `null_dict(D)`

- *Description:* `D` is an empty dictionary.

create_dict/2: PREDICATE

Usage: `create_dict(Term,Dict)`

- *Description:* `Dict` has names for all variables in `Term`.
- *The following properties should hold at call time:*
  `Term` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*
  `Dict` is a dictionary of variable names. (vndict:varnamedict/1)

create_pretty_dict/2: PREDICATE

Usage: `create_pretty_dict(Term,Dict)`

- *Description:* `Dict` has names for all variables in `Term`. The difference with `create_dict/2` is that prettier names are generated
- *The following properties should hold at call time:*
  `Term` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*
  `Dict` is a dictionary of variable names. (vndict:varnamedict/1)

complete_dict/3: PREDICATE

Usage: `complete_dict(Dict,Term,NewDict)`

- *Description:* `NewDict` is `Dict` augmented with the variables of `Term` not yet in `Dict`.
- *The following properties should hold at call time:*

  `Dict` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `NewDict` is a free variable. (term_typing:var/1)

complete_vars_dict/3: PREDICATE

Usage: `complete_vars_dict(Dict,Vars,NewDict)`

- *Description:* `NewDict` is `Dict` augmented with the variables of the list `Vars` not yet in `Dict`.
- *The following properties should hold at call time:*

  `Dict` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Vars` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `NewDict` is a free variable. (term_typing:var/1)

prune_dict/3: PREDICATE

Usage: `prune_dict(Term,Dict,NewDict)`

- *Description:* `NewDict` is `Dict` reduced to just the variables of `Term`.
- *The following properties should hold at call time:*

  `Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Dict` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `NewDict` is a free variable. (term_typing:var/1)

sort_dict/2: PREDICATE

Usage: `sort_dict(D,Dict)`

- *Description:* `D` is sorted into `Dict`.
- *The following properties should hold at call time:*

  `D` is a dictionary of variable names. (vndict:varnamedict/1)
- *The following properties should hold upon exit:*

  `Dict` is a dictionary of variable names. (vndict:varnamedict/1)

dict2varnamesl/2: PREDICATE

Usage: `dict2varnamesl(Dict,VNs)`

- *Description:* Translates `Dict` to `VNs`.
- *The following properties should hold at call time:*

  `Dict` is a dictionary of variable names. (vndict:varnamedict/1)
- *The following properties should hold upon exit:*

  `VNs` is a list of `Name=Var` pairs, where `Var` is a variable and `Name` its name. (dict_types:varnamesl/1)

varnamesl2dict/2: PREDICATE

Usage: `varnamesl2dict(VNs,Dict)`

- *Description:* Translates `VNs` to `Dict`.
- *The following properties should hold at call time:*

  `VNs` is a list of `Name=Var` pairs, where `Var` is a variable and `Name` its name. (dict_types:varnamesl/1)
- *The following properties should hold upon exit:*

  `Dict` is a dictionary of variable names. (vndict:varnamedict/1)

find_name/4: PREDICATE

`find_name(Vars,Names,V,Name)`

Given that `vars_names_dict(Dict,Vars,Names)` holds, it acts as `rename(X,Dict)`, but the name of `X` is given as `Name` instead of unified with it.

prettyvars/2: PREDICATE

Usage:

- *Description:* Give names to the variables in the term `Term` using the dictionary `Dict`. Intended to replace `prettyvars/1` in those places where is possible to get the dictionary of variables.
- *Call and exit should be compatible with:*

  `Arg1` is any term. (basic_props:term/1)

  `Arg2` is a list of `Name=Var` pairs, where `Var` is a variable and `Name` its name. (dict_types:varnamesl/1)
- *The following properties should hold at call time:*

  `Arg2` is currently a term which is not a free variable. (term_typing:nonvar/1)

rename/2: PREDICATE

Usage: `rename(Term,Dict)`

- *Description:* Unifies each variable in `Term` with its name in `Dict`. If no name is found, a new name is created.
- *The following properties should hold at call time:*

  `Dict` is a dictionary of variable names. (vndict:varnamedict/1)

varnamedict/1: REGTYPE

Usage: `varnamedict(D)`

- *Description:* `D` is a dictionary of variable names.

vars_names_dict/3: PREDICATE

Usage: `vars_names_dict(Dict,Vars,Names)`

- *Description:* `Varss` is a sorted list of variables, and `Names` is a list of their names, which correspond in the same order.

– *Call and exit should be compatible with:*
`Dict` is a dictionary of variable names. (vndict:varnamedict/1)
`Vars` is a list. (basic_props:list/1)
`Names` is a list. (basic_props:list/1)

PART X - Miscellaneous standalone utilities

Author(s): , The Computational logic, Languages, , Implementation, and Parallelism (CLIP) Lab, `http://www.cliplab.org/`, `webmaster@clip.dia.fi.upm.es`, School of CS, T. U. of Madrid (UPM), IMDEA Software Institute.

This is the documentation for a set of miscellaneous standalone utilities contained in the `etc` directory of the Ciao distribution.

159 Automatic configuration module -base predicates

Author(s): Edison Mera.

This module is used to load automatically the modules contained in the folder components when a program starts. This can be used to define path aliases. Such modules can also define the extra components of a system.

159.1 Usage and interface (autoconfig)

- **Library usage:**
  `:- use_module(library(autoconfig)).`
- **Exports:**
  - *Predicates:*
    `component_description/4`, `main_lpdoc_settings/2`, `component_src/2`, `file_search_path_auto/2`, `library_directory_auto/1`, `component_ins/2`, `show_components/0`, `autoconfig_components/0`, `cleanup_autoconfig_db/0`, `load_components_sysavail/1`, `load_autoconfig_db/1`, `load_autoconfig_loop/0`, `process_autoconfig_fact/1`, `load_config_protected/1`, `handle_autoconfig_error/2`, `component_list/3`.
  - *Multifiles:*
    `file_search_path/2`, `library_directory/1`, `Amfclause/2`.
- **Other modules used:**
  - *System library modules:*
    `system`, `format`, `messages`, `read`, `streams`, `autoconfig/autoconfig_base`.

159.2 Documentation on exports (autoconfig)

component_description/4: PREDICATE

No further documentation available for this predicate.

The predicate is of type *data*.

main_lpdoc_settings/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *data*.

component_src/2: PREDICATE

Usage:

- *Description:* Gets the path name where the sources of the component reside.

file_search_path_auto/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *data*.

library_directory_auto/1: PREDICATE

No further documentation available for this predicate.

The predicate is of type *data*.

component_ins/2: PREDICATE

Usage:

– *Description:* Gets the path name where the component is installed.

show_components/0: PREDICATE

No further documentation available for this predicate.

autoconfig_components/0: PREDICATE

No further documentation available for this predicate.

cleanup_autoconfig_db/0: PREDICATE

No further documentation available for this predicate.

load_components_sysavail/1: PREDICATE

No further documentation available for this predicate.

load_autoconfig_db/1: PREDICATE

No further documentation available for this predicate.

load_autoconfig_loop/0: PREDICATE

No further documentation available for this predicate.

process_autoconfig_fact/1: PREDICATE

No further documentation available for this predicate.

load_config_protected/1: PREDICATE

No further documentation available for this predicate.

handle_autoconfig_error/2: PREDICATE

No further documentation available for this predicate.

component_list/3: PREDICATE

No further documentation available for this predicate.

159.3 Documentation on multifiles (`autoconfig`)

file_search_path/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *dynamic*.

library_directory/1: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *dynamic*.

Λmfclause/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *data*.

160 A Program to Help Cleaning your Directories

Author(s): Manuel Carro.

A simple program for traversing a directory tree and deciding which files may be deleted in order to save space and not to loose information.

160.1 Usage (cleandirs)

```
cleandirs [--silent] <initial_dir> <delete_options> <backup_options>
cleandirs explores <initial_dir> (which should be an absolute path)
and looks for backup files and files which can be generated from other
files, using a plausible heuristic aimed at retaining the same amount
of information while recovering some disk space.  The heuristic is
based on the extension of the filename.

Delete options is one of:
   --list: just list the files/directories which are amenable to be deleted,
           but do not delete them. SAFE.
    --ask: list the files/directories and ask for deletion. UNSAFE if you
           make a mistake.
 --delete: just delete the files/directories without asking.  I envy your
           brave soul if you choose this option.

Backup options is one of:
 --includebackups: include backup files in the list of files to check.
 --excludebackups: do not include backup files in the list of files
                   to check.
    --onlybackups: include only backup files in the list of files to check.

Symbolic links are not traversed.  Special files are not checked.
```

Invoking the program with no arguments will return an up-to-date information on the options.

160.2 Known bugs and planned improvements (`cleandirs`)

- Recursive removal of subdirectories relies on the existence of a recursive /bin/rm command in your system.

161 Printing the declarations and code in a file

Author(s): Manuel Hermenegildo.

A simple program for printing assertion information (predicate declarations, property declarations, type declarations, etc.) and printing code-related information (imports, exports, libraries used, etc.) on a file. The file should be a single Ciao or Prolog source file. It uses the Ciao compiler's pass one to do it. This program is specially useful for example for checking what assertions the assertion normalizer is producing from the original assertions in the file or to check what the compiler is actually seeing after some of the syntactic expansions (but before goal translations).

161.1 Usage (fileinfo)

```
fileinfo -asr <filename.asr>
   : pretty prints the contents of <filename.asr>

fileinfo [-v] [-m] <-a|-f|-c|-e> <filename> [libdir1] ... [libdirN]
-v : verbose output (e.g., lists all files read)
-m : restrict info to current module
-a : print assertions
-f : print code and interface (imports/exports, etc.)
-c : print code only
-e : print only errors - useful to check syntax of assertions in file

fileinfo -h
   : print this information

Note that system lib paths *must* be given explicitly, e.g. :

fileinfo -m -c foo.pl \
         /home/clip/System/ciao/lib \
         /home/clip/System/ciao/library \
```

161.2 More detailed explanation of options (fileinfo)

- If the `-a` option is selected, `fileinfo` prints the assertions (only code-oriented assertions – not comment-oriented assertions) in the file *after normalization*. If the `-f` option is selected `fileinfo` prints the file interface, the declarations contained in the file, and the actual code. The `-c` option prints only the code. If the `-e` option is selected `fileinfo` prints only any sintactic and import-export errors found in the file, including the assertions.
- `filename` must be the name of a Prolog or Ciao source file.
- This filename can be followed by other arguments which will be taken to be library directory paths in which to look for files used by the file being analyzed.
- If the `-m` option is selected, only the information related to the current module is printed.
- The `-v` option produces verbose output. This is very useful for debugging, since all the files accessed during assertion normalization are listed.
- In the `-asr` usage, `fileinfo` can be used to print the contents of a `.asr` file in human-readable form.

162 Printing the contents of a bytecode file

Author(s): Daniel Cabeza.

This simple program takes as an argument a bytecode (.po) file and prints out in symbolic form the information contained in the file. It uses compiler and engine builtins to do so, so that it keeps track with changes in bytecode format.

162.1 Usage (viewpo)

```
viewpo <file1>.po
   : print .po contents in symbolic form

viewpo -h
   : print this information
```

163 callgraph (library)

163.1 Usage and interface (callgraph)

- **Library usage:**
  `:- use_module(library(callgraph)).`
- **Exports:**
  - *Predicates:*
    `call_graph/2`, `reachability/4`.
- **Other modules used:**
  - *System library modules:*
    `assertions/c_itf_props`, `sets`, `terms`, `graphs/ugraphs`, `xrefs/xrefsread`.

163.2 Documentation on exports (callgraph)

call_graph/2: PREDICATE

Usage: `call_graph(File,Graph)`

- *Description:* `Graph` is the call-graph of the code in `File`.
- *The following properties should hold at call time:*
  `File` is an atom describing the name of a file. (c_itf_props:filename/1)
  `Graph` is a free variable. (term_typing:var/1)
- *The following properties hold upon exit:*
  `Graph` is an ugraph. (ugraphs:ugraph/1)

reachability/4: PREDICATE

Usage: `reachability(Graph,Sources,Reached,UnReached)`

- *Description:* `Reached` are the vertices in `Graph` reachable from `Sources`, `UnReached` are the rest.
- *The following properties should hold at call time:*
  `Graph` is an ugraph. (ugraphs:ugraph/1)
  `Sources` is a list. (basic_props:list/1)
  `Reached` is a free variable. (term_typing:var/1)
  `UnReached` is a free variable. (term_typing:var/1)

164 Gathering the dependent files for a file

Author(s): Daniel Cabeza, Manuel Hermenegildo.

This simple program takes a single Ciao or Prolog source filename (which is typically the main file of an application). It prints out the list of all the dependent files, i.e., all files needed in order to build the application, including those which reside in libraries. This is particularly useful in Makefiles, for building standalone distributions (e.g., .tar files) automatically.

The filename should be followed by other arguments which will be taken to be library directory paths in which to look for files used by the file being analyzed.

164.1 Usage (get_deps)

```
get_deps [-u <filename>] <filename> [lib_dir1] ... [lib_dirN]
           : return dependent files for <filename>
             found in [lib_dir1] ... [lib_dirN]

get_deps -h
           : print this information
```

165 Finding differences between two Prolog files

Author(s): Francisco Bueno.

This simple program works like the good old diff but for files that contain Prolog code. It prints out the clauses that it finds are different in the files. Its use avoids textual differences such as different variable names and different formatting of the code in the files.

165.1 Usage (pldiff)

```
pldiff <file1> <file2>
   : find differences

pldiff -h
   : print this information
```

but you can also use the program as a library and invoke the predicate:

```
pldiff( <filename> , <filename> )
```

165.2 Known bugs and planned improvements (pldiff)

- Currently uses variant/2 to compare clauses. This is useful, but there should be an option to select the way clauses are compared, e.g., some form of equivalence defined by the user.

166 The Ciao lpmake scripting facility

Author(s): Manuel Hermenegildo, The CLIP Group, clip@dia.fi.upm.es, http://www.clip.dia.fi.upm.es/, Facultad de Informática, Universidad Politécnica de Madrid.

Note: lpmake and the make library are still under development, and they may change in future releases.

lpmake is a Ciao application which uses the Ciao make library to implement a dependency-driven scripts in a similar way to the Un*x make facility.

The original purpose of the Un*x make utility is to determine automatically which pieces of a large program needed to be recompiled, and issue the commands to recompile them. In practice, make is often used for many other purposes: it can be used to describe any task where some files must be updated automatically from others whenever these change. lpmake can be used for the same types of applications as make, and also for some new ones, and, while being simpler, it offers a number of advantages over make. The first one is *portability*. When compiled to a bytecode executable lpmake runs on any platform where a Ciao engine is available. Also, the fact that typically many of the operations are programmed in Prolog within the makefile, not needing external applications, improves portability further. The second advantage of lpmake is *improved programming capabilities*. While lpmake is simpler than make, lpmake allows using the Ciao Prolog language within the scripts. This allows establising more complex dependencies and programming powerful operations within the make file, and without resorting to external packages (e.g., operating system commands), which also helps portability. A final advantage of lpmake is that it supports a form of *autodocumentation*: comments associated to targets can be included in the configuration files. Calling lpmake in a directory which has such a configuration file explains what commands the configuration file support and what these commands will do.

166.1 General operation

To prepare to use lpmake, and in a similar way to make, you must write a *configuration file*: a module (typically called Makefile.pl) that describes the relationships among files in your program or application, and states the commands for updating each file. In the case of compiling a program, typically the executable file is obtained from object files, which are in turn obtained by compiling source files. Another example is running latex and dvips on a set of source .tex files to generate a document in dvi and postscript formats.

Once a suitable make file exists, each time you change some source files, simply typing lpmake suffices to perform all necessary operations (recompilations, processing text files, etc.). The lpmake program uses the dependency rules in the makefile and the last modification times of the files to decide which of the files need to be updated. For each of those files, it issues the commands recorded in the makefile. For example, in the latex/ dvips case one rule states that the .dvi file whould be updated from the .tex files whenever one of them changes and another rule states that the .ps file needs to be updated from a .dvi file every time it changes. The rules also describe the commands to be issued to update the files.

So, the general process is as follows: lpmake executes commands in the configuration file to update one or more target *names*, where *name* is often a program, but can also be a file to be generated or even a "virtual" target. lpmake updates a target if it depends on prerequisite files that have been modified since the target was last modified, or if the target does not exist. You can provide command line arguments to lpmake to control which files should be regenerated, or how.

166.2 Format of the Configuration File

`lpmake` uses as default configuration file the file `Makefile.pl`, if it is present in the current directory. This can be overridden and another file used by means of the `-m` option. The configuration file must be a *module* and this module must make use of the `make` package. This package provides syntax for defining the dependency rules and functionality for correctly interpreting these rules.

The configuration file can contain such rules and also arbitrary Ciao Prolog predicates, and can also import other Ciao modules, packages, or make file. This is useful to implement inherintance across diferent configuration files, i.e., the values declared in a configuration file can be easily made to override those defined in another, using the standard Ciao rules for module overriding, reexport, etc. The syntax of the rules is described in Chapter 91 [The Ciao Make Package], page 479, together with some examples.

166.3 lpmake usage

```
Supported command line options:

lpmake [-v] [-d Name1=Value1] ... [-d Namen=Valuen] \
<command1> ... <commandn>

  Process commands <command1> ... <commandn>, using file 'Makefile.pl'
  or directory 'installer' in the current directory as configuration
  file. The configuration file must be a module.

  The optional argument '-v' produces verbose output, reporting on the
  processing of the dependency rules.  Very useful for debugging
  makefiles.

  The argument '-d' indicates that a variable definition Name=Value
  follows.  The effect of this is adding the fact 'name_value(Name, Value).'
  (i.e., 'name_value(Name) := Value.'), defined in the module
  library(make(make_rt)).

lpmake [-v] [-d Name1=Value1] ... [-d Namen=Valuen] \
[[-m|-l] <.../Configfile1.pl>] [[-m|-l] <.../Configfilen.pl>] \
        <command1> ... <commandn>

  Same as above, but using files <.../Configfilex.pl> as configuration
  file. One or more configuration files can be used. When using more
  than one configuration file, the additional configuration files are
  loaded dynamically into the first one with the predicate
  register_config_file/1.  Using -l instead of -m indicates that this
  configuration file is a library module (i.e., it will be looked for
  in the libraries).

lpmake -h     [ [-m|-l] <.../Configfile.pl> ]
lpmake -help  [ [-m|-l] <.../Configfile.pl> ]
lpmake --help [ [-m|-l] <.../Configfile.pl> ]
```

```
Print this help message. If a configuration file is available in the
current directory or is given as an option, and the commands in it
are commented, then information on these commands is also printed.
```

166.4 Acknowledgments (lpmake)

Some parts of the documentation are taken from the documentation of GNU's gmake.

166.5 Known bugs and planned improvements (lpmake)

- Rename or add a default directory makedir/Makedir, instead of installer directory, as recommended by Manuel Herme. – EMM

167 Find out which architecture we are running on

Author(s): Manuel Carro, Robert Manchek.

The architecure and operating system the engine is compiled for determines whether we can use or not certain libraries. This script, taken from a PVM distribution, uses a heuristic (which may need to be tuned from time to time) to find out the platform. It returns a string which is used throughout the engine (in #ifdefs) to enable/disable certain characteristics.

167.1 Usage (ciao_get_arch)

```
Usage: ciao_get_arch
```

167.2 More details (ciao_get_arch)

Look at the script itself...

168 Print out WAM code

Author(s): Manuel Carro.

This program prints to standard output a symbolic form of the Wam code the compiler generates for a given source file.

168.1 Usage (compiler_output)

```
Print WAM code for a .pl file

Usage: compiler_output <file.pl>
```

169 Compile Ciao in an arbitrary subdirectory

Author(s): Manuel Carro.

A simple bash script for compile the whole Ciao distribution, in order to test automatically whether something is broken.

169.1 Usage (auto_compile_ciao)

```
Usage: auto_compile_ciao ciaodir_name destdir_name
```

169.2 More details (auto_compile_ciao)

The script copies the ciao distribution passed on as first argument to a subdirectory of the directory name passed as second argument. The subdirectory is always the same, in order to speed up tests made repeteadly in a distribution. It also deletes from the destination files which do not appear any longer in the sources, and tries not to copy files which will eventually be generated or deleted prior to compilation.

After that, the `SETTINGS` file is updated to reflect the new location, the sources are cleaned up, and a regular compilation is started.

170 Gathering all modules in a directory

Author(s): Daniel Cabeza, Manuel Carro.

A simple bash script for collecting files which are modules, in order to compile automatically the CIAO libraries.

170.1 Usage (collect_modules)

```
Usage: collect_modules module_name
```

170.2 More details (collect_modules)

Look at the Makefiles in lib and library

PART XI - Contributed libraries

Author(s): The CLIP Group.

This part includes a number of libraries which have contributed by users of the Ciao system. Over time, some of these libraries are moved to the main library directories of the system.

171 Block Declarations

Author(s): Rémy Haemmerlé.
Version: 0.1 (2008/25/5)
This package provides compatibility with SICStus' block declarations

171.1 Usage and interface (block_doc)

- **Library usage:**
  `:- use_package(block).`
  or
  `:- module(...,...,[block]).`
- **New operators defined:**
  `block/1` [1150,fx].
- **New declarations defined:**
  `block/1`.

171.2 Documentation on new declarations (block_doc)

block/1: DECLARATION

Usage: :- `block(BlockSpecs)`.

– *Description:* In this declaration `BlockSpecs` specifies a disjunction of conditions. Each condition is of the form `predname(C1, ..., CN)` where each `CI` is either a '`-`' if the call must suspend until the corresponding argument is bound, or anything else otherwise.

– *Convention:* The recommended style is to write the block declarations in front of the source code of the predicate they refer to. Indeed, they are part of the source code of the predicate and must precede the first clause. Moreover it is suggested to use '`?`' for specifying non conditioned arguments.

– *Example :* The following definition calls to `merge/3` having uninstantiated arguments in the first and third position or in the second and third position will suspend.

```
:- block merge(-,?,-), merge(?,-,-).

merge([], Y, Y).
merge(X, [], X).
merge([H|X], [E|Y], [H|Z]) :- H @< E,  merge(X, [E|Y], Z).
merge([H|X], [E|Y], [E|Z]) :- H @>= E, merge([H|X], Y, Z).
```

– *The following properties hold at call time:*
`BlockSpecs` is a sequence or list of `callables`. (basic_props:sequence_or_list/2)

172 A Chart Library

Author(s): Isabel Martín García.

This library is intended to eaose the task of displaying some graphical results. This library allows the programmer to visualize different graphs and tables without knowing anything about specific graphical packages.

You need to install the BLT package in your computer. BLT is an extension to the Tk toolkit and it does not require any patching of the Tcl or Tk source files. You can find it in `http://www.tcltk.com/blt/index.html`

Basically, when the user invokes a predicate, the library (internally) creates a bltwish interpreter and passes the information through a socket to display the required widget. The interpreter parses the received commands and executes them.

The predicates exported by this library can be classified in four main groups, according to the types of representation they provide.

- bar charts
- line graphs
- scatter graphs
- tables

To represent graphs, the Cartesian coordinate system is used. I have tried to show simple samples for every library exported predicate in order to indicate how to call them.

172.1 Bar charts

In this section we shall introduce the general issues about the set of barchart predicates. By calling the predicates that pertain to this group a bar chart for plotting two-dimensional data (X-Y coordinates) can be created. A bar chart is a graphic means of comparing numbers by displaying bars of lengths proportional to the y-coordinates they represented. The barchart widget has many configurable options such as title, header text, legend and so on. You can configure the appearance of the bars as well. The bar chart widget has the following components:

Header text
: The text displayed at the top of the window. If it is `''` no text will be displayed.

Save button
: The button placed below the header text. Pops up a dialog box for the user to select a file to save the graphic in PostScript format.[1]

Bar chart title
: The title of the graph. It is displayed at the top of the bar chart graph. If text is `''` no title will be displayed.

X axis title
: X axis title. If text is `''` no x axis title will be displayed.

Y axis title
: Y axis title. If text is `''` no y axis title will be displayed.

X axis
: X coordinate axis. The x axis is drawn at the bottom margin of the bar chart graph. The x axis consists of the axis line, ticks and tick labels. Tick labels can be numbers or plain text. If the labels are numbers, they could be displayed at uniform intervals (the numbers are treated as normal text) or depending on its x-coodinate value. You can also set limits (maximum and minimum) for the x axis, but only if the tick labels are numeric.

[1] Limitation: Some printers can have problems if the PostScript file is too complex (i.e. too many points/lines appear in the picture).

Y axis
: Y coordinate axis. You can set limits (maximum and minimum) for the y axis. The y axis is drawn at the right margin of the bar chart graph.The y axis consists of the axis line, ticks and tick labels. The tick labels are numeric values determined from the data and are drawn at uniform intervals.

Bar chart graph
: This is the plotting area, placed in the center of the window and surrounded by the axes, the axis titles and the legend (if any). The range of the axes controls what region of the data is plotted. By default, the minimum and maximum limits are determined from the data, but you can set them (as mentioned before). Data points outside the minimum and maximum value of the axes are not plotted.

Legend
: The legend displays the name and symbol of each bar. The legend is placed in the right margin of the Bar chart graph.

Footer text
: Text displayed at the lower part of the window. If text is '' no header text will be displayed.

Quit button
: Button placed below the footer text. Click it to close the window.

All of them are arranged in a window. However you can, for example, show a bar chart window without legend or header text. Other configuration options will be explained later.

In addition to the window appearance there is another important issue about the bar chart window, namely its behaviour in response to user actions. The association user actions to response is called *bindings*. The main bindings currently specified are the following:

Default bindings
: Those are well known by most users. They are related to the frame displayed around the window. As you know, you can interactively move, resize, close, iconify, deiconify, send to another desktop etc. a window.

Bindings related to bar chart graph and its legend
: Clicking the left mouse key over a legend element, the corresponding bar turns out into red. After clicking again, the bar toggles to its original look. In addition, you can do zoom-in by pressing the left mouse key over the bar chart graph and dragging to select an area. To zoom out simply press the right mouse button.

  When the pointer passes over the plotting area the cross hairs are drawn. The cross hairs consists of two intersecting lines (one vertical and one horizontal). Besides, if the pointer is over a legend element, its background changes.

Bindings related to buttons
: There are two buttons in the main widget. Clicking the mouse on the Save button a "Save as" dialog box is popped up. The user can select a file to save the graph. If the user choose a file that already exists, the dialog box prompts the user for confirmation on whether the existing file should be overwritten or not. Furthermore, you can close the widget by clicking on the Quit button.

  When the pointer passes over a button the button color changes.

The predicates that belong to this group are those whose names begin with **barchart** and **genmultibar**. If you take a look at the predicate names that pertain to this group, you will notice that they are not self-explanatory. It would have been better to name the predicates in a way that allows the user to identify the predicate features by its name, but it would bring about very long names (i.e barchart_WithoutLegend_BarsAtUniformIntervals_RandomBarsColors). For this reason I decided to simply add a number after barchart to name them.

172.2 Line graphs

It is frequently the case that several datasets need to be displayed on the same plot. If so, you may wish to distinguish the points in different datasets by joining them by lines of different color, or by plotting with symbols of different types. This set of predicates allows the programmer to represent two-dimensional data (X-Y coordinates). Each dataset contains x and y vectors containing the coordinates of the data. You can configure the appearance of the points and the lines which the points are connected with. The configurable line graph components are:

line graph
: This is the plotting area, placed in the center of the window and surrounded by the axes, the axes titles and the legend (if any). The range of the axes controls what region of the data is plotted. By default, the minimum and maximum limits are determined from the data, but you can set them. Data points outside the minimum and maximum value of the axes are not plotted. You can specify how connecting line segments joining successive datapoints are drawn by setting the `Smooth` argument. Smooth can be either linear, step, natural and quadratic. Furthermore, you can select the appearance of the points and lines.

Legend
: The legend displays the name and symbol of each line. The legend is placed in the right margin of the graph.

The elements header, footer, quit and save buttons, the titles and the axes are quite similar to those in barchart graphs, except in that the tick labels will be numbers. All of them are arranged in a window by the geometry manager. However you can, as we mentioned in the above paragraphs, show a line graph window without any titles or footer text. Other configuration options will be explained later in this section or in the corresponding modules.

Related to the behaviour of the widgets in response to user actions (bindings) we will remark the following features:

Bindings related to line graph and its legend
: Clicking the left mouse key over a legend element, the corresponding line turns out into blue. Repeating the action reverts the line to its original color. Moreover, you can do zoom-in by clicking the left mouse key over the bar chart graph and dragging a rectangle defining the area you want to zoom in. To zoom out simply press the right mouse button.

  When the pointer passes over the plotting area the cross hairs are drawn. The cross hairs consists of two intersecting lines (one vertical and one horizontal). Besides, if the pointer is over a legend element, its background changes.

Other bindings
: The default bindings and the bindings related to the save and quit buttons are similar to those in the bar chart graphs.

The predicates that belong to this group are those whose names begin with **graph_**.

172.3 Scatter graphs

The challenge of this section is to introduce some general aspects about the scatter graph predicates group. By invoking the scatter graph predicates the user can represent two-dimensional point datasets. Often you need to display one or several point datasets on the same plot. If so, you may wish to distinguish the points that pertain to different datasets by using plotting symbols of different types, or by displaying them in different colors. This set of predicates allows you to represent two-dimensional data (X-Y coordinates). Each dataset contains x and y vectors containing the coordinates of the data. You can configure the appearance of the points. The configurable scatter graph components are:

scatter graph
: This is the plotting area, placed in the center of the window and surrounded by the axes, the axes titles and the legend (if any). The range of the axes controls what region of the data is plotted. By default, the minimum and maximum limits are determined from the data, but you can set them (as we mentioned before). Data points outside the minimum and maximum value of the axes are not plotted. The user can select the appearance of the points.

Legend
: The legend displays the name and symbol of each point dataset. The legend is drawn in the right margin of the graph.

The elements header, footer, quit and save buttons, the titles and the axes are similar to those in barchart graphs except for that, as in line graphs, the tick labels will be numbers. All of them are arranged in a window by the geometry manager. However you can, for example, show a scatter graph window without titles or footer text, as we mentioned before. Other configuration options will be explained later, in the corresponding modules.

Related to the behaviour of the widgets in response to user actions (bindings) the following features are:

Bindings related to scatter graph and its legend
: Clicking the left mouse key over a legend element, the points which belong to the corresponding dataset turn out into blue. Repeating the action toggles the point dataset to its original color. Moreover, you can do zoom-in by clicking the left mouse key over the bar chart graph and dragging a rectangle defining the area you want to zoom-in on. To do zoom-out simply press the right mouse button.

  When the pointer passes over the plotting area the cross hairs are drawn. The cross hairs consists of two intersecting lines (one vertical and one horizontal). Besides, if the pointer is over a legend element, its background changes.

Other bindings
: The default bindings and the bindings related to the save and quit buttons are similar to those in the bar chart graphs.

The predicates that belong to this group are those whose names began with **scattergraph_**.

172.4 Tables

The purpose of this section is to allow the user to display results in a table. A table is a regular structure in which:

- Every row has the same number of columns, or
- Every column has the same number of rows.

The widget configurable components are as follows:

Title
: Title of the widget, it is displayed centered at the top of the canvas. If text is '' no title will be displayed.

Header text
: Left centered text displayed bellow the title. If text is '' no header text will be displayed.

Table
: Is placed in the center of the window. The table is composed by cells ordered in rows and columns. The cell values can be either any kind of text or numbers and they can be empty as well (see the type definition in the corresponding chapter module). A table is a list of lists. Each sublist is a row, so every sublist in the table must contain the same number of alements.

Footer text
: Left centered text displayed at the lower part of the window. If text is '' no header text will be displayed.

Quit button
: Button placed below the footer text. You can click it to close the window.

If the arguments are not in a correct format an exception will be thrown. Moreover, these widgets have the default bindings and the binding related to the quit button:

The set of predicates that belongs to this group are those which names begin with **table_widget**.

172.5 Overview of widgets

Although you don't have to worry about how to arrange the widgets, here is an overview of how Tcl-tk, the underlying graphical system currently used by chartlib, performs this task. Quoting from the book *Tcl and Tk toolkit*, John K. Ousterhout.

The X Window System provides many facilities for manipulating windows in displays. The root window may have any number of child windows, each of wich is called a top-level window. Top-level windows may have children of their own, wich may have also children, and so on. The descendants of top-level windows are called internal windows. Internal windows are usedfor individual controls such as buttons, text entries, and for grouping controls together. An X-application tipically manages several top-level windows. Tk uses X to implement a set of controls with the Motif look and feel. These controls are called widgets. Each widget is implemented using one X window, and the terms "window" and "widget" will be used interchangeably in this document. As with windows, widgets are nested in hierarchical structures. In this library top-level widgets (nonleaf or main) are just containers for organizing and arranging the leaf widgets (components). Thereby, the barchart widget is a top-level window wich contains some widget components.

Probably the most painstaking aspect of building a graphical application is getting the placement and size of the widgets just right. It usually takes many iterations to align widgets and adjust their spacing. That's because managing the geometry of widgets is simply not a packing problem, but also graphical design problem. Attributes such as alignment, symmetry, and balance are more important than minimizing the amount of space used for packing. Tk is similar to other X toolkits in that it does not allow widgets to determine their own geometries. A widget will not even appeared unless it is managed by a geometry manager. This separation of geometry management from internal widget behaviour allows multiple geometry managers to exist simultaneously and permits any widget to be used with any geometry manager. A geometry manager's job is to arrange one or more *slave* widgets relative to a *master* widgets. There are some geometry managers in Tk such as pack, place and canvas widget. We will use another one call table.

The table geometry manager arranges widgets in a table. It's easy to align widgets (horizontally and vertically) or to create empty space to balance the arrangement of the widgets. Widgets (called slaves in the Tk parlance) are arranged inside a containing widget (called the master). Widgets are positioned at row,column locations and may span any number of rows or columns. More than one widget can occupy a single location. The placement of widget windows determines both the size and arrangement of the table. The table queries the requested size of each widget. The requested size of a widget is the natural size of the widget (before the widget is shrunk or expanded). The height of each row and the width of each column is the largest widget spanning that row or column. The size of the table is in turn the sum of the row and column sizes. This is the table's normal size. The total number of rows and columns in a table is determined from the indices specified. The table grows dynamically as windows are added at larger indices.

172.6 Usage and interface (chartlib)

- **Library usage:**
  `:- use_module(library(chartlib)).`
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/genbar2`, `chartlib/genbar3`, `chartlib/genbar4`, `chartlib/genmultibar`, `chartlib/table_widget1`, `chartlib/table_widget2`, `chartlib/table_widget3`, `chartlib/table_widget4`, `chartlib/gengraph1`, `chartlib/gengraph2`, `chartlib/chartlib_errhandle`.

172.7 Documentation on exports (chartlib)

barchart1/7: (UNDOC_REEXPORT)
Imported from `genbar1` (see the corresponding documentation for details).

barchart1/9: (UNDOC_REEXPORT)
Imported from `genbar1` (see the corresponding documentation for details).

percentbarchart1/7: (UNDOC_REEXPORT)
Imported from `genbar1` (see the corresponding documentation for details).

barchart2/7: (UNDOC_REEXPORT)
Imported from `genbar2` (see the corresponding documentation for details).

barchart2/11: (UNDOC_REEXPORT)
Imported from `genbar2` (see the corresponding documentation for details).

percentbarchart2/7: (UNDOC_REEXPORT)
Imported from `genbar2` (see the corresponding documentation for details).

barchart3/7: (UNDOC_REEXPORT)
Imported from `genbar3` (see the corresponding documentation for details).

barchart3/9: (UNDOC_REEXPORT)
Imported from `genbar3` (see the corresponding documentation for details).

percentbarchart3/7: (UNDOC_REEXPORT)
Imported from `genbar3` (see the corresponding documentation for details).

barchart4/7: (UNDOC_REEXPORT)
Imported from `genbar4` (see the corresponding documentation for details).

barchart4/11: (UNDOC_REEXPORT)
Imported from `genbar4` (see the corresponding documentation for details).

percentbarchart4/7: (UNDOC_REEXPORT)
Imported from `genbar4` (see the corresponding documentation for details).

multibarchart/8: (UNDOC_REEXPORT)
Imported from `genmultibar` (see the corresponding documentation for details).

multibarchart/10: (UNDOC_REEXPORT)
Imported from `genmultibar` (see the corresponding documentation for details).

tablewidget1/4: (UNDOC_REEXPORT)
Imported from `table_widget1` (see the corresponding documentation for details).

tablewidget1/5: (UNDOC_REEXPORT)
Imported from `table_widget1` (see the corresponding documentation for details).

tablewidget2/4: (UNDOC_REEXPORT)
Imported from `table_widget2` (see the corresponding documentation for details).

tablewidget2/5: (UNDOC_REEXPORT)
Imported from `table_widget2` (see the corresponding documentation for details).

tablewidget3/4: (UNDOC_REEXPORT)
Imported from `table_widget3` (see the corresponding documentation for details).

tablewidget3/5: (UNDOC_REEXPORT)
Imported from `table_widget3` (see the corresponding documentation for details).

tablewidget4/4: (UNDOC_REEXPORT)
Imported from `table_widget4` (see the corresponding documentation for details).

tablewidget4/5: (UNDOC_REEXPORT)
Imported from `table_widget4` (see the corresponding documentation for details).

graph_b1/9: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

graph_b1/13: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

graph_w1/9: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

graph_w1/13: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

scattergraph_b1/8: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

scattergraph_b1/12: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

scattergraph_w1/8: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

scattergraph_w1/12: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

graph_b2/9: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

graph_b2/13: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

graph_w2/9: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

graph_w2/13: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

scattergraph_b2/8: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

scattergraph_b2/12: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

scattergraph_w2/8: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

scattergraph_w2/12: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

chartlib_text_error_protect/1: (UNDOC_REEXPORT)
Imported from `chartlib_errhandle` (see the corresponding documentation for details).

chartlib_visual_error_protect/1: (UNDOC_REEXPORT)
Imported from `chartlib_errhandle` (see the corresponding documentation for details).

172.8 Known bugs and planned improvements (`chartlib`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

173 Low level Interface between Prolog and blt

Author(s): Isabel Martín García.

This module exports some predicates to interact with Tcl-tk, particularly with the bltwish program. Bltwish is a windowing shell consisting of the Tcl command languaje, the Tk toolkit plus the additional commands that comes with the BLT library and a main program that reads commands. It creates a main window and then processes Tcl commands.

173.1 Usage and interface (`bltclass`)

- **Library usage:**
  `:- use_module(library(bltclass)).`
- **Exports:**
  - *Predicates:*
    `new_interp/1`, `tcltk_raw_code/2`, `interp_file/2`.
  - *Regular Types:*
    `bltwish_interp/1`.
- **Other modules used:**
  - *System library modules:*
    `strings`.

173.2 Documentation on exports (`bltclass`)

new_interp/1: PREDICATE

`new_interp(Interp)`

Creates a bltwish interprter and returns a socket. The socket allows the comunication between Prolog and Tcl-tk. Thus, bltwish receives the commands through the socket.

Usage:

- *The following properties should hold at call time:*
  `Interp` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  bltclass:bltwish_interp(Interp) (bltclass:bltwish_interp/1)

tcltk_raw_code/2: PREDICATE

`tcltk_raw_code(Command_Line,Interp)`

Sends a command line to the interpreter. Tcl-tk parses and executes it.

Usage:

- *The following properties should hold at call time:*
  `Command_Line` is a string (a list of character codes). (basic_props:string/1)
  bltclass:bltwish_interp(Interp) (bltclass:bltwish_interp/1)

bltwish_interp/1: REGTYPE

`bltwish_interp(Interp)`

This type defines a bltwish interpreter. In fact, the bltwish interpreter receives the commands through the socket created.

```
bltwish_interp(Interp) :-
        stream(Interp).
```

interp_file/2: PREDICATE

`interp_file(File,Interp)`

Sends the script file (File) to the interpreter through the socket. A script file is a file that contains commands that Tcl-tk can execute.

Usage:

– *The following properties should hold at call time:*

`File` is a source name. (streams_basic:sourcename/1)

bltclass:bltwish_interp(Interp) (bltclass:bltwish_interp/1)

174 Error Handler for Chartlib

Author(s): Isabel Martín García.

This module is an error handler. If the format of the arguments is not correct in a call to a chartlib predicate an exception will be thrown . You can wrap the chartlib predicates with the predicates exported by this module to handle automatically the errors if any.

174.1 Usage and interface (`chartlib_errhandle`)

- **Library usage:**
  `:- use_module(library(chartlib_errhandle)).`
- **Exports:**
  - *Predicates:*
    `chartlib_text_error_protect/1`, `chartlib_visual_error_protect/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/bltclass`, `chartlib/install_utils`.

174.2 Documentation on exports (`chartlib_errhandle`)

chartlib_text_error_protect/1: PREDICATE

`chartlib_text_error_protect(G)`

This predicate catches the thrown exception and sends it to the appropiate handler. The handler will show the error message in the standard output.

Meta-predicate with arguments: `chartlib_text_error_protect(goal)`.

Usage:

- *The following properties should hold at call time:*
  `G` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

chartlib_visual_error_protect/1: PREDICATE

`chartlib_visual_error_protect(G)`

This predicate catches the thrown exception and sends it to the appropiate handler. The handler will pop up a message box.

Meta-predicate with arguments: `chartlib_visual_error_protect(goal)`.

Usage:

- *The following properties should hold at call time:*
  `G` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

174.3 Documentation on internals (chartlib_errhandle)

handler_type/1: REGTYPE

`handler_type(X)`

The library chartlib includes two error handlers already programmed.

```
handler_type(text).
handler_type(visual).
```

error_message/2: PREDICATE

`error_message(ErrorCode,ErrorMessage)`

Binds the error code with its corresponding text message.

Usage:

– *The following properties should hold at call time:*

`ErrorCode` is an atom. (basic_props:atm/1)

`ErrorMessage` is an atom. (basic_props:atm/1)

error_file/2: PREDICATE

`error_file(ErrorCode,ErrorFile)`

Binds the error code with its corresponding script error file.

Usage:

– *The following properties should hold at call time:*

`ErrorCode` is an atom. (basic_props:atm/1)

`ErrorFile` is an atom. (basic_props:atm/1)

175 Color and Pattern Library

Author(s): Isabel Martín García.

This module contains predicates to access and check conformance to the available colors and patterns.

175.1 Usage and interface (color_pattern)

- **Library usage:**
  `:- use_module(library(color_pattern)).`
- **Exports:**
  - *Predicates:*
    `color/2`, `pattern/2`, `random_color/1`, `random_lightcolor/1`, `random_darkcolor/1`, `random_pattern/1`.
  - *Regular Types:*
    `color/1`, `pattern/1`.
- **Other modules used:**
  - *System library modules:*
    `random/random`.

175.2 Documentation on exports (color_pattern)

color/1: REGTYPE

```
color(Color)
    color('GreenYellow').
    color('Yellow').
    color('White').
    color('Wheat').
    color('BlueViolet').
    color('Violet').
    color('MediumTurquoise').
    color('DarkTurquoise').
    color('Turquoise').
    color('Thistle').
    color('Tan').
    color('Sienna').
    color('Salmon').
    color('VioletRed').
    color('OrangeRed').
    color('MediumVioletRed').
    color('IndianRed').
    color('Red').
    color('Plum').
    color('Pink').
    color('MediumOrchid').
    color('DarkOrchid').
```

```
color('Orchid').
color('Orange').
color('Maroon').
color('Magenta').
color('Khaki').
color('Grey').
color('LightGray').
color('DimGray').
color('DarkSlateGray').
color('YellowGreen').
color('SpringGreen').
color('SeaGreen').
color('PaleGreen').
color('MediumSpringGreen').
color('MediumSeaGreen').
color('LimeGreen').
color('ForestGreen').
color('DarkOliveGreen').
color('DarkGreen').
color('Green').
color('Goldenrod').
color('Gold').
color('Brown').
color('Firebrick').
color('Cyan').
color('Coral').
color('SteelBlue').
color('SlateBlue').
color('SkyBlue').
color('Navy').
color('MidnightBlue').
color('MediumSlateBlue').
color('MediumBlue').
color('LightSteelBlue').
color('LightBlue').
color('DarkSlateBlue').
color('CornflowerBlue').
color('CadetBlue').
color('Blue').
color('Black').
color('MediumAquamarine').
color('Aquamarine').
```

Defines available colors for elements such as points, lines or bars.

color/2: PREDICATE

Usage: `color(C1,C2)`

– *Description:* Test whether the color `C1` is a valid color or not. If `C1` is a variable the predicate will choose a valid color randomly. If `C1` is a ground term that is not a valid color an exception (error9) will be thrown

- *The following properties should hold at call time:*
  color_pattern:color(C1) (color_pattern:color/1)
- *The following properties should hold upon exit:*
  color_pattern:color(C2) (color_pattern:color/1)

pattern/1: REGTYPE

`pattern(Pattern)`

```
pattern(pattern1).
pattern(pattern2).
pattern(pattern3).
pattern(pattern4).
pattern(pattern5).
pattern(pattern6).
pattern(pattern7).
pattern(pattern8).
pattern(pattern9).
```

Defines valid patterns used in the stipple style bar attribute.

pattern/2: PREDICATE

Usage: `pattern(P1,P2)`

- *Description:* Test whether the pattern `P1` is a valid pattern or not. If `P1` is a variable the predicate will choose a valid pattern randomly. If `P1` is a ground term that is not a valid pattern an exception (error10) will be thrown.
- *The following properties should hold at call time:*
  color_pattern:pattern(P1) (color_pattern:pattern/1)
- *The following properties should hold upon exit:*
  color_pattern:pattern(P2) (color_pattern:pattern/1)

random_color/1: PREDICATE

`random_color(Color)`

This predicate choose a valid color among the availables randomly.

Usage:

- *The following properties should hold at call time:*
  color_pattern:color(Color) (color_pattern:color/1)

random_lightcolor/1: PREDICATE

`random_lightcolor(Color)`

This predicate choose a valid light color among the availables randomly.

Usage:

- *The following properties should hold at call time:*
  `Color` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  color_pattern:color(Color) (color_pattern:color/1)

random_darkcolor/1: PREDICATE

`random_darkcolor(Color)`

This predicate choose a valid dark color among the availables randomly.

Usage:

- *The following properties should hold at call time:*
  `Color` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  color_pattern:color(Color) (color_pattern:color/1)

random_pattern/1: PREDICATE

`random_pattern(Pattern)`

This predicate choose a valid pattern among the availables randomly.

Usage:

- *The following properties should hold at call time:*
  `Pattern` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  color_pattern:pattern(Pattern) (color_pattern:pattern/1)

176 Barchart widgets - 1

Author(s): Isabel Martín García.

This module defines predicates to show barchart widgets. The three predicates exported by this module plot two-variable data as regular bars in a window. They all share the following features:

- No numeric values for the `x` axis are needed because they will be interpreted as labels. See `xbarelement1/1` definition type.
- The bars will be displayed at uniform intervals.
- The user can either select the appearance of the bars (background color, foreground color and stipple style) or not. See the `xbarelement1` type definition. Thus, the user can call each predicate in two ways.
- The bar chart has a legend. One entry (symbol and label) per bar.
- If you don't want to display text in the elements header, barchart title, x axis title, y axis title or footer, simply type `''` as the value of the argument.
- The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error1` or `error3` will be thrown, depending on the error type. `error1` means that `XVector` and `YVector` do not contain the same number of elements and `error3` indicates that not all the `XVector` elements contain a correct number of attributes .

Particular features will be pointed out in the corresponding predicate.

176.1 Usage and interface (genbar1)

- **Library usage:**
  `:- use_module(library(genbar1)).`
- **Exports:**
  - *Predicates:*
    `barchart1/7`, `barchart1/9`, `percentbarchart1/7`.
  - *Regular Types:*
    `yelement/1`, `axis_limit/1`, `header/1`, `title/1`, `footer/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/bltclass`, `chartlib/test_format`, `chartlib/color_pattern`, `chartlib/install_utils`, `lists`, `random/random`.

176.2 Documentation on exports (genbar1)

barchart1/7: PREDICATE

`barchart1(Header,BarchartTitle,XTitle,XVector,YTitle,YVector,Footer)`

The `y` axis range is determined from the limits of the data. Two examples are given to demonstrate clearly how to call the predicates. In the first example the user sets the bar appearance, in the second one the appearance features will be chosen by the system and

the colors that have been assigned to the variables Color1, Color2 and Pattern will be shown also.

Example 1:

```
barchart1('This is the header text',
  'Barchart title',
  'xaxistitle',
  [ ['bar1','legend_element1','Blue','Yellow','pattern1'],
          ['bar2','legend_element2','Plum','SeaGreen','pattern2'],
          ['bar3','legend_element3','Turquoise','Yellow',
    'pattern5'] ],
  'yaxixtitle',
  [20,10,59],
  'footer').
```

Example 2:

```
barchart1('This is the header text',
  'Barchart title',
  'xaxistitle',
  [ ['element1','legend_element1',Color1,Color2,Pattern],
           ['element2','legend_element2'],
           ['element3','legend_element3'] ],
  'yaxixtitle',
  [20,10,59],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`BarchartTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xbarelement1`s. (basic_props:list/2)

`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVector` is a list of `yelements`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

barchart1/9: PREDICATE

`barchart1(Header,BTitle,XTitle,XVector,YTitle,YVector,YMax,YMin,Footer)`

You can set the minimum and maximum limits of the `y` axis. Data outside the limits will not be plotted. Each limit, as you can check by looking at the `axis_limit/1` definition, is a number. If the argument is a variable the limit will be calculated from the data (i.e., if `YMax` value is YValueMax the maximum y axis limit will calculated using the largest data value).

Example:

```
barchart1('This is the header text',
  'Barchart title',
  'xaxistitle',
  [ ['element1','e1','Blue','Yellow','pattern1'],
      ['element2','e2','Turquoise','Plum','pattern5'],
```

```
    ['element3','e3','Turquoise','Green','pattern5'] ],
'yaxixtitle',
[20,10,59],
70,
_,
'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`BTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xbarelement1`s. (basic_props:list/2)

`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVector` is a list of `yelements`. (basic_props:list/2)

genbar1:axis_limit(YMax) (genbar1:axis_limit/1)

genbar1:axis_limit(YMin) (genbar1:axis_limit/1)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

percentbarchart1/7: PREDICATE

`percentbarchart1(Header,BTitle,XTitle,XVector,YTitle,YVector,Footer)`

The y axis maximum coordinate value is 100. The `x` axis limits are automatically worked out.

Example:

```
percentbarchart1('This is a special barchart to represent percentages',
  'Barchart with legend',
  'My xaxistitle',
  [ [1,'bar1','Blue','Yellow','pattern1'],
       [8,'bar2','MediumTurquoise','Plum','pattern5'] ],
  'My yaxixtitle',
  [80,10],
  'This is the footer text').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`BTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xbarelement1`s. (basic_props:list/2)

`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVector` is a list of `yelements`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

yelement/1: REGTYPE

```
yelement(Y) :-
        number(Y).
```

Y is the bar lenght, so it must be a numeric value.

Both Prolog and Tcl-Tk support integers and floats. Integers are usually specified in decimal, but if the first character is 0 the number is read in octal (base 8), and if the first two characters are 0x, the number is read in hexadecimal (base16). Float numbers may be specified using most of the forms defined for ANSI C, including the following examples:

- 9.56
- 5.88e-2
- 5.1E2

Note: Be careful when using floats. While 8. or 7.e4 is interpreted by Tcl-tk as 8.0 and 7.0e4, Prolog will not read them as float numbers. Example:

```
?- number(8.e+5).
{SYNTAX ERROR: (lns 130-130) , or ) expected in arguments
number ( 8
** here **
. e + 5 ) .
}

no
?- number(8.).
{SYNTAX ERROR: (lns 138-138) , or ) expected in arguments
number ( 8
** here **
. ) .
}

no

?- number(8.0e+5).

yes
?- number(8.0).

yes
```

Precision: Tcl-tk internally represents integers with the C type `int`, which provides at least 32 bits of precision on most machines. Since Prolog integers can (in some implementations) exceed 32 bits but the precision in Tcl-tk depends on the machine, it is up to the progammer to ensure that the values fit into the maximum precision of the machine for integers. Real numbers are represented with the C type `double`, which is usually represented with 64-bit values (about 15 decimal digits of precision) using the IEEE Floating Point Standard.

Conversion: If the list is composed by integers and floats, Tcl-tk will convert integers to floats.

axis_limit/1: REGTYPE

```
axis_limit(X) :-
        number(X).
```

```
axis_limit(_1).
```

This type is defined in order to set the minimum and maximum limits of the axes. Data outside the limits will not be plotted. Each limit, is a number or a variable. If the argument is not a number the limit will be calculated from the data (i.e., if YMax value is `Var` the maximum y axis limit will be calculated using the largest data value).

header/1: REGTYPE

Usage: `header(X)`

– *Description:* `X` is a text (an atom) describing the header of the graph.

title/1: REGTYPE

Usage: `title(X)`

– *Description:* `X` is a text (an atom) to be used as label, usually not very long.

footer/1: REGTYPE

Usage: `footer(X)`

– *Description:* `X` is a text (an atom) describing the footer of the graph.

176.3 Documentation on internals (genbar1)

xbarelement1/1: REGTYPE

```
xbarelement1([XValue,LegendElement]) :-
        atomic(XValue),
        atomic(LegendElement).
xbarelement1([XValue,LegendElement,ForegColor,BackgColor,SPattern]) :-
        atomic(XValue),
        atomic(LegendElement),
        color(ForegColor),
        color(BackgColor),
        pattern(SPattern).
```

Defines the attributes of the bar.

`XValue` bar label. Although `XValue` values may be numbers, the will be treated as labels. Different elements with the same label will produce different bars.

`LegendElement`
Legend element name. It may be a number or an atom and equal or different to the XValue. Every `LegendElement` value of the list must be unique.

`ForegColor`
It sets the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
It sets the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern` It sets the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

176.4 Known bugs and planned improvements (`genbar1`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

177 Barchart widgets - 2

Author(s): Isabel Martín García.

This module defines predicates which show barchart widgets. The three predicates exported by this module plot two-variable data as regular bars in a window. They all share the following features:

- Numeric values for the x axis are needed, otherwise it does not work properly. See `xbarelement2/1` definition type.
- The bar position is proportional to the x-coordinate value.
- The user can either select the appearance of the bars (background color, foreground color and stipple style) or not. See the `xbarelement2/1` type definition. Thus, the user can call each predicate in two ways.
- The bar chart has a legend and one entry (symbol and label) per bar.
- If you do not want to display text in the elements header, barchart title, x axis title, y axis title or footer, simply type `''` as the value of the argument.
- The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contain elements but are not correct, the exception `error1` or `error3` will be thrown, depending on the error type. `error1` means that `XVector` and `YVector` does not contain the same number of elements and `error3` indicates that not all the `XVector` elements contain a correct number of attributes .

Particular features will be pointed out in the corresponding predicate.

177.1 Usage and interface (genbar2)

- **Library usage:**
  `:- use_module(library(genbar2)).`
- **Exports:**
  - *Predicates:*
    `barchart2/7`, `barchart2/11`, `percentbarchart2/7`.
  - *Regular Types:*
    `xbarelement2/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

177.2 Documentation on exports (genbar2)

barchart2/7: PREDICATE

`barchart2(Header,BarchartTitle,XTitle,XVector,YTitle,YVector,Footer)`

The maximum and minimum limits for axes are determined from the data.

Example:

```
barchart2('This is the header text',
  'Barchart with legend',
  'My xaxistitle',
  [ [1,'bar1','Blue','Yellow','pattern1'],
       [2,'bar2','MediumTurquoise','Plum','pattern5'] ],
  'My yaxixtitle',
  [20,10],
  'This is the footer text').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`BarchartTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xbarelement2`s. (basic_props:list/2)

`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVector` is a list of `yelements`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

barchart2/11: PREDICATE

`barchart2(Header,BT,XT,XVector,XMax,XMin,YT,YVector,YMax,YMin,Footer)`

You can set the minimum and maximum limits of the axes. Data outside the limits will not be plotted. Each limit, as you can check looking at the `axis_limit/1` definition, is a number. If the argument is a variable the limit will be calculated from the data (i.e., if `YMax` value is YValueMax the maximum y axis limit will calculated using the largest data value).

Example:

```
barchart2('This is the header text',
  'Barchart with legend',
  'My xaxistitle',
  [ [1,'bar1',Color1,Color2,Pattern1],
         [2,'bar2',Color3,Color4,Pattern2] ],
  10,
  -10,
  'My yaxixtitle',
  [20,10],
  100,
  -10,
  'The limits for the axes are set by the user').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`BT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xbarelement2`s. (basic_props:list/2)

genbar1:axis_limit(XMax) (genbar1:axis_limit/1)

genbar1:axis_limit(XMin) (genbar1:axis_limit/1)

`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVector` is a list of `yelements`. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

percentbarchart2/7: PREDICATE

`percentbarchart2(Header,BTitle,XTitle,XVector,YTitle,YVector,Footer)`

The y axis maximum coordinate value is 100. The x axis limits are autoarrange.

Example:

```
percentbarchart2('This is a special barchart to represent percentages',
  'Barchart with legend',
  'My xaxistitle',
  [ [1,'bar1','Blue','Yellow','pattern1'],
          [2,'bar2','MediumTurquoise','Plum','pattern5'] ],
  'My yaxixtitle',
  [80,10],
  'This is the footer text').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`BTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XVector` is a list of `xbarelement2`s. (basic_props:list/2)
`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVector` is a list of `yelements`. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

xbarelement2/1: REGTYPE

```
xbarelement2([XValue,LegendElement]) :-
        number(XValue),
        atomic(LegendElement).
xbarelement2([XValue,LegendElement,ForegColor,BackgColor,SPattern]) :-
        number(XValue),
        atomic(LegendElement),
        color(ForegColor),
        color(BackgColor),
        pattern(SPattern).
```

Defines the attributes of the bar.

`XValue` x-coordinate position of the bar. Different elements with the same abscissas will produce overlapped bars.

`LegendElement`
Element legend name. It may be a number or an atom and equal or different to the XValue. Every `LegendElement` value of the list must be unique.

`ForegColor`
: Is the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
: Is the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern`
: Is the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

178 Depict barchart widgets - 3

Author(s): Isabel Martín García.

This module defines predicates which depict barchart widgets. The three predicates exported by this module plot two-variable data as regular bars in a window and are similar to those exported in the genbar1 module except in that these defined in this module do not display a legend. Thus, not all the argument types are equal.

The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contain elements but are not correct, the exception `error1` or `error3` will be thrown, depending on the error type. `error1` means that `XVector` and `YVector` do not contain the same number of elements and `error3` indicates that not all the `XVector` elements contain a correct number of attributes .

178.1 Usage and interface (genbar3)

- **Library usage:**
  `:- use_module(library(genbar3)).`
- **Exports:**
  - *Predicates:*
    `barchart3/7`, `barchart3/9`, `percentbarchart3/7`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

178.2 Documentation on exports (genbar3)

barchart3/7: PREDICATE

`barchart3(Header,BarchartTitle,XTitle,XVector,YTitle,YVector,Footer)`

As we mentioned in the above paragraph, this predicate is comparable to `barchart1/8` except in the `XVector` argument type.

Example:

```
barchart3('This is the header text',
  'Barchart without legend',
  'My xaxistitle',
  [['bar1'],['bar2']],
  'My yaxixtitle',
  [20,10],
  'This is the footer text').
```

Usage:

- *The following properties should hold at call time:*

  `Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

  `BarchartTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

  `XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xbarelement3`s. (basic_props:list/2)
`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVector` is a list of `yelements`. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

barchart3/9: PREDICATE

`barchart3(Header,BTitle,XTitle,XVector,YTitle,YVector,YMax,YMin,Footer)`

As we mentioned, this predicate is quite similar to the `barchart1/10` except in the `XVector` argument type, because the yielded bar chart lacks of legend.

Example:

```
barchart3('This is the header text',
  'Barchart without legend',
  'My xaxistitle',
  [['bar1'],['bar2']],
  'My yaxixtitle',
  30,
  5,
  [20,10],
  'This is the footer text').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`BTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XVector` is a list of `xbarelement3`s. (basic_props:list/2)
`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVector` is a list of `yelements`. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

percentbarchart3/7: PREDICATE

`percentbarchart3(Header,BTitle,XTitle,XVector,YTitle,YVector,Footer)`

The y axis maximum coordinate value is 100. The x axis limits are autoarrange.

Example:

```
percentbarchart3('This is a special barchart to represent percentages',
          'Barchart without legend',
          'My xaxistitle',
          [ ['pr1','Blue','Yellow','pattern1'],
            ['pr2','MediumTurquoise','Plum','pattern5'] ],
          'My yaxixtitle',
          [80,10],
          'This is the footer text').
```

Usage:

– *The following properties should hold at call time:*
  `Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
  `BTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `XVector` is a list of `xbarelement3`s. (basic_props:list/2)
  `YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `YVector` is a list of `yelements`. (basic_props:list/2)
  `Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

178.3 Documentation on internals (genbar3)

xbarelement3/1: REGTYPE

```
xbarelement3([XValue]) :-
        atomic(XValue).
xbarelement3([XValue,ForegColor,BackgColor,StipplePattern]) :-
        atomic(XValue),
        color(ForegColor),
        color(BackgColor),
        pattern(StipplePattern).
```

Defines the attributes of the bar.

`XValue` bar label. Although `XValue` values may be numbers, the will be treated as labels. Different elements with the same label will produce different bars.

`ForegColor`
It sets the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
It sets the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern` It sets the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

179 Depict barchart widgets - 4

Author(s): Isabel Martín García.

This module defines predicates which depict barchart widgets. The three predicates exported by this module plot two-variable data as regular bars in a window and are similar to those exported in genbar2 module except in that those defined in this module doesn't display a legend. Thus, the user does not have to define legend element names.

The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error1` or `error3` will be thrown, depending on the error type. `error1` means that `XVector` and `YVector` do not contain the same number of elements and `error3` indicates that not all the `XVector` elements contain a correct number of attributes .

179.1 Usage and interface (genbar4)

- **Library usage:**
  `:- use_module(library(genbar4)).`
- **Exports:**
  - *Predicates:*
    `barchart4/7`, `barchart4/11`, `percentbarchart4/7`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

179.2 Documentation on exports (genbar4)

barchart4/7: PREDICATE

`barchart4(Header,BarchartTitle,XTitle,XVector,YTitle,YVector,Footer)`

As we mentioned in the above paragraph, this predicate is comparable to `barchart2/8` except in the `XVector` argument type.

Example:

```
barchart4('This is the header text',
  'Barchart without legend',
  'My xaxistitle',
  [[2],[5],[6]],
  'My yaxixtitle',
  [20,10,59],
  'Numeric values in the xaxis').
```

Usage:

- *The following properties should hold at call time:*

  `Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

  `BarchartTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

  `XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xbarelement4`s. (basic_props:list/2)
`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVector` is a list of `yelements`. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

barchart4/11: PREDICATE

`barchart4(Hder,BT,XT,XVector,XMax,XMin,YT,YVector,YMax,YMin,Fter)`

As we stated before, this predicate is quite similar to `barchart2/10` except in the following aspects:

- The `XVector` argument type, because the yielded bar chart lacks the legend.
- The user can set limits for both `x` axis and `y` axis.

Example:

```
barchart4('This is the header text, you can write a graph description',
  'Barchart without legend',
  'My xaxistitle',
  [[2,'Blue','Yellow','pattern1'],
       [20,'MediumTurquoise','Plum','pattern5'],
       [30,'MediumTurquoise','Green','pattern5']],
  50,
  -10,
  'My yaxixtitle',
  [20,10,59],
  100,
  -10,
  'Numeric values in the xaxis').
```

Usage:

– *The following properties should hold at call time:*

`Hder` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`BT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XVector` is a list of `xbarelement4`s. (basic_props:list/2)
genbar1:axis_limit(XMax) (genbar1:axis_limit/1)
genbar1:axis_limit(XMin) (genbar1:axis_limit/1)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVector` is a list of `yelements`. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`Fter` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

percentbarchart4/7: PREDICATE

`percentbarchart4(Header,BTitle,XTitle,XVector,YTitle,YVector,Footer)`

The y axis maximum coordinate value is 100. The x axis limits are automatically worked out. This predicate is useful when the bar height represents percentages.

Example:

```
percentbarchart4('This is the header text',
  'Barchart without legend',
  'My xaxistitle',
  [[2,'Blue','Yellow','pattern1'],[5,'Yellow','Plum','pattern5'],
       [6,'MediumTurquoise','Green','pattern5']],
  'My yaxixtitle',
  [20,10,59],
  'Numeric values in the xaxis').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`BTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xbarelement4`s. (basic_props:list/2)

`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVector` is a list of `yelements`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

179.3 Documentation on internals (genbar4)

xbarelement4/1: REGTYPE

Defines the attributes of the bar.

`XValue` x-coordinate position of the bar. Different elements with the same abscissas will produce overlapped bars.

`ForegColor`
It sets the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
It sets the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern` It sets the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

180 Depic line graph

Author(s): Isabel Martín García.

This module defines predicates which depict line graph and scatter graph widgets. All eigth predicates exported by this module plot two-variable data. Each point is defined by its X-Y coordinate values. A dataset is defined by two lists xvector and yvector, which contain the points coordinates. As you might guess, the values placed in the the same position in both lists are the coordinates of a point. They both share the following features:

- Numeric values for vector elements are needed. We'll use two vectors to represent the X-Y coordinates of each set of plotted data, but in this case every dataset shares the X-vector, i.e., x-coordinate of points with the same index[1] in different datasets is the same. Thus, the numbers of points in each yvector must be equal to the number of points in the xvector.
- The active element color is navyblue, which means that when you select a legend element, the corresponding line or point dataset turns into navyblue.
- The user can either select the appearance of the lines and/or points of each dataset or not. If not, the system will choose the colors for the lines and the points among the available ones in accordance with the plot background color and it will also set the points size and symbol to the default. If the plot background color is black, the system will choose a lighter color, and the system will select a darker color when the plot background color is white. Thus, the user can define the appearanse attributes of each dataset in four different ways. Take a look at the `attributes/1` type definition and see the examples to understand it clearly.
- The graph has a legend and one entry (symbol and label) per dataset.
- If you do not want to display text in the element header, barchart title, xaxis title, yaxis title or footer, simply give `''` as the value of the argument.
- The predicates check whether the format of the arguments is correct as well. The testing process involves some verifications. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error4` will be thrown.

The names of the line graph predicates begin with **graph_** and those corresponding to the scatter graph group begin with **scattergraph_**.

[1] It should be pointed out that I am refering to an index as the position of an element in a list.

180.1 Usage and interface (gengraph1)

- **Library usage:**
  `:- use_module(library(gengraph1)).`
- **Exports:**
  - *Predicates:*
    `graph_b1/9`, `graph_b1/13`, `graph_w1/9`, `graph_w1/13`, `scattergraph_b1/8`, `scattergraph_b1/12`, `scattergraph_w1/8`, `scattergraph_w1/12`.
  - *Regular Types:*
    `vector/1`, `smooth/1`, `attributes/1`, `symbol/1`, `size/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/bltclass`, `chartlib/genbar1`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

180.2 Documentation on exports (gengraph1)

graph_b1/9: PREDICATE

`graph_b1(Header,GTitle,XTitle,XVector,YTitle,YVectors,LAtts,Footer,Smooth)`

Besides the features mentioned at the begining of the chapter, the displayed graph generated when calling this predicate has the following distinguishing characteristics:

- The plotting area background color is black.
- The cross hairs color is white.
- The axes limits are determined from the data.

Example:

```
graph_b1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  'yaxixtitle',
  [ [10,35,40],[25,50,60] ],
  [ ['element1','Blue','Yellow','plus',6],['element2',Outline,Color] ],
  'footer',
  'linear').
```

Usage:

- *The following properties should hold at call time:*
  `Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
  `GTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  gengraph1:vector(XVector) (gengraph1:vector/1)
  `YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `YVectors` is a list of `vectors`. (basic_props:list/2)
  `LAtts` is a list of `attributess`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)
gengraph1:smooth(Smooth) (gengraph1:smooth/1)

graph_b1/13: PREDICATE

`graph_b1(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,LAtts,Footer,Smooth)`

The particular features related to this predicate are described below:

- The plotting area background color is black.
- The cross hairs color is white.
- You can set the minimum and maximum limits of the axes. Data outside the limits will not be plotted.

Example:

```
graph_b1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  50,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50,
  _,
  [['line1','circle',4],['line2',OutlineColor,Color]],
  'footer',
  'step').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
gengraph1:vector(XV) (gengraph1:vector/1)
genbar1:axis_limit(XMax) (genbar1:axis_limit/1)
genbar1:axis_limit(XMin) (genbar1:axis_limit/1)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVs` is a list of `vectors`. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`LAtts` is a list of `attributess`. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)
gengraph1:smooth(Smooth) (gengraph1:smooth/1)

graph_w1/9: PREDICATE

`graph_w1(Header,GTitle,XTitle,XVector,YTitle,YVectors,LAtts,Footer,Smooth)`

This predicate is quite similar to `graph_b1/9`. The differences lies in the plot background color and in the cross hairs color, which are white and black respectively.

Example:

```
graph_w1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,40,50],
  'yaxixtitle',
  [ [10,35,40,50],[25,20,60,40] ],
  [['line1','Blue','DarkOrchid'],['line2','circle',3]],
  'footer',
  'quadratic').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`GTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

gengraph1:vector(XVector) (gengraph1:vector/1)

`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVectors` is a list of `vectors`. (basic_props:list/2)

`LAtts` is a list of `attributess`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

gengraph1:smooth(Smooth) (gengraph1:smooth/1)

graph_w1/13: PREDICATE

`graph_w1(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,LAtts,Footer,Smooth)`

This predicate is quite similar to `graph_b1/13`, the differences between them are listed below:

- The plotting area background color is white.
- The cross hairs color is black.

Example:

```
graph_w1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  100,
  10,
  'yaxixtitle',
  [[10,35,40],[25,20,60]],
  _,
  _,
  [['element1','Blue','Yellow'],['element2','Turquoise','Plum']],
  'footer',
  'quadratic').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

gengraph1:vector(XV) (gengraph1:vector/1)
genbar1:axis_limit(XMax) (genbar1:axis_limit/1)
genbar1:axis_limit(XMin) (genbar1:axis_limit/1)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVs` is a list of `vector`s. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`LAtts` is a list of `attribute`s. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)
gengraph1:smooth(Smooth) (gengraph1:smooth/1)

scattergraph_b1/8: PREDICATE

`scattergraph_b1(Header,GTitle,XTitle,XVector,YTitle,YVectors,PAtts,Footer)`

Apart from the features brought up at the beginning of the chapter, the scatter graph displayed invoking this predicate has the following characteristics:

- The plotting area background color is black.
- The cross hairs color is white.
- The axes limits are determined from the data.

Example:

```
scattergraph_b1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [10,15,20],
  'yaxixtitle',
  [[10,35,20],[15,11,21]],
  [['element1','Blue','Yellow'],['element2','Turquoise','Plum']],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
gengraph1:vector(XVector) (gengraph1:vector/1)
`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVectors` is a list of `vector`s. (basic_props:list/2)
`PAtts` is a list of `attribute`s. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

scattergraph_b1/12: PREDICATE

`scattergraph_b1(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,PAtts,Footer)`

The particular features related to this predicate are described below:

- The plotting area background color is black.
- The cross hairs color is white.

- You can set the minimum and maximum limits of the axes. Data outside the limits will not be plotted.

Example:

```
scattergraph_b1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  50,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50,
  _,
  [['point dataset1','Blue','Yellow'],['point dataset2']],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
gengraph1:vector(XV) (gengraph1:vector/1)
genbar1:axis_limit(XMax) (genbar1:axis_limit/1)
genbar1:axis_limit(XMin) (genbar1:axis_limit/1)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVs` is a list of `vectors`. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`PAtts` is a list of `attributess`. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

scattergraph_w1/8: PREDICATE

`scattergraph_w1(Header,GT,XT,XVector,YT,YVectors,PAtts,Footer)`

This predicate is quite similar to `scattergraph_b1/8` except in the following:

- The plotting area background color is black.
- The cross hairs color is white.
- If the user does not fix the points colors, they will be chosen among the lighter ones.

Example:

```
scattergraph_w1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  'yaxixtitle',
  [[10,35,40],[25,20,60]],
  [['e1','Blue','Green'],['e2','MediumVioletRed','Plum']],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

gengraph1:vector(XVector) (gengraph1:vector/1)

`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVectors` is a list of `vectors`. (basic_props:list/2)

`PAtts` is a list of `attributes`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

scattergraph_w1/12: PREDICATE

`scattergraph_w1(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,PAtts,Footer)`

This predicate is quite similar to `scattergraph1_b1/13`, the differences between them are listed below:

- The plotting area background color is white.
- The cross hairs color is black.

Example:

```
scattergraph_w1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  150,
  5,
  'yaxixtitle',
  [[10,35,40],[25,20,60]],
  _,
  -10,
  [['e1','Blue','Yellow'],['e2','MediumTurquoise','Plum']],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

gengraph1:vector(XV) (gengraph1:vector/1)

genbar1:axis_limit(XMax) (genbar1:axis_limit/1)

genbar1:axis_limit(XMin) (genbar1:axis_limit/1)

`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVs` is a list of `vectors`. (basic_props:list/2)

genbar1:axis_limit(YMax) (genbar1:axis_limit/1)

genbar1:axis_limit(YMin) (genbar1:axis_limit/1)

`PAtts` is a list of `attributes`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

vector/1: REGTYPE

```
vector(X) :-
        list(X,number).
```

The type vector defines a list of numbers (integers or floats).

smooth/1: REGTYPE

```
smooth(Smooth)
```

```
smooth(linear).
smooth(cubic).
smooth(quadratic).
smooth(step).
```

Specifies how connecting segments are drawn between data points. If `Smooth` is `linear`, a single line segment is drawn, connecting both data points. When `Smooth` is `step`, two line segments will be drawn, the first line is a horizontal line segment that steps the next X-coordinate and the second one is a vertical line, moving to the next Y-coordinate. Both `cubic` and `quadratic` generate multiple segments between data points. If `cubic`is used, the segments are generated using a cubic spline. If `quadratic`, a quadratic spline is used. The default is linear.

attributes/1: REGTYPE

```
attributes([ElementName]) :-
        atomic(ElementName).
attributes([ElementName,OutLine,Color]) :-
        atomic(ElementName),
        color(OutLine),
        color(Color).
attributes([ElementName,Symbol,Size]) :-
        atomic(ElementName),
        symbol(Symbol),
        size(Size).
attributes([ElementName,OutLine,Color,Symbol,Size]) :-
        atomic(ElementName),
        color(OutLine),
        color(Color),
        symbol(Symbol),
        size(Size).
```

Each line or point dataset in the graph has its own attributes, which are defined by this type. The name of the dataset, specified in the `ElementName` argument, may be either a number or an atom. The second argument is the color of a thin line around each point in the dataset and the Color argument is the points and lines color. Both `OutLine` and `Color` must be a valid color (see available values in `color/1`), otherwise a random color according to the plot background color will be selected. The `Symbol` must be a valid symbol and the `Size` must be a number. Be careful if you want to especify the `Symbol` and the `Size`, otherwise the predicate will not work as you expect. If you don't select a symbol and a size for a dataset the default values will be square and 1 pixel.

symbol/1: REGTYPE

```
symbol(Symbol)
```

```
symbol(square).
symbol(circle).
symbol(diamond).
symbol(plus).
symbol(cross).
symbol(splus).
symbol(scross).
symbol(triangle).
```

`Symbol` stands for the shape of the points whether in scatter graphs or in line graphs.

size/1: REGTYPE

`size(Size)`

```
size(Size) :-
        number(Size).
```

`Size` stands for the size in pixels of the points whether in scatter graphs or in line graphs.

181 Line graph widgets

Author(s): Isabel Martín García.

This module defines predicates which show line graph widgets. All eight predicates exported by this module plot two-variable data. Each point is defined by its X-Y coordinate values. Every predicate share the following features:

- A dataset is defined by three lists xvector, yvector and attributes. The arguments named `XVectors` (or `XVs`), `YVectors` (or `YVs`) and `LAtts`[1] contain this information. Those arguments must be lists whose elements are also lists. The first dataset is defined by the firts element of the three lists, the second dataset is defined by the second element of the three lists and so on.
- Numeric values for the vector elements are needed. We will use two vectors to represent the X-Y coordinates of each set of data plotted. In these predicates the vectors can have different number of points. However, the number of elements in xvector and yvector that pertain to a certain dataset must be, obviously, equal.
- The active line color is blue, which means that when you select a legend element, the corresponding line turns into navyblue.
- The user can either select the appearance for the lines and the points or not. See the `attributes/1` type definition. Thus, the user can call each predicate in different ways ways.
- The graph has a legend and one entry (symbol and label) per dataset.
- If you do not want to display text in the elements header, barchart title, xaxis title, yaxis title or footer, simply give `''` as the value of the argument.
- The predicates check whether the format of the arguments is correct as well. The testing process involves some verifications. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error4` will be thrown.

181.1 Usage and interface (gengraph2)

- **Library usage:**
  `:- use_module(library(gengraph2)).`
- **Exports:**
  - *Predicates:*
    `graph_b2/9`, `graph_b2/13`, `graph_w2/9`, `graph_w2/13`, `scattergraph_b2/8`, `scattergraph_b2/12`, `scattergraph_w2/8`, `scattergraph_w2/12`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/gengraph1`, `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

181.2 Documentation on exports (gengraph2)

[1] In scatter graphs the attibute that contains the features of a point dataset is `PAtts`.

graph_b2/9: PREDICATE

`graph_b2(Header,GTitle,XTitle,XVectors,YTitle,YVectors,LAtts,Footer,Sm)`

Besides the features mentioned at the begining of the module chapter, the displayed graph generated calling this predicate has the following distinguish characteristics:

- The plotting area background color is black.
- The cross hairs color is white.
- The axis limits are determined from the data.

Example:

```
graph_b2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,30,59],[25,50]],
  'yaxixtitle',
  [[10,35,40],[25,50]],
  [['line1','Blue','Yellow'],['line2']],
  'footer',
  'natural').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`GTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVectors` is a list of `vector`s. (basic_props:list/2)

`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVectors` is a list of `vector`s. (basic_props:list/2)

`LAtts` is a list of `attributes`s. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

gengraph1:smooth(Sm) (gengraph1:smooth/1)

graph_b2/13: PREDICATE

`graph_b2(Header,GT,XT,XVs,XMax,XMin,YT,YVs,YMax,YMin,LAtts,Footer,Smooth)`

In addition to the features brought up at the begining of the module chapter, this graph has the following:

- The plotting area background color is black.
- The cross hairs color is white.
- You can set the maximum and minimum values for the graph axes.

Example:

```
graph_b2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,10,59],[15,30,35]],
  50,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
```

```
50.5,
_,
[['line1','Blue','Yellow'],['line','MediumTurquoise','Plum']],
'footer',
'step').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XVs` is a list of `vector`s. (basic_props:list/2)
genbar1:axis_limit(XMax) (genbar1:axis_limit/1)
genbar1:axis_limit(XMin) (genbar1:axis_limit/1)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVs` is a list of `vector`s. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`LAtts` is a list of `attributes`s. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)
gengraph1:smooth(Smooth) (gengraph1:smooth/1)

graph_w2/9: PREDICATE

`graph_w2(Header,GT,XT,XVectors,YTitle,YVectors,LAtts,Footer,Smooth)`

This predicate is quite similar to `graph_b2/9`. The difference lies in the graph appearance, as you can see below.

- The plotting area background color is white.
- The cross hairs color is black.

Example:

```
graph_w2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[10,30,59],[25,50]],
  'yaxixtitle',
  [[10,35,40],[25,40]],
  [['element1','Blue','DarkOrchid'],['element2','DarkOliveGreen',
    'Firebrick']],
  'footer',
  'natural').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XVectors` is a list of `vector`s. (basic_props:list/2)
`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`YVectors` is a list of `vectors`. (basic_props:list/2)
`LAtts` is a list of `attributess`. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)
gengraph1:smooth(Smooth) (gengraph1:smooth/1)

graph_w2/13: PREDICATE

`graph_w2(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,LAtts,Footer,Smooth)`

This predicate is comparable to `graph_b2/13`. The differences lie in the plot background color and in the cross hairs color, wich are white and black respectively.

Example:

```
graph_w2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[10,30,59],[10,35,40]],
  80,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50,
  _,
  [['element1','Blue','Green'],['element2','Turquoise','Black']],
  'footer',
  'linear').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XV` is a list of `vectors`. (basic_props:list/2)
genbar1:axis_limit(XMax) (genbar1:axis_limit/1)
genbar1:axis_limit(XMin) (genbar1:axis_limit/1)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVs` is a list of `vectors`. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`LAtts` is a list of `attributess`. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)
gengraph1:smooth(Smooth) (gengraph1:smooth/1)

scattergraph_b2/8: PREDICATE

`scattergraph_b2(Header,GT,XT,XVectors,YT,YVectors,PAtts,Footer)`

Apart from the features brought up at the beginning of the chapter, the scatter graph displayed when invoking this predicate has the following features:

- The plotting area background color is black.

- The cross hairs color is white.
- The axis limits are determined from the data.

Example:

```
scattergraph_b2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[10,15,20],[8,30,40]],
  'yaxixtitle',
  [[10,35,20],[15,11,21]],
  [['element1','Blue','Yellow'],['element2','MediumTurquoise','Plum']],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XVectors` is a list of `vectors`. (basic_props:list/2)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVectors` is a list of `vectors`. (basic_props:list/2)
`PAtts` is a list of `attributess`. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

scattergraph_b2/12: PREDICATE

`scattergraph_b2(Header,GT,XT,XVs,XMax,XMin,YT,YVs,YMax,YMin,PAtts,Footer)`

The particular features related to this predicate are described below:

- The plotting area background color is black.
- The cross hairs color is white.
- You can set the minimum and maximum limits of the axes. Data outside the limits will not be plotted.

Example:

```
scattergraph_b2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,30,50],[18,40,59]],
  50,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50,
  _,
  [['point dataset1'],['point dataset2']],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XVs` is a list of `vector`s. (basic_props:list/2)
genbar1:axis_limit(XMax) (genbar1:axis_limit/1)
genbar1:axis_limit(XMin) (genbar1:axis_limit/1)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVs` is a list of `vector`s. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`PAtts` is a list of `attribute`s. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

scattergraph_w2/8: PREDICATE

`scattergraph_w2(Header,GTitle,XTitle,XVs,YTitle,YVs,PAtts,Footer)`

This predicate is quite similar to `scattergraph_w1/8` except in the following:

- The plotting area background color is black.
- The cross hairs color is white.
- If the user do not provide the colors of the points, they will be chosen among the lighter ones.

Example:

```
scattergraph_w2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,30,40,15,30,35,20,30]],
  'yaxixtitle',
  [[10,30,40,25,20,25,20,25]],
  [['set1','cross',4]],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
gengraph1:vector(XVs) (gengraph1:vector/1)
`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVs` is a list of `vector`s. (basic_props:list/2)
`PAtts` is a list of `attribute`s. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

scattergraph_w2/12: PREDICATE

`scattergraph_w2(Header,GT,XT,XVs,XMax,XMin,YT,YVs,YMax,YMin,PAtts,Footer)`

This predicate is comparable to `scattergraph_w2/13`, the differences between them are listed below:

- The plotting area background color is white.
- The cross hairs color is black.

Example:

```
scattergraph_w2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,10,59],[15,30,50]],
  150,
  5,
  'yaxixtitle',
  [[10,35,40],[25,20,60]],
  _,
  -10,
  [['e1','Blue','Yellow'],['e2','MediumTurquoise','Plum']],
  'footer').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
`GT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`XVs` is a list of `vector`s. (basic_props:list/2)
genbar1:axis_limit(XMax) (genbar1:axis_limit/1)
genbar1:axis_limit(XMin) (genbar1:axis_limit/1)
`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
`YVs` is a list of `vector`s. (basic_props:list/2)
genbar1:axis_limit(YMax) (genbar1:axis_limit/1)
genbar1:axis_limit(YMin) (genbar1:axis_limit/1)
`PAtts` is a list of `attributes`s. (basic_props:list/2)
`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

182 Multi barchart widgets

Author(s): Isabel Martín García.

This module defines predicates which show barchart widgets. These bar charts are somewhat different from the bar charts generated by the predicates in modules genbar1, genbar2, genbar3 and genbar4. Predicates in the present module show different features of each dataset element in one chart at the same time. Each bar chart element is a group of bars, and the element features involve three vectors defined as follows:

- xvector is a list containing the names (atoms) of the bars (n elements). Each bar group will be displayed at uniform intervals.
- yvector is a list that contains m sublists, each one is composed of n elements. The i-sublist contains the y-values of the i-BarAttribute element for all of the XVector elements.
- bar_attributtes is a list containing the appearance features of the bars (m elements). Each element of the list can be partial or complete, which means that you can define as bar attributes only the element name or by setting the element name, its background and foreground color and its stipple pattern.

Other relevant aspects about this widgets are:

- If you don't want to display text in the elements header, barchart title, xaxis title, yaxis title or footer, simply type `''` as the value of the argument.
- The bar chart has a legend, and one entry (symbol and label) per feature group bar.
- The user can either select the appearance of the bars (background color, foreground color and stipple style) or not. See the multibar_attribute type definition.
- Data points can have their bar segments displayed in one of the following modes: stacked, aligned, overlapped or overlayed. They user can change the mode clicking in the checkboxes associated to each mode.
- The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error5` or `error6` will be thrown, depending on what is incorrect. `error5` means that `XVector` and each element of `YVector` do not contain the same number of elements or that `YVector` and `BarsAtt` do not contain the same number of elements, while `error6` indicates that not all the `BarsAtt` elements contain a correct number of attributes.

The examples will help you to understand how these predicates should be called.

182.1 Usage and interface (genmultibar)

- **Library usage:**
  `:- use_module(library(genmultibar)).`
- **Exports:**
  - *Predicates:*
    `multibarchart/8`, `multibarchart/10`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

182.2 Documentation on exports (genmultibar)

multibarchart/8: PREDICATE

`multibarchart(Header,BTitle,XTitle,XVector,YTitle,BarsAtts,YVector,Footer)`

The x axis limits are autoarrange. The user can call the predicate in two ways. In the first example the user sets the appearance of the bars, in the second one the appearance features will be chosen by the library.

Example1:

```
multibarchart('This is the Header text',
'My BarchartTitle',
'Processors',
['processor1','processor2','processor3','processor4'],
'Time (seconds)',
[['setup time','MediumTurquoise','Plum','pattern2'],
    ['sleep time','Blue','Green','pattern5'],
    ['running time','Yellow','Plum','pattern1']],
[[20,30,40,50],[10,8,5,35],[60,100,20,50]],
'This is the Footer text').
```

Example2:

```
multibarchart('This is the Header text',
'My BarchartTitle',
'Processors',
['processor1','processor2','processor3','processor4'],
'Time (seconds)',
[['setup time'],['sleep time'],['running time']],
[[20,30,40,50],[10,8,5,35],[60,100,20,50]],
'This is the Footer text').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`BTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xelements`. (basic_props:list/2)

`YTitle` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`BarsAtts` is a list of `multibar_attributes`. (basic_props:list/2)

`YVector` is a list of `yelements`. (basic_props:list/2)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

multibarchart/10: PREDICATE

`multibarchart(Header,BT,XT,XVector,YT,BAtts,YVector,YMax,YMin,Footer)`

This predicate is quite similar to `multibarchart/8`, except in that you can choose limits in the y axis. The part of the bars placed outside the limits will not be plotted.

Example2:

```
multibarchart('This is the Header text',
'My BarchartTitle',
'Processors',
```

```
['processor1','processor2','processor3','processor4'],
'Time (seconds)',
[['setup time'],['sleep time'],['running time']],
[[20,30,40,50],[10,8,5,35],[60,100,20,50]],
[80],
[0],
'This is the Footer text').
```

Usage:

– *The following properties should hold at call time:*

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

`BT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`XVector` is a list of `xelements`. (basic_props:list/2)

`YT` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`BAtts` is a list of `multibar_attributes`. (basic_props:list/2)

`YVector` is a list of `yelements`. (basic_props:list/2)

genbar1:axis_limit(YMax) (genbar1:axis_limit/1)

genbar1:axis_limit(YMin) (genbar1:axis_limit/1)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

182.3 Documentation on internals (genmultibar)

multibar_attribute/1: REGTYPE

```
multibar_attribute([LegendElement]) :-
        atomic(LegendElement).
multibar_attribute([LegendElement,ForegroundColor,BackgroundColor,StipplePattern
        atom(LegendElement),
        color(ForegroundColor),
        color(BackgroundColor),
        pattern(StipplePattern).
```

Defines the attributes of each feature bar along the different datasets.

LegendElement
: Legend element name. It may be a number or an atom. Every `LegendElement` value of the list must be unique.

`ForegroundColor`
: It sets the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgroundColor`
: It sets the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`StipplePattern`
: It sets the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

xelement/1: REGTYPE

```
xelement(Label) :-
        atomic(Label).
```

This type defines a dataset label. Although `Label` values may be numbers, the will be treated as atoms, So it will be displayed at uniform intervals along the x axis.

183 table_widget1 (library)

Author(s): Isabel Martín García.

In addition to the features explained in the introduction, the predicates exported by this module depict tables in which the font weight for the table elements is bold.

If the arguments are not in a correct format the exception `error8` will be thrown.

183.1 Usage and interface (`table_widget1`)

- **Library usage:**
  `:- use_module(library(table_widget1)).`
- **Exports:**
  - *Predicates:*
    `tablewidget1/4`, `tablewidget1/5`.
  - *Regular Types:*
    `table/1`, `image/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/test_format`, `chartlib/install_utils`, `lists`.

183.2 Documentation on exports (`table_widget1`)

tablewidget1/4: PREDICATE

`tablewidget1(Title,Header,ElementTable,Footer)`

Shows a regular table in a window. The user does not choose a background image.

Example:

```
tablewidget1('This is the title',
     'Header text',
     [['Number of processors','8'],['Average processors','95'],
         ['Average Tasks per fork','7.5']],
     'Footer text').
```

Usage:

- *The following properties should hold at call time:*
  `Title` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
  table_widget1:table(ElementTable) (table_widget1:table/1)
  `Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

tablewidget1/5: PREDICATE

`tablewidget1(Title,Header,ElementTable,Footer,BackgroundImage)`

Shows a regular table in a window. The user must set a background image. See the `image/1` type definition.

Example:

```
tablewidget1('This is the title',
     'Header text',
     [['Number of processors','8'],['Average processors','95'],
         ['Average Tasks per fork','7.5']],
     'Footer text',
     './images/rain.gif')
```

Usage:

– *The following properties should hold at call time:*

`Title` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

table_widget1:table(ElementTable) (table_widget1:table/1)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

table_widget1:image(BackgroundImage) (table_widget1:image/1)

table/1: REGTYPE

A table is a list of rows, each row must contain the same number of elements, otherwise the table wouldn't be regular and an exception will be thrown by the library. The rows list may not be empty.

```
table([X]) :-
        row(X).
table([X|Xs]) :-
        row(X),
        table(Xs).
```

image/1: REGTYPE

Some predicates allow the user to set the widget background image, whose is what this type is intended for. The user has to take into account the following restrictions:

- The image must be in gif format.
- The file path must be absolute.

183.3 Documentation on internals (`table_widget1`)

row/1: REGTYPE

```
row([X]) :-
        cell_value(X).
row([X|Xs]) :-
        cell_value(X),
        row(Xs).
```

Each row is a list of elements whose type is `cell_value/1`. A row cannot be an empty list, as you can see in the definition type.

row/1: REGTYPE

```
row([X]) :-
        cell_value(X).
row([X|Xs]) :-
        cell_value(X),
        row(Xs).
```

Each row is a list of elements whose type is `cell_value/1`. A row cannot be an empty list, as you can see in the definition type.

cell_value/1: REGTYPE

This type defines the possible values that a table element have. If any cell value is `''`, the cell will be displayed empty.

```
cell_value(X) :-
        atomic(X).
```

184 table_widget2 (library)

Author(s): Isabel Martín García.

In addition to the features explained in the introduction, predicates exported by this module display tables in which the font weight for the elements placed in the first row is bold. The remaining elements are in medium weight font.

If the arguments are not in a correct format the exception `error8` will be thrown.

184.1 Usage and interface (table_widget2)

- **Library usage:**
  `:- use_module(library(table_widget2)).`
- **Exports:**
  - *Predicates:*
    `tablewidget2/4`, `tablewidget2/5`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/table_widget1`, `chartlib/test_format`, `chartlib/install_utils`, `lists`.

184.2 Documentation on exports (table_widget2)

tablewidget2/4: PREDICATE

`tablewidget2(Title,Header,ElementTable,Footer)`

Shows a regular table in a window. The system sets a default background image for the widget.

Example:

```
tablewidget2('COM Features',
     'Extracted from "Inside COM" book ',
     [['Feature','Rich people','Bean Plants','C++','COM'],
       ['Edible','Yes','Yes','No','No'],
       ['Supports inheritance','Yes','Yes','Yes','Yes and No'],
       ['Can run for President','Yes','No','No','No']],
     'What do you think about COM?').
```

Usage:

- *The following properties should hold at call time:*
  `Title` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
  table_widget1:table(ElementTable) (table_widget1:table/1)
  `Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

tablewidget2/5: PREDICATE

`tablewidget2(Title,Header,ElementTable,Footer,BackgroundImage)`

This predicate and `tablewidget2/4` are quite similar, except that in the already one defined you must set the background image.

Example:

```
tablewidget2('COM Features',
     'Extracted from "Inside COM" book ',
     [['Feature','Rich people','Bean Plants','C++','COM'],
       ['Edible','Yes','Yes','No','No'],
       ['Supports inheritance','Yes','Yes','Yes','Yes and No'],
       ['Can run for President','Yes','No','No','No']],
     'What do you think about COM?',
     './images/rain.gif').
```

Usage:

– *The following properties should hold at call time:*

`Title` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

table_widget1:table(ElementTable) (table_widget1:table/1)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

table_widget1:image(BackgroundImage) (table_widget1:image/1)

185 table_widget3 (library)

Author(s): Isabel Martín García.

The predicates exported by this module display data in a regular table, as we brought up in the introduction. Both predicates have in common that the font weight for the elements placed in the first column is bold and the remaining elements are in medium font weight.

If the arguments are not in a correct format the exception `error8` will be thrown.

185.1 Usage and interface (`table_widget3`)

- **Library usage:**
  `:- use_module(library(table_widget3)).`
- **Exports:**
  - *Predicates:*
    `tablewidget3/4`, `tablewidget3/5`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/table_widget1`, `chartlib/test_format`, `chartlib/install_utils`, `lists`.

185.2 Documentation on exports (`table_widget3`)

tablewidget3/4: PREDICATE

`tablewidget3(Title,Header,ElementTable,Footer)`

Shows a regular table in a window. The user does not choose a background image.

Example:

```
tablewidget3('This is the title',
     'Header text',
     [['Number of processors','8'],['Average processors','95'],
       ['Tasks per fork','7.5']],
     'Footer text').
```

Usage:

- *The following properties should hold at call time:*
  `Title` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
  table_widget1:table(ElementTable) (table_widget1:table/1)
  `Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

tablewidget3/5: PREDICATE

`tablewidget3(Title,Header,ElementTable,Footer,BackgroundImage)`

Shows a regular table in a window. The user must set a background image.

Example:

```
tablewidget3('This is the title',
     'Header text',
     [['Number of processors','8'],['Average processors','95'],
         ['Average Tasks per fork','7.5']],
     'Footer text',
     './images/rain.gif')
```

Usage:

– *The following properties should hold at call time:*

`Title` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

table_widget1:table(ElementTable) (table_widget1:table/1)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

table_widget1:image(BackgroundImage) (table_widget1:image/1)

186 table_widget4 (library)

Author(s): Isabel Martín García.

In addition to the features explained in the introduction, predicates exported by this module display tables in which the font weight for the elements placed in the first row and column is bold. The remaining elements are in medium weight font.

If the arguments are not in a correct format the exception `error8` will be thrown.

186.1 Usage and interface (`table_widget4`)

- **Library usage:**
  `:- use_module(library(table_widget4)).`
- **Exports:**
  - *Predicates:*
    `tablewidget4/4`, `tablewidget4/5`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/table_widget1`, `chartlib/test_format`, `chartlib/install_utils`, `lists`.

186.2 Documentation on exports (`table_widget4`)

tablewidget4/4: PREDICATE

`tablewidget4(Title,Header,ElementTable,Footer)`

Shows a regular table in a window. The system sets a default background image for the widget.

Example:

```
tablewidget4('Some sterEUtypes',
  'Source: Eurostat yearbook, 1999',
  [['Country','Adult alcohol intake per year (litres)',
       'Cigarettes smoked per day per adult',
             'Suicides per 100000 people'],
      ['Finland','8.4','2.2','26.3'],['Spain','11.4','5.3','7.5'],
      ['Austria','11.9','4.6','20.7'],['Britain','9.4','4.2','7.1'],
      ['USA','4.7','4.9','13'],['European Union','11.1','4.5','11.9']],
  'This is part of the published table').
```

Usage:

- *The following properties should hold at call time:*
  `Title` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)
  `Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)
  table_widget1:table(ElementTable) (table_widget1:table/1)
  `Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

tablewidget4/5: PREDICATE

`tablewidget4(Title,Header,ElementTable,Footer,BackgroundImage)`

This predicate and `tablewidget4/4` are comparable, except that in the already defined you must set the background image.

Example:

```
tablewidget4('Some sterEUtypes',
  'Source: Eurostat yearbook, 1999',
  [['Country','Adult alcohol intake per year (litres)',
       'Cigarettes smoked per day per adult',
           'Suicides per 100000 people'],
      ['Finland','8.4','2.2','26.3'],['Spain','11.4','5.3','7.5'],
      ['Austria','11.9','4.6','20.7'],['Britain','9.4','4.2','7.1'],
      ['USA','4.7','4.9','13'],['European Union','11.1','4.5','11.9']],
  'This is part of the published table',
  './images/rain.gif').
```

Usage:

– *The following properties should hold at call time:*

`Title` is a text (an atom) to be used as label, usually not very long. (genbar1:title/1)

`Header` is a text (an atom) describing the header of the graph. (genbar1:header/1)

table_widget1:table(ElementTable) (table_widget1:table/1)

`Footer` is a text (an atom) describing the footer of the graph. (genbar1:footer/1)

table_widget1:image(BackgroundImage) (table_widget1:image/1)

187 test_format (library)

Author(s): Isabel Martín García.

Most of the predicates exported by this module perform some checks to determine whether the arguments attain some conditions or not. In the second case an exception will be thrown. To catch the exceptions you can use the following metapredicates when invoking chartlib exported predicates:

- `chartlib_text_error_protect/1`
- `chartlib_text_error_protect/1`

Both metapredicates are defined in the chartlib_errhandle module that comes with this library. Some of the predicates have a `Predicate` argument which will be used in case of error to show which chartlib predicate causes the error.

187.1 Usage and interface (`test_format`)

- **Library usage:**
  `:- use_module(library(test_format)).`
- **Exports:**
  - *Predicates:*
    `equalnumber/3`, `not_empty/4`, `not_empty/3`, `check_sublist/4`, `valid_format/4`, `vectors_format/4`, `valid_vectors/4`, `valid_attributes/2`, `valid_table/2`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

187.2 Documentation on exports (`test_format`)

equalnumber/3: PREDICATE

`equalnumber(X,Y,Predicate)`

Test whether the list `X` and the list `Y` contain the same number of elements.

Usage:

- *The following properties should hold at call time:*
  `X` is a list. (basic_props:list/1)
  `Y` is a list. (basic_props:list/1)
  `Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

not_empty/4: PREDICATE

`not_empty(X,Y,Z,Predicate)`

Tests whether at least one the lists `X`, `Y` or `Z` are empty.

Usage:

– *The following properties should hold at call time:*

`X` is a list. (basic_props:list/1)

`Y` is a list. (basic_props:list/1)

`Z` is a list. (basic_props:list/1)

`Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

not_empty/3: PREDICATE

`not_empty(X,Y,Predicate)`

Tests whether the lists `X` or `Y` are empty.

Usage:

– *The following properties should hold at call time:*

`X` is a list. (basic_props:list/1)

`Y` is a list. (basic_props:list/1)

`Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

check_sublist/4: PREDICATE

`check_sublist(List,Number,Number,Predicate)`

Tests if the number of elements in each sublist of `List` is `Number1` or `Number2`.

Usage:

– *The following properties should hold at call time:*

`List` is a list. (basic_props:list/1)

`Number` is currently instantiated to an integer. (term_typing:integer/1)

`Number` is currently instantiated to an integer. (term_typing:integer/1)

`Predicate` is an atom. (basic_props:atm/1)

valid_format/4: PREDICATE

`valid_format(XVector,YVector,BarsAttributes,Predicate)`

Tests the following restrictions:

- The `XVector` number of elements is the same as each `YVector` sublist number of elements.
- The `YVector` length is equal to `BarsAttributes` length.

Usage:

– *The following properties should hold at call time:*

`XVector` is a list. (basic_props:list/1)

`YVector` is a list. (basic_props:list/1)

`BarsAttributes` is a list. (basic_props:list/1)

`Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

vectors_format/4: PREDICATE

`vectors_format(XVector,YVectors,LinesAttributes,Predicate)`

Tests the following conditions:

- `YVectors` list and `LinesAttributes` list have the same number of elements.
- `XVector` list and each `YVectors` element have the same number of elements.
- Each sublist of `LinesAttributes` is composed of 5, 3 or 1 elements.

Usage:

– *The following properties should hold at call time:*

`XVector` is a list. (basic_props:list/1)

`YVectors` is a list. (basic_props:list/1)

`LinesAttributes` is a list. (basic_props:list/1)

`Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

valid_vectors/4: PREDICATE

`valid_vectors(XVector,YVectors,LinesAttributes,Predicate)`

Tests the following conditions:

- `XVector` list, `YVectors` list and `LinesAttributes` list have the same number of elements.
- Each sublist of `LinesAttributes` is composed of 5, 3 or 1 element.

Usage:

– *The following properties should hold at call time:*

`XVector` is a list. (basic_props:list/1)

`YVectors` is a list. (basic_props:list/1)

`LinesAttributes` is a list. (basic_props:list/1)

`Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

valid_attributes/2: PREDICATE

`valid_attributes(BarsAttibuttes,Predicate)`

Check if each `BarsAttibuttes` element is a list composed of one or four elements.

Usage:

– *The following properties should hold at call time:*

`BarsAttibuttes` is a list. (basic_props:list/1)

`Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

valid_table/2: PREDICATE

`valid_table(ElementTable,Predicate)`

All of the `ElementTable` sublists have the same number of elements and are not empty.

Usage:

– *The following properties should hold at call time:*

`ElementTable` is a list. (basic_props:list/1)

`Predicate` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

188 Doubly linked lists

Author(s): David Trallero Mena.

This library implements "doubly linked" lists, in the sense that they can be traversed in both directions with good complexity. An index is used for referencing the current element in the list. This index can be modified by the *next* and *prev* predicates. The value of the current index can be obtained via the *top* predicate

188.1 Usage and interface (ddlist)

- **Library usage:**
  `:- use_module(library(ddlist)).`
- **Exports:**
  - *Predicates:*
    `null_ddlist/1`, `create_from_list/2`, `to_list/2`, `next/2`, `prev/2`, `insert/3`, `insert_top/3`, `insert_after/3`, `insert_begin/3`, `insert_end/3`, `delete/2`, `delete_top/2`, `delete_after/2`, `remove_all_elements/3`, `top/2`, `rewind/2`, `forward/2`, `length/2`, `length_next/2`, `length_prev/2`, `ddlist_member/2`.
  - *Regular Types:*
    `ddlist/1`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

188.2 Documentation on exports (ddlist)

null_ddlist/1: PREDICATE

Usage: `null_ddlist(A)`

- *Description:* `NullList` is an empty ddlist.
- *The following properties should hold at call time:*
  `A` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `A` is a "doubly linked" list. (ddlist:ddlist/1)

create_from_list/2: PREDICATE

Usage: `create_from_list(List,DDList)`

- *Description:* Creates a doubly linked list from normal list `List`.
- *The following properties should hold at call time:*
  `List` is a list. (basic_props:list/1)
  `DDList` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `DDList` is a "doubly linked" list. (ddlist:ddlist/1)

to_list/2: PREDICATE

Usage: `to_list(DDList,List)`

- *Description:* Converts from doubly linked list to list.
- *The following properties should hold at call time:*

  `DDList` is a "doubly linked" list. (ddlist:ddlist/1)

  `List` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `List` is a list. (basic_props:list/1)

next/2: PREDICATE

Usage: `next(OldList,NewList)`

- *Description:* `NewList` is `OldList` but index is set to the element following the current element of OldList. It satisfies `next(A,B), prev(B,A)`.
- *The following properties should hold at call time:*

  `OldList` is a "doubly linked" list. (ddlist:ddlist/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

prev/2: PREDICATE

Usage: `prev(OldList,NewList)`

- *Description:* `NewList` is `OldList` but index is set to the element before the current element of `OldList`.
- *The following properties should hold at call time:*

  `OldList` is a "doubly linked" list. (ddlist:ddlist/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

insert/3: PREDICATE

Usage: `insert(List,Element,NewList)`

- *Description:* `NewList` is like `List` but with `Element` inserted **before** the current index. It satisfies `insert(X , A , Xp) , delete(Xp , X)`.
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Element` is any term. (basic_props:term/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

insert_top/3: PREDICATE

Usage: `insert_top(List,Element,NewList)`

- *Description:* Put `Element` as new top of `NewList` and push the rest of elements after it. It satisfies top(NewList , element)
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Element` is any term. (basic_props:term/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

insert_after/3: PREDICATE

Usage: `insert_after(List,Element,NewList)`

- *Description:* `NewList` is like `List` but with `Element` inserted **after** the current index. It satisfies `insert_after(X, A, Xp), delete_after(Xp, X)`.
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Element` is any term. (basic_props:term/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

insert_begin/3: PREDICATE

Usage: `insert_begin(List,Element,NewList)`

- *Description:* `NewList` is like `List` with `Element` as first element.
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Element` is any term. (basic_props:term/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

insert_end/3: PREDICATE

Usage: `insert_end(List,Element,NewList)`

- *Description:* `NewList` is like `List` with `Element` as last element.
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Element` is any term. (basic_props:term/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

delete/2: PREDICATE

Usage: `delete(OldList,NewList)`

- *Description:* `NewList` does not have the previous element (top(prev)) of `OldList`.
- *The following properties should hold at call time:*

  `OldList` is a "doubly linked" list. (ddlist:ddlist/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

delete_top/2: PREDICATE

Usage: `delete_top(OldList,NewList)`

- *Description:* `NewList` does not have the current element (top) of `OldList`.
- *The following properties should hold at call time:*

  `OldList` is a "doubly linked" list. (ddlist:ddlist/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

delete_after/2: PREDICATE

Usage: `delete_after(OldList,NewList)`

- *Description:* `NewList` does not have next element to current element (top) of `OldList`.
- *The following properties should hold at call time:*

  `OldList` is a "doubly linked" list. (ddlist:ddlist/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

remove_all_elements/3: PREDICATE

Usage: `remove_all_elements(OldList,E,NewList)`

- *Description:* Remove all elements that unify with `E` from `OldList`. `NewList` is the result of this operation. The pointer is not modified unless there it is pointing at element that unifies with `E`.
- *The following properties should hold at call time:*

  `OldList` is a "doubly linked" list. (ddlist:ddlist/1)

  `E` is currently a term which is not a free variable. (term_typing:nonvar/1)
- *The following properties should hold upon exit:*

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

top/2: PREDICATE

Usage: `top(List,Element)`

- *Description:* `Element` is the element pointed by index.
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Element` is any term. (basic_props:term/1)

rewind/2: PREDICATE

Usage: `rewind(OldList,NewList)`

- *Description:* `NewList` is the `OldList` but index is set to 0.
- *The following properties should hold at call time:*

  `OldList` is a "doubly linked" list. (ddlist:ddlist/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

forward/2: PREDICATE

Usage: `forward(OldList,NewList)`

- *Description:* `NewList` is the `OldList` but index is set to lentgh of `NewList`.
- *The following properties should hold at call time:*

  `OldList` is a "doubly linked" list. (ddlist:ddlist/1)

  `NewList` is a "doubly linked" list. (ddlist:ddlist/1)

length/2: PREDICATE

Usage: `length(List,Len)`

- *Description:* `Len` is the length of the `List`
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Len` is an integer. (basic_props:int/1)

length_next/2: PREDICATE

Usage: `length_next(List,Len)`

- *Description:* `Len` is the length from the current index till the end.
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Len` is an integer. (basic_props:int/1)

length_prev/2: PREDICATE

Usage: `length_prev(List,Len)`

- *Description:* `Len` is the length from the beginning till the current index.
- *The following properties should hold at call time:*

  `List` is a "doubly linked" list. (ddlist:ddlist/1)

  `Len` is an integer. (basic_props:int/1)

ddlist/1: REGTYPE

Usage: `ddlist(X)`

- *Description:* `X` is a "doubly linked" list.

ddlist_member/2: PREDICATE

Usage: `ddlist_member(X,DDList)`

- *Description:* Success if `X` is member of `DDList`. `X` first unifies with elements of the forward list, i.e. from the top till the end, and later with elements from the top to the beginning.
- *The following properties should hold at call time:*

  `X` is any term. (basic_props:term/1)

  `DDList` is a "doubly linked" list. (ddlist:ddlist/1)

188.3 Other information (`ddlist`)

Two simple examples of the use of the ddlist library package follow.

188.3.1 Using insert_after

```
:- module( ddl1 , _ , [] ).

:- use_module(library(ddlist)).

main(A,B):-
        % L = []
        null_ddlist( L ),
        % L = [1]
        insert_after( L  , 1 , L1 ),
        % L = [1,2]
        insert_after( L1 , 2 , L2 ),
        % L = [1,3,2]
        insert_after( L2 , 3 , L3 ),
        % L = [1,3,2] => A = [1]
        top( L3 , A ),
        % L = [3,2]
        next( L3 , PL3 ),
        % L = [3,2] => A = [3]
        top( PL3 , B ).
```

188.3.2 More Complex example

```
:- module( ddl2 , _ , [] ).

:- use_module(library(ddlist)).

main(A,B):-
        % L = []
        null_ddlist( L ),
        % L = [1]
        insert_after( L  , 1 , L1 ),
        % L = [1,2]
        insert_after( L1 , 2 , L2 ),
        % L = [1,2]
        insert( L2 , 3 , L3 ),
        % L = [3,1,2]
        prev( L3 , PL3 ),
        % L = [],
        forward( PL3 , FOR ),
        % L = [2]
        prev( FOR , FOR1 ),
        % L = [2] => A = 2
        top( FOR1 , A ),
        % L = [1,2]
        prev( FOR1 , FOR2 ),
        % L = [2]
        delete_after( FOR2 , FOR3 ),
        % L = [3,2]
        prev( FOR3, FOR4 ),
```

```
% L = [3,2] => B = 3
top( FOR4 , B ).
```

Ciao DHT Implementation

Author(s): Arsen Kostenko.

General documentation pending

189 Top-level user interface to DHT

Author(s): Arsen Kostenko.

This module contains just a top-level interface to the utilities provided by the DHT system in Ciao. The 'philosophy' of the current approach is that most details are hidden behind simple read/write primitives and that the handler is exposed to the client for a concrete DHT. By doing things this way we expect to preserve the simplicity of DHT usage while providing the freedom of being able to switch between various instances of the Ciao DHT system

189.1 Usage and interface (`dht_client`)

- **Library usage:**
  `:- use_module(library(dht_client)).`
- **Exports:**
  - *Predicates:*
    `dht_connect/2`, `dht_connect/3`, `dht_disconnect/1`, `dht_consult_b/4`, `dht_consult_nb/4`, `dht_extract_b/4`, `dht_extract_nb/4`, `dht_store/4`, `dht_hash/3`.
- **Other modules used:**
  - *System library modules:*
    `sockets/sockets`, `dht/dht_misc`.

189.2 Documentation on exports (`dht_client`)

dht_connect/2: PREDICATE

Connect to the DHT specified by `Server` (IP address).

Usage: `dht_connect(Server,Connection)`

- *Description:* Perform a straightforward connection from the client-side of a DHT node. The information about DHT node to connect to is supplied as `Server`. It could equally be a DNS name or an IP address.
- *The following properties should hold at call time:*
  `Server` is an atom. (basic_props:atm/1)
  `Connection` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `Server` is ground. (basic_props:gnd/1)
  `Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

dht_connect/3: PREDICATE

Connect to the DHT specified by `Server` (IP address).

Usage: `dht_connect(Server,Port,Connection)`

– *Description:* Perform a straightforward connection from the client-side of a DHT node. The information about DHT node to connect to is supplied as combination of `Server` and `Port`, if a non standart port is used for server-to-client communication. It could equally be a DNS name or an IP address.

– *The following properties should hold at call time:*

`Server` is an atom. (basic_props:atm/1)

`Port` is an integer. (basic_props:int/1)

`Connection` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Server` is an atom. (basic_props:atm/1)

`Port` is an integer. (basic_props:int/1)

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

dht_disconnect/1: PREDICATE

Disconnect from DHT, identified by special supplied connection.

Usage: `dht_disconnect(Connection)`

– *Description:* Issues 'end_of_file' token to the stream supplied as `Connection` and closes it without delay.

– *The following properties should hold at call time:*

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

dht_consult_b/4: PREDICATE

Look either for exact predicate or predicate matching the pattern in DHT.

Usage: `dht_consult_b(Conn,Key,Value,Resp)`

– *Description:* `dht_consult/4` performs a lookup in the DHT represented by `Conn` (see `dht_connect/2`) and searches for `Value` previously associated with the `Key`. `Value` may be partially instantiated in which case matching against the tuples stored in DHT is performed.

– *The following properties should hold at call time:*

`Conn` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Key` is an atom. (basic_props:atm/1)

`Value` is any term. (basic_props:term/1)

`Resp` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Conn` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Key` is an atom. (basic_props:atm/1)

`Value` is any term. (basic_props:term/1)

`Resp` is ground. (basic_props:gnd/1)

dht_consult_nb/4: PREDICATE

Usage: `dht_consult_nb(Connection,Key,Value,Response)`

- *Description:* `dht_consult/4` performs a lookup in the DHT represented by `Conn` (see `dht_connect/2`) and searches for `Value` previously associated with the `Key`. `Value` may be partially instantiated in which case matching against the tuples stored in DHT is performed.
- *The following properties should hold at call time:*

  `Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

  `Key` is an atom. (basic_props:atm/1)

  `Value` is any term. (basic_props:term/1)

  `Response` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

  `Key` is an atom. (basic_props:atm/1)

  `Value` is any term. (basic_props:term/1)

  `Response` is ground. (basic_props:gnd/1)

dht_extract_b/4: PREDICATE

Extract from DHT an exact predicate of type `Key(Value)` or one that matches given pattern.

Usage: `dht_extract_b(Connection,Key,Value,Response)`

- *Description:* This predicate extracts information from the DHT connected to by `Connection`, that is stored under key `Key` if it matches the pattern supplied as `Value`
- *The following properties should hold at call time:*

  `Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

  `Key` is an atom. (basic_props:atm/1)

  `Value` is any term. (basic_props:term/1)

  `Response` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

  `Key` is an atom. (basic_props:atm/1)

  `Value` is any term. (basic_props:term/1)

  `Response` is ground. (basic_props:gnd/1)

dht_extract_nb/4: PREDICATE

Extract from DHT an exact predicate of type `Key(Value)` or one that matches given pattern.

Usage: `dht_extract_nb(Connection,Key,Value,Response)`

– *Description:* This predicate extracts information from the DHT connected to by `Connection`, that is stored under key `Key` if it matches the pattern supplied as `Value`

– *The following properties should hold at call time:*

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Key` is an atom. (basic_props:atm/1)

`Value` is any term. (basic_props:term/1)

`Response` is ground. (basic_props:gnd/1)

dht_store/4: PREDICATE

Store data to DHT in form of `Key(Value)` predicate. No free variables are allowed in predicate.

Usage: `dht_store(Connection,Key,Value,Response)`

– *Description:* The value provided in `Value` is stored under a key given as `Key` inside the DHT mentioned as `Connection`

– *The following properties should hold at call time:*

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Key` is an atom. (basic_props:atm/1)

`Value` is any term. (basic_props:term/1)

`Response` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Key` is an atom. (basic_props:atm/1)

`Value` is any term. (basic_props:term/1)

`Response` is ground. (basic_props:gnd/1)

dht_hash/3: PREDICATE

Get value of hash function for a given term.

Usage 1: `dht_hash(Connection,Value,Hash)`

– *Description:* Get (in `Hash`) the hash of `Value` as determined by the DHT pointed to by `Connection`. Implemented mostly for testing purposes.

– *The following properties should hold at call time:*

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Value` is any term. (basic_props:term/1)

`Hash` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Value` is any term. (basic_props:term/1)

`Hash` is an integer. (basic_props:int/1)

Usage 2: `dht_hash(Connection,Value,Hash)`

– *Description:* Check whether `Hash` is equal to the hash of `Value` as determined by the DHT pointed to by `Connection`. Implemented mostly for testing purposes.

– *The following properties should hold at call time:*

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Value` is any term. (basic_props:term/1)

`Hash` is an integer. (basic_props:int/1)

– *The following properties should hold upon exit:*

`Connection` is a predicate of type `dht_connection/2`, where first argument is of type `atm/1` and second of type `streams_basic:stream/1` (dht_client:dht_connection_type/1)

`Value` is any term. (basic_props:term/1)

`Hash` is an integer. (basic_props:int/1)

190 Top-level interface to a DHT server

Author(s): Arsen Kostenko.

190.1 Usage and interface (dht_server)

- **Library usage:**
  `:- use_module(library(dht_server)).`
- **Exports:**
  - *Predicates:*
    `dht_server/1`, `dht_prolog/1`.
- **Other modules used:**
  - *System library modules:*
    `sockets/sockets`, `system`, `format`, `dht/dht_config`, `dht/dht_logic_misc`, `dht/dht_s2s`, `dht/dht_s2c`.

190.2 Documentation on exports (dht_server)

dht_server/1: PREDICATE

`main/1`: start the DHT server. Here is a step-by-step bahavior:

1. set all values of `dht_config.pl` module to default.
2. modify those, for which command-line arguments were supplied.
3. modify server number separately, since it depends on two command-line arguments : `--server-id` and `--hash-power`.
4. output resulting values to terminal.
5. start client side communication by executing `dht_s2c:dht_s2c_mian/0`.
6. start server side communication by executing `dht_s2s:dht_s2s_mian/0`.

Usage: `dht_server(Arguments)`

- *The following properties should hold at call time:*
  `Arguments` is associated with simple list, that represents pairs of command line arguments (argument and its value). Possible values are: `--join-host`, `--hash-power`, `--server-id`, `--s2c-port`, `--s2c-threads`, `--s2s-port`, `--s2s-threads`. All of the arguments (except `--join-host`) accept integer values. In case of `--join-host` value of argument should be equal to IP/DNS address of host running a copy of DHT. (dht_server:dht_arguments_list/1)

dht_prolog/1: PREDICATE

Another style to launch the DHT server. All the parameters are passed in the list. Members of the list are of type `prameter_name(parameter_value)`, where `parameter_name` corresponds to name of the command line argument without two leading dashes (`--`) and with internal dash replaced by the underscore (`_`). All the values are of integer type, except the value of `join_host`, which should be an atom.

191 Server to client communication module

Author(s): Arsen Kostenko.

This module describes the server-2-client side behavior of any node. Since the behavior is not very different this module shares a number of fearures with `dht_s2c.pl`:

- extensive usage of the Ciao threading mechanism;
- interface made as simple as possible;
- `dht_server.pl` module is the only usage point;
- parameters are passed through the `dht_config.pl` module.

191.1 Usage and interface (`dht_s2c`)

- **Library usage:**
  `:- use_module(library(dht_s2c)).`
- **Exports:**
  - *Predicates:*
    `dht_s2c_main/0`.
- **Other modules used:**
  - *System library modules:*
    `sockets/sockets`, `concurrency/concurrency`, `dht/dht_config`, `dht/dht_misc`, `dht/dht_logic`, `dht/dht_logic_misc`.

191.2 Documentation on exports (`dht_s2c`)

dht_s2c_main/0: PREDICATE

Generally speaking, this predicate must perform some common tasks like:

- listen to a port for incoming connections from clients,
- and process requests from clients.

All the parameters needed are received from initial configuration, which is stored in `dht_config.pl` module.

192 Server to server communication module

Author(s): Arsen Kostenko.

This module describes server-2-server side behavior of any node. Since this includes various communication and inspection tasks that should be performed in parallel, this module makes extensive usage of Ciao threading mechanism. On the other hand, module must be as simple as possible in terms of usage. Therefore, only a single predicate `dht_s2s_main/0` is exposed to outer world and rest of complexity is hidden inside. This predicate is used from `dht_server.pl` module. All the parameters are passed through `dht_config.pl` module.

192.1 Usage and interface (`dht_s2s`)

- **Library usage:**
  `:- use_module(library(dht_s2s)).`
- **Exports:**
  - *Predicates:*
    `dht_s2s_main/0`.
- **Other modules used:**
  - *System library modules:*
    `sockets/sockets`, `system`, `concurrency/concurrency`, `dht/dht_config`, `dht/dht_misc`, `dht/dht_logic`.

192.2 Documentation on exports (`dht_s2s`)

dht_s2s_main/0: PREDICATE

Generally speaking, this predicate must perform some conventional tasks like:

- set local part of DHT to initial state,
- contact a successor node if there is any,
- and finally launch several threads that listen to streams, process incoming requests and inspect state of local finger-table.

All parameters (like listen port, number of threads, host to join, etc) are received from `dht_config.pl` module

193 DHT-related logics

Author(s): Arsen Kostenko.

This module implements a core DHT functionality, like finger-table manipulation and lookup search. Keep in mind that remote calls (known as remote predicate calls in Prolog) are extracted to a separate module as well as low-lever database handling. In turn, the logic module is utilized by higher-lever modules, like the server-2-server and server-2-client communication modules.

`Id` is treated as the value of the hash function used all over the DHT.

193.1 Usage and interface (`dht_logic`)

- **Library usage:**
  `:- use_module(library(dht_logic)).`
- **Exports:**
  - *Predicates:*
    `dht_init/1`, `dht_finger/2`, `dht_successor/1`, `dht_check_predecessor/1`, `dht_closest_preceding_finger/2`, `dht_find_predecessor/2`, `dht_find_successor/2`, `dht_join/1`, `dht_notify/1`, `dht_stabilize/0`, `dht_fix_fingers/0`, `dht_id_by_node/2`, `dht_find_and_consult_b/2`, `dht_consult_server_b/3`, `dht_find_and_consult_nb/2`, `dht_consult_server_nb/3`, `dht_find_and_extract_b/2`, `dht_extract_from_server_b/3`, `dht_find_and_extract_nb/2`, `dht_extract_from_server_nb/3`, `dht_find_and_store/2`, `dht_store_to_server/4`.
- **Other modules used:**
  - *System library modules:*
    `dht/dht_rpr`, `dht/dht_config`, `dht/dht_logic_misc`, `dht/dht_storage`, `dht/dht_routing`.

193.2 Documentation on exports (`dht_logic`)

dht_init/1: PREDICATE

Predicated performs the initialization of a single-node DHT.

Usage: `dht_init(OwnId)`

- *Description:* The predicate is intended to perform various initialization functions like finger_table creation, hostname and IP address retrieval. The value supplied in `OwnId` is treated as value of the hash function used all over the DHT.
- *The following properties should hold at call time:*
  `OwnId` is an integer. (basic_props:int/1)

dht_finger/2: PREDICATE

Get the node identifier (composition of identifier and IP-address) by using index in the finger table. Prolog synonym for `finger[k].node`.

Usage: `dht_finger(Idx,Finger)`

- *Description:* `dht_finger/2` implements the array looking up necessary to retrive information from the finger table, where first argument `Idx` if acting as array index and `Finger` as corresponding array value.

– *The following properties should hold at call time:*
  `Idx` is an integer. (basic_props:int/1)
  `Finger` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
  `Idx` is an integer. (basic_props:int/1)
  `Finger` is ground. (basic_props:gnd/1)

dht_successor/1: PREDICATE

Wrapper around `dht_finger/1`, where first argument is defaulted to '1'

Usage: `dht_successor(Successor)`

– *Description:* `dht_successor/1` a simple wrapper around `dht_finger/2`, that looks up the first row of so-called finger-table
– *The following properties should hold at call time:*
  `Successor` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
  `Successor` is ground. (basic_props:gnd/1)

dht_check_predecessor/1: PREDICATE

`dht_check_predecessor/1` predicate is called by external nodes when they run `dht_stabilize/0`. Since there is no other way to learn about a predecessor's failure, but checking explicitly once predecessor is required. that is why behavior of `dht_check_predecessor` is following:

1. give 'nil' as predecessor if it is stored in database that way, which happens if node is unaware of any other nodes on the ring,
2. otherwise, get current value of predecessor,
3. try calling predecessor with any arbitrary predicate in our case `dht_successor/1`,
4. if an exception is issued by remote call - reset predecessor to 'nil',
5. get value of predecessor once again and bind this value to the answer. We also check that in case of finger-nodes failure, but this would work out only in poorly populated Chord-ring

Usage 1: `dht_check_predecessor(PredecessorId)`

– *Description:* Get value of predecessor for current node.
– *The following properties should hold at call time:*
  `PredecessorId` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
  `PredecessorId` is ground. (basic_props:gnd/1)

Usage 2: `dht_check_predecessor(PredecessorId)`

– *Description:* Check whether value supplied is equal to id of predecessor.
– *The following properties should hold at call time:*
  `PredecessorId` is ground. (basic_props:gnd/1)
– *The following properties should hold upon exit:*
  `PredecessorId` is ground. (basic_props:gnd/1)

dht_closest_preceding_finger/2: PREDICATE

Perform search over current finger table, in order to find entry pointing to node that is more closely located to value supplied via `Id`. Here is original part of code from Chord paper.

```
n.closest_preceding_finger(id){
    for i = m downto 1 {
       if (finger[i].node in (n, id)){
          return finger[i].node;
       }
    }
    return n;
}
```

.

Usage: `dht_closest_preceding_finger(Id,Finger)`

- *Description:* `dht_closest_preceding_finger/2` is searching local finger-table for the entry which points to a node, that is 'closer' (in terms of DHT distance) to the identifier specified at `Id`. It should hold that identifier of the node found is greater than identifier of current node and lesser than the identifier supplied in `Id`. No estimations concerning other nodes in between them are made. Furthermore, a cyclic structure of identifiers is preserved: identifier '0' is lesser then identifier '1' but greater then the highest identifier in DHT.
- *The following properties should hold at call time:*

  `Id` is an integer. (basic_props:int/1)

  `Finger` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Id` is an integer. (basic_props:int/1)

  `Finger` is ground. (basic_props:gnd/1)

dht_find_predecessor/2: PREDICATE

Perform search over existing DHT structure. The resulting node is expected to precede the one identified by `Id`. Again, a small quote from Chord-paper source code.

```
n.find_predecessor(id){
    n' is n,
    while(id not_in (n', n'.successor] ){
       n' = n'.closest_preceding_finger(id);
    }
    return n';
}
```

Usage: `dht_find_predecessor(Id,Predecessor)`

- *Description:* `dht_find_predecessor/2` searches all over DHT for a node, which is 'the closest' (in terms of DHT distance) to the index specified as `Id`. In other words, the searched node must have the index lesser than the identifier specified in `Id` and there must not be any other nodes between identifier specified in `Id` and the node found.
- *The following properties should hold at call time:*

  `Id` is an integer. (basic_props:int/1)

  `Predecessor` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Id` is an integer. (basic_props:int/1)

`Predecessor` is ground. (basic_props:gnd/1)

dht_find_successor/2: PREDICATE

Usage: `dht_find_successor(Id,Successor)`

– *Description:* `dht_find_successor/2` has behavior similar to `dht_find_predecessor/2` except that it gives a node that directly succeeds the identifier specifies. In other words, the identifier of the node found is greater than the identifier specified in `Id` and there are no other nodes between the node found and the node specified in `Id`

– *The following properties should hold at call time:*

`Id` is an integer. (basic_props:int/1)

`Successor` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Id` is an integer. (basic_props:int/1)

`Successor` is ground. (basic_props:gnd/1)

dht_join/1: PREDICATE

It performs the join procedure on the node pointed by the argument. Here is the corresponding quote:

```
n.join(Next){
    predecessor = nil;
    successor = Next.find_successor(n);
}
```

Usage: `dht_join(NodeIP)`

– *Description:* `dht_join/2` is executed every time some node decides to join some DHT. The only information needed for execution of join is a valid ID / IP combination of any existing node, which must be supplied with `NodeId`

– *The following properties should hold at call time:*

`NodeIP` is an atom. (basic_props:atm/1)

dht_notify/1: PREDICATE

This predicate performs 'notification'. Notification is part of adaptation process launched by `dht_stabilize/0`. A quote from Chord paper that refers to this section is given below:

```
n.notify(NewNodeId){
    if (predecessor is nil ||
          NewNodeId in (predecessor, n)){
        predecessor = NewNodeId;
    }
}
```

Usage: `dht_notify(NewNode)`

- *Description:* `dht_notify/1` is called on current node, once any other DHT node specified by `NewNode` regards current node at it's successor.
- *The following properties should hold at call time:*

  `NewNode` is ground. (basic_props:gnd/1)

dht_stabilize/0: PREDICATE

`dht_stabilize`

Perform stabilization on the successor node by asking successor's predecessor value. If the value returned is equal to current node, just stay calm, otherwise try to adopt the newly returned result as new successor. Most of the 'dirty' work is performed by `stabilize_successor/2` predicate. The corresponding Chord-paper quote is given below:

```
n.stabilize(){
    x = successor.predecessor;
    if (x in (n, successor)){
        successor = x;
    }
    successor.notify(n);
}
```

There is also a small simplification scheme, since before calling `dht_join/1` each node assumes itself as the only member of the circle, the very first case of `dht_stabilize/0` does nothing if successor is actually equal to current node.

Usage:

- *Description:* `dht_stabilize/0` is a eternally repeated predicate, which aims at stabilizing first-level references of the finger-table, while multiple concurrent joins and failures can happen. Its main goal is to ask its own successor to report its predecessor. If the reported node is different from the one that is calling `dht_stabilize/0`, there should be someone in between current node and its the successor. So a newly reported node should be registered as the successor instead of an old one. Technically, once an inconsistency between actual state of DHT and finger-table is found a newly found node is asked to perform `dht_notify/1`, with current node as an argument.

dht_fix_fingers/0: PREDICATE

`dht_fix_fingers`

This predicate takes care of maintaining the finger table entries (except the first one) up to date. The first entry is taken care of by a specialized predicate `dht_stabilize/0`, since there is much more responsibility on first entry (a direct successor). Rest of the same task is performed here, by `dht_fix_fingers/0`. In the Chord paper notation this part look like:

```
n.fix_fingers(){
    i = random index > 1 into finger[];
    finger[i].node = find_successor(finger[i].start);
}
```

.

Usage:

– *Description:* `dht_fix_fingers/0` is yet another randomly repeated predicate, which aims at stabilizing high-level references of finger-table, while multiple concurrent joins and failures happen. Once started, `dht_fix_fingers/0` picks a random (but not first) entry of finger table, and searches for a node responsible for the identifiers specified in the entry. In case, node that was found is different from the one currently specified, current node is replaced by a new one.

dht_id_by_node/2: PREDICATE

This predicate is entirely used by remote calls. Since there is `dht_rpr_id_by_node/2` for current module. This is an effort to avoid module-re-exportation (`dht_routing.pl` and `dht_rpr.pl`).

Usage: `dht_id_by_node(Node,NodeID)`

– *Description:* Get node identity by node number.

– *The following properties should hold at call time:*

`Node` is an integer. (basic_props:int/1)

`NodeID` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Node` is an integer. (basic_props:int/1)

`NodeID` is ground. (basic_props:gnd/1)

dht_find_and_consult_b/2: PREDICATE

`dht_find_and_consult_b/2` is meant to perform two actions:

- search for the node responsible for value supplied as a `Key`;
- perform `dht_consult_server_b/3` on a node found.

This is the first predicate of the whole `dht_find_and_*/2` family of predicates. Name of each member of the family gives a hint on implementation. And as it is presented by the name of the family, they share some part of implementation - all the members of the family perform search for particular DHT-node, which is achieved by `find_server/3` predicate.

Usage 1: `dht_find_and_consult_b(Key,Value)`

– *Description:* An invocation of this type would bind all free variables in `Value` to the values present in the local database of the node responsible for `Key`.

– *The following properties should hold at call time:*

`Key` is an integer. (basic_props:int/1)

`Value` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Key` is an integer. (basic_props:int/1)

`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_find_and_consult_b(Key,Value)`

– *Description:* Invocation with two ground arguments is equal to checking the presence of the term specified by `Value` inside the DHT.

– *The following properties should hold at call time:*

`Key` is an integer. (basic_props:int/1)

`Value` is ground. (basic_props:gnd/1)

dht_consult_server_b/3: PREDICATE

Basically forms the second half of `dht_find_and_consult/2` predicate. This predicate takes no care about search of corresponding server. The only thing it does - given a server try to locate a predicate under given `Key` there. Of course there two possible variants of application:

Usage 1: `dht_consult_server_b(NodeId,Key,Value)`

- *Description:* First variant deals with real consulting, when the value is unknown. Therefore, after predicate is successfully executed, a real value, that is stored under `Key` is associated with third argument (`Value`)
- *The following properties should hold at call time:*

  `NodeId` is ground. (basic_props:gnd/1)

  `Key` is ground. (basic_props:gnd/1)

  `Value` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `NodeId` is ground. (basic_props:gnd/1)

  `Key` is ground. (basic_props:gnd/1)

  `Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_consult_server_b(NodeId,Key,Value)`

- *Description:* Second variant is more similar to check for existence, All arguments are ground by the time predicate is called, so the only use is success/failure of predicate itself.
- *The following properties should hold at call time:*

  `NodeId` is ground. (basic_props:gnd/1)

  `Key` is ground. (basic_props:gnd/1)

  `Value` is ground. (basic_props:gnd/1)
- *The following properties should hold upon exit:*

  `NodeId` is ground. (basic_props:gnd/1)

  `Key` is ground. (basic_props:gnd/1)

  `Value` is ground. (basic_props:gnd/1)

dht_find_and_consult_nb/2: PREDICATE

`dht_find_and_consult_nb/2` is meant to perform two actions:

- search for the node responsible for value supplied as a `Key`;
- perform `dht_consult_server_nb/3` on a node found.

This is the first predicate of the whole `dht_find_and_*/2` family of predicates. Name of each member of the family gives a hint on implementation. And as it is presented by the name of the family, they share some part of implementation - all the members of the family perform search for particular DHT-node, which is achieved by `find_server/3` predicate.

Usage 1: `dht_find_and_consult_nb(Key,Value)`

- *Description:* An invocation of this type would bind all free variables in `Value` to the values present in the local database of the node responsible for `Key`.
- *The following properties should hold at call time:*

  `Key` is an integer. (basic_props:int/1)

  `Value` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Key` is an integer. (basic_props:int/1)

`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_find_and_consult_nb(Key,Value)`

– *Description:* Invocation with two ground arguments is equal to checking the presence of the term specified by `Value` inside the DHT.

– *The following properties should hold at call time:*

`Key` is an integer. (basic_props:int/1)

`Value` is ground. (basic_props:gnd/1)

dht_consult_server_nb/3: PREDICATE

Basically forms the second half of `dht_find_and_consult/2` predicate. This predicate takes no care about search of corresponding server. The only thing it does - given a server try to locate a predicate under given `Key` there. Of course there two possible variants of application:

Usage 1: `dht_consult_server_nb(NodeId,Key,Value)`

– *Description:* First variant deals with real consulting, when the value is unknown. Therefore, after predicate is successfully executed, a real value, that is stored under `Key` is associated with third argument (`Value`)

– *The following properties should hold at call time:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_consult_server_nb(NodeId,Key,Value)`

– *Description:* Second variant is more similar to check for existence, All arguments are ground by the time predicate is called, so the only use is success/failure of predicate itself.

– *The following properties should hold at call time:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is ground. (basic_props:gnd/1)

– *The following properties should hold upon exit:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is ground. (basic_props:gnd/1)

dht_find_and_extract_b/2: PREDICATE

`dht_find_and_extract_b/2` is meant to perform two actions:

- search for node responsible for value supplied as a `Key`;

- perform `dht_extract_from_server_b/3` on a node found.

Unlike `dht_find_and_consult/2`, this predicate removes matching records form the local databases of the corresponding nodes.

Usage 1: `dht_find_and_extract_b(Key,Value)`

– *Description:* An invocation of this type would bind all free variables in `Value` to values present in the local database of the corresponding node, and the values against which the matching was performed are erased.

– *The following properties should hold at call time:*

`Key` is an integer. (basic_props:int/1)

`Value` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Key` is an integer. (basic_props:int/1)

`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_find_and_extract_b(Key,Value)`

– *Description:* Invocation with two ground arguments is equal to checking presence of term specified by `Value` inside the DHT, and removing it in case of successful search.

– *The following properties should hold at call time:*

`Key` is an integer. (basic_props:int/1)

`Value` is ground. (basic_props:gnd/1)

dht_extract_from_server_b/3: PREDICATE

This predicate is also used entirely as a second part of `dht_find_and_extract/2` predicate. It's behavior differs from similar `dht_consult_server_b/3` predicate, only in action that is performed over DHT. In this case 'extraction' of predicates, instead of simple 'consultation'

Usage 1: `dht_extract_from_server_b(NodeId,Key,Value)`

– *Description:* First variant deals with blind 'extraction', when the value is unknown. Therefore, after predicate is successfully executed, a real value, that is stored under `Key` is associated with third argument (`Value`)

– *The following properties should hold at call time:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_extract_from_server_b(NodeId,Key,Value)`

– *Description:* Second variant is more similar to pointed elimination. All arguments are ground by the time predicate is called, so the only use is success and elimination of predicate itself or general failure on contrary.

– *The following properties should hold at call time:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is ground. (basic_props:gnd/1)

– *The following properties should hold upon exit:*
`NodeId` is ground. (basic_props:gnd/1)
`Key` is ground. (basic_props:gnd/1)
`Value` is ground. (basic_props:gnd/1)

dht_find_and_extract_nb/2: PREDICATE

`dht_find_and_extract_nb/2` is meant to perform two actions:

- search for node responsible for value supplied as a `Key`;
- perform `dht_extract_from_server_nb/3` on a node found.

Unlike `dht_find_and_consult/2`, this predicate removes matching records form the local databases of the corresponding nodes.

Usage 1: `dht_find_and_extract_nb(Key,Value)`

– *Description:* An invocation of this type would bind all free variables in `Value` to values present in the local database of the corresponding node, and the values against which the matching was performed are erased.
– *The following properties should hold at call time:*
`Key` is an integer. (basic_props:int/1)
`Value` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Key` is an integer. (basic_props:int/1)
`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_find_and_extract_nb(Key,Value)`

– *Description:* Invocation with two ground arguments is equal to checking presence of term specified by `Value` inside the DHT, and removing it in case of successful search.
– *The following properties should hold at call time:*
`Key` is an integer. (basic_props:int/1)
`Value` is ground. (basic_props:gnd/1)

dht_extract_from_server_nb/3: PREDICATE

This predicate is also used entirely as a second part of `dht_find_and_extract/2` predicate. It's behavior differs from similar `dht_consult_server_b/3` predicate, only in action that is performed over DHT. In this case 'extraction' of predicates, instead of simple 'consultation'

Usage 1: `dht_extract_from_server_nb(NodeId,Key,Value)`

– *Description:* First variant deals with blind 'extraction', when the value is unknown. Therefore, after predicate is successfully executed, a real value, that is stored under `Key` is associated with third argument (`Value`)
– *The following properties should hold at call time:*
`NodeId` is ground. (basic_props:gnd/1)
`Key` is ground. (basic_props:gnd/1)
`Value` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`NodeId` is ground. (basic_props:gnd/1)
`Key` is ground. (basic_props:gnd/1)
`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_extract_from_server_nb(NodeId,Key,Value)`

– *Description:* Second variant is more similar to pointed elimination. All arguments are ground by the time predicate is called, so the only use is success and elimination of predicate itself or general failure on contrary.

– *The following properties should hold at call time:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is ground. (basic_props:gnd/1)

– *The following properties should hold upon exit:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`Value` is ground. (basic_props:gnd/1)

dht_find_and_store/2: PREDICATE

First part of this predicate is similar to rest of `dht_find_and_*/2` family - perform search over existing DHT structure. After search - storage operation is performed.

Usage: `dht_find_and_store(Key,Value)`

– *Description:* `dht_find_and_store/2` is meant to perform two actions:

- search for a node responsible for the value supplied as `Key`;
- perform `dht_store_to_server/4` on node found.

Since the arguments of `dht_store_to_server/4` must be ground both arguments of `dht_find_and_store` are ground too.

– *The following properties should hold at call time:*

`Key` is an integer. (basic_props:int/1)

`Value` is ground. (basic_props:gnd/1)

dht_store_to_server/4: PREDICATE

Second part of `dht_find_and_store/2` predicate.

Usage: `dht_store_to_server(NodeId,Key,KeyHash,Value)`

– *Description:* Store `Value` under given `Key` and also record relation between `Key` and `KeyHash`.

– *The following properties should hold at call time:*

`NodeId` is ground. (basic_props:gnd/1)

`Key` is ground. (basic_props:gnd/1)

`KeyHash` is ground. (basic_props:gnd/1)

`Value` is ground. (basic_props:gnd/1)

194 Finger table and routing information

Author(s): Arsen Kostenko.

This module holds the basic operations over the finger table and other routing information. Developed for the sake of simplicity, it should be used only within the `dht_logic.pl` file. Probably the most important and abstract part of the routing is the finger table. Here is a finger table copy of the node representing identifier 0 (from the Chord paper):

```
finger_table(1, 1, finger_interval(1,2), 1).
 finger_table(2, 2, finger_interval(2,4), 3).
 finger_table(3, 4, finger_interval(4,0), 0).
```

.

This table reflects the case where there are 8 identifiers in total in the identifier circle and three running nodes with identifiers 0, 1, and 3. In general each entry can be represented as `finger_table(idx, start, interval, succ)`. Here is a brief description of each argument:

- `idx` - Since arrays are not native for Prolog, I put the index as the first argument to the finger_table predicate to achieve indexing.
- `start` - ID that starts the corresponding section of the table.
- `interval` - IDs that fit into the corresponding section of table, represented in the form: `finger_interval(interval_start, interval_end).`, where:
  - interval_start - ID that starts this interval.
  - interval_end - first ID of the next interval.
- `succ` - ID of node responsible for the corresponding section of table, represented in `node_id(id, ip).` form, where:
  - id - ID of a node.
  - ip - IP address of a node.

194.1 Usage and interface (`dht_routing`)

- **Library usage:**
  `:- use_module(library(dht_routing)).`
- **Exports:**
  - *Predicates:*
    `dht_finger_table/2`, `dht_finger_start/2`, `dht_update_finger/2`, `dht_set_finger/4`, `dht_predecessor/1`, `dht_set_predecessor/1`, `dht_reset_predecessor/0`.

194.2 Documentation on exports (`dht_routing`)

dht_finger_table/2: PREDICATE

It serves as a read-only interface to the finger table information as follows: `Idx` stands for an index in an array, and `Node` is the number of the node which is recorded in the entry with that index.

Usage 1: `dht_finger_table(Idx,Node)`

- *Description:* This case is equal to getting any (possibly random) entry from the finger table.

– *The following properties should hold at call time:*

`Idx` is a free variable. (term_typing:var/1)

`Node` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Idx` is an integer. (basic_props:int/1)

`Node` is an integer. (basic_props:int/1)

Usage 2: `dht_finger_table(Idx,Node)`

– *Description:* Get some (one or several if backtracking is exploited) indexes that mention particular node numer, supplied as `Node`.

– *The following properties should hold at call time:*

`Idx` is a free variable. (term_typing:var/1)

`Node` is an integer. (basic_props:int/1)

– *The following properties should hold upon exit:*

`Idx` is an integer. (basic_props:int/1)

`Node` is an integer. (basic_props:int/1)

Usage 3: `dht_finger_table(Idx,Node)`

– *Description:* Get the identifier of the node, indexed by `Idx`. Theoretically, there should be no more than on entry for each value of index.

– *The following properties should hold at call time:*

`Idx` is an integer. (basic_props:int/1)

`Node` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`Idx` is an integer. (basic_props:int/1)

`Node` is an integer. (basic_props:int/1)

Usage 4: `dht_finger_table(Idx,Node)`

– *Description:* Check whether a particular combination (index and node number) is present in finger table.

– *The following properties should hold at call time:*

`Idx` is an integer. (basic_props:int/1)

`Node` is an integer. (basic_props:int/1)

dht_finger_start/2: PREDICATE

This predicate may be regarded as a read-only interface to map between the index is a finger table and the beginning of the section of the DHT circle.

Usage 1: `dht_finger_start(Idx,NextId)`

– *Description:* Get any entry, in other words and entry that has any index and points to any segment in the circle. Common constraints on finger tables, do hold anyway:

- result unifies with the content of finger table;
- predicate enumerates possible results on backtracking.

– *The following properties should hold at call time:*

`Idx` is a free variable. (term_typing:var/1)

`NextId` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*
  `Idx` is an integer. (basic_props:int/1)
  `NextId` is an integer. (basic_props:int/1)

Usage 2: `dht_finger_start(Idx,NextId)`
– *Description:* Ask for the index of entry that mentions a particular node as the starting one.
– *The following properties should hold at call time:*
  `Idx` is a free variable. (term_typing:var/1)
  `NextId` is an integer. (basic_props:int/1)
– *The following properties should hold upon exit:*
  `Idx` is an integer. (basic_props:int/1)
  `NextId` is an integer. (basic_props:int/1)

Usage 3: `dht_finger_start(Idx,NextId)`
– *Description:* Get the starting node for a certain entry of finger table.
– *The following properties should hold at call time:*
  `Idx` is an integer. (basic_props:int/1)
  `NextId` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
  `Idx` is an integer. (basic_props:int/1)
  `NextId` is an integer. (basic_props:int/1)

Usage 4: `dht_finger_start(Idx,NextId)`
– *Description:* Check for the presence of a correspondence between a certain entry and its starting node.
– *The following properties should hold at call time:*
  `Idx` is an integer. (basic_props:int/1)
  `NextId` is an integer. (basic_props:int/1)

dht_update_finger/2: PREDICATE

`dht_update_finger/2` takes care of changing node value to `NodeId` for entry with index number equal to `Idx`. This predicate has entirely imperative behavior. Both arguments are to be ground at the moment of call.

Usage: `dht_update_finger(Idx,NodeId)`
– *Description:* Stores supplied information, previously erasing all old information.
– *The following properties should hold at call time:*
  `Idx` is an integer. (basic_props:int/1)
  `NodeId` is an integer. (basic_props:int/1)

dht_set_finger/4: PREDICATE

This predicate sets the value of finger table entries. If any entry with the same index (`Idx`) exists, it is erased before new value is asserted.

Usage: `dht_set_finger(Idx,Start,End,Node)`
– *Description:* All the arguments are to be ground and of type integer.

– *The following properties should hold at call time:*
`Idx` is an integer. (basic_props:int/1)
`Start` is an integer. (basic_props:int/1)
`End` is an integer. (basic_props:int/1)
`Node` is an integer. (basic_props:int/1)

dht_predecessor/1: PREDICATE

A common read-only interface to get or check the ID of the predecessor node.

Usage 1: `dht_predecessor(PredId)`

– *Description:* Get number of predecessor node.
– *The following properties should hold at call time:*
`PredId` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`PredId` is an integer. (basic_props:int/1)

Usage 2: `dht_predecessor(PredId)`

– *Description:* Check whether particular number is associated with current predecessor.
– *The following properties should hold at call time:*
`PredId` is an integer. (basic_props:int/1)

dht_set_predecessor/1: PREDICATE

Write interface for predecessor ID. It checks the type of its argument and saves argument locally.

Usage: `dht_set_predecessor(PredId)`

– *Description:* Save `PredId` as the ID of predecessor for current node.
– *The following properties should hold at call time:*
`PredId` is an integer. (basic_props:int/1)

dht_reset_predecessor/0: PREDICATE

Set value of preceding node index to 'nil' whatever it's prior value is.

195 Various wrappers for DHT logics module

Author(s): Arsen Kostenko.

This module contains miscellaneous predicates related to the `dht_logic.pl` module. Mostly various calculation-wrappers.

195.1 Usage and interface (`dht_logic_misc`)

- **Library usage:**
  `:- use_module(library(dht_logic_misc)).`
- **Exports:**
  - *Predicates:*
    `hash_size/1`, `highest_hash_number/1`, `consistent_hash/2`, `next_on_circle/2`, `not_in_circle_oc/3`, `in_circle_oo/3`, `in_circle_oc/3`.
- **Other modules used:**
  - *System library modules:*
    `indexer/hash`, `dht/dht_config`.

195.2 Documentation on exports (`dht_logic_misc`)

hash_size/1: PREDICATE

This predicate calculates `(2**m)`, where 'm' is equal to `hash_power/1` received from system wide configurations stored in `dht_config.pl`.

Usage: `hash_size(Size)`

- *Description:* The only purpose of `hash_size/1` predicate is to get corresponding value from system wide configurations stored in `dht_config.pl` file and convert it into the number of nodes virtually available in the current DHT installation.
- *The following properties should hold at call time:*
  `Size` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `Size` is ground. (basic_props:gnd/1)
  `Size` is an integer. (basic_props:int/1)

highest_hash_number/1: PREDICATE

This predicate calculates `(2**m)-1`, where 'm' is equal to `hash_power/1` received from system wide configurations stored in `dht_config.pl`.

Usage 1: `highest_hash_number(N)`

- *Description:* If used with a ground argument `highest_hash_number/1` simply checks whether the value supplied corresponds to the biggest hash number possible in the DHT.
- *The following properties should hold at call time:*
  `N` is an integer. (basic_props:int/1)

Usage 2: `highest_hash_number(N)`

- *Description:* Otherwise (if argument happens to be a free variable) the value of `N` is bound to the highest hash number possible in the DHT.
- *The following properties should hold at call time:*

  `N` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `N` is an integer. (basic_props:int/1)

consistent_hash/2: PREDICATE

This kind of computation is usually performed every time, when one needs to get value of hash-function.

Usage: `consistent_hash(Term,DHTHash)`

- *Description:* Straightforward computation of hash (`DHTHash`) on the basis of `Term` supplied.
- *The following properties should hold at call time:*

  `Term` is any term. (basic_props:term/1)

  `DHTHash` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Term` is any term. (basic_props:term/1)

  `DHTHash` is an integer. (basic_props:int/1)

next_on_circle/2: PREDICATE

Performs the calculation of `(id+1) mod ((2**m)-1)`, where `id` is the first argument supplied, and `m` is equal to `hash_power/1`.

Usage: `next_on_circle(Id,Num)`

- *Description:* `next_on_circle/2` is a calculation wrapping. One can only use it with first argument ground and equal to integer value. What is more, that value **MUST** be kept within certain bounds: value of `Id` **MUST** meet the constraints `0<=Id<=HighNum`, where `HighNum` is retrieved via `highest_hash_number/1` predicate.
- *The following properties should hold at call time:*

  `Id` is an integer. (basic_props:int/1)

  `Num` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Id` is an integer. (basic_props:int/1)

  `Num` is an integer. (basic_props:int/1)

not_in_circle_oc/3: PREDICATE

`not_in_circle_oc/3`: the 'oc' suffix stands for "open-closed" interval. The predicate implements the behavior of the expression: `Id not_in (a,b]`. where both 'a' and 'b' are numbers/identifiers on the DHT-ring.

Usage: `not_in_circle_oc(Id,Start,End)`

- *Description:* Yet another wrapper around simple calculations. All arguments are expected to be ground, by the time the predicate is called. The predicate checks whether the value supplied as `Id` fits into circle sector defined by values of `Start` and `End`. If the condition is not true - the whole predicate fails.
- *The following properties should hold at call time:*

  `Id` is an integer. (basic_props:int/1)

  `Start` is an integer. (basic_props:int/1)

  `End` is an integer. (basic_props:int/1)

in_circle_oo/3: PREDICATE

`in_circle_oo/3`: the 'oo' suffix stands for "open-open" circle interval. The predicate implements the behavior of following expression: `Id in (a,b)`.

Usage: `in_circle_oo(Id,Start,End)`

- *Description:* Check whether value of `Id` fits into sector defined by `Start` and `End` excluding both, fail otherwise.
- *The following properties should hold at call time:*

  `Id` is an integer. (basic_props:int/1)

  `Start` is an integer. (basic_props:int/1)

  `End` is an integer. (basic_props:int/1)

in_circle_oc/3: PREDICATE

`in_circle_oc/3`: the 'oc' suffix stands for "open-closed" interval. The predicate is based on `in_circle_oo/3` and considers the interval to be closed on the right. This predicate implements the behavior of the expression: `Id in (a,b]`

Usage: `in_circle_oc(Id,Start,End)`

- *Description:* Check whether value of `Id` fits into sector defined by `Start` and `End` excluding first and including second. Fail if the condition does not hold.
- *The following properties should hold at call time:*

  `Id` is an integer. (basic_props:int/1)

  `Start` is an integer. (basic_props:int/1)

  `End` is an integer. (basic_props:int/1)

196 Remote predicate calling utilities

Author(s): Arsen Kostenko.

RPR stands for Remote PRedicate calling. The basic functionality of a remote procedure (or predicate, in Prolog terms of Prolog) call is gathered here. Thus module contains predicates for the execution of remote calls and manipulation routines of the module-specific database.

196.1 Usage and interface (dht_rpr)

- **Library usage:**
  `:- use_module(library(dht_rpr)).`
- **Exports:**
  - *Predicates:*
    `dht_rpr_register_node/1`, `dht_rpr_register_node/2`, `dht_rpr_node_by_id/2`, `dht_rpr_id_by_node/2`, `dht_rpr_compose_id/3`, `dht_rpr_clear_by_node/1`, `dht_rpr_node/1`, `dht_rpr_call/2`, `dht_rpr_call/3`, `node_id/2`.
  - *Regular Types:*
    `dht_rpr_node_id/1`.
- **Other modules used:**
  - *System library modules:*
    `format`, `sockets/sockets`, `dht/dht_config`, `dht/dht_misc`.

196.2 Documentation on exports (dht_rpr)

dht_rpr_register_node/1: PREDICATE

Sometimes information from remote nodes is received in the form of a `node_id/2`. In these cases a single argument predicate might be useful.

Usage: `dht_rpr_register_node(NodeID)`

- *Description:* Save node identity to module-specific DB.
- *The following properties should hold at call time:*
  `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

dht_rpr_register_node/2: PREDICATE

General write interface to DB of physical nodes (those that have IP addresses). Information is re-written every time, so no old entries are expected to remain.

Usage: `dht_rpr_register_node(Node,NodeIP)`

- *Description:* `dht_rpr_register_node/2` is responsible for the management of a module-specific database that stores information on node identifiers and IP addresses corresponding to them. Despite there is only one usage mode the behavior may differ depending on the state of module-specific database. For instance, if the database already contains information about a node, whose identifier is equal to the one supplied in `Node`, a newly supplied entry would be written over the old one. A new entry is added to the module-specific database otherwise.

– *The following properties should hold at call time:*

`Node` is an integer. (basic_props:int/1)

`NodeIP` is ground. (basic_props:gnd/1)

dht_rpr_node_by_id/2: PREDICATE

Just a convenient wrapper around module-specific data structures, which is used in combination with Ciao functional syntax.

Usage 1: `dht_rpr_node_by_id(NodeID,Node)`

– *Description:* Extract value of node from the node identifier `NodeID`.

– *The following properties should hold at call time:*

`NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

`Node` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

`Node` is ground. (basic_props:gnd/1)

Usage 2: `dht_rpr_node_by_id(NodeID,Node)`

– *Description:* Check whether the value of the `NodeID` node identifier corresponds to the `Node` value.

– *The following properties should hold at call time:*

`NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

`Node` is ground. (basic_props:gnd/1)

– *The following properties should hold upon exit:*

`NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

`Node` is ground. (basic_props:gnd/1)

Usage 3: `dht_rpr_node_by_id(NodeID,Node)`

– *Description:* Return the node identifier associated to the exact node number.

– *The following properties should hold at call time:*

`NodeID` is a free variable. (term_typing:var/1)

`Node` is ground. (basic_props:gnd/1)

– *The following properties should hold upon exit:*

`NodeID` is a term of type `node_id/2` with first argument as integer and second as free variable or IP/DNS address (dht_rpr:dht_rpr_comp_node_addr/1)

`Node` is ground. (basic_props:gnd/1)

Usage 4: `dht_rpr_node_by_id(NodeID,Node)`

– *Description:* This case is merely useless, however perfectly possible.

– *The following properties should hold at call time:*

`NodeID` is a free variable. (term_typing:var/1)

`Node` is a free variable. (term_typing:var/1)

dht_rpr_id_by_node/2: PREDICATE

Convenient wrapper around internal data structures, as well as `dht_rpr_node_by_id/2`, this predicate is usually used in combination with Ciao functional syntax.

Usage 1: `dht_rpr_id_by_node(Node,NodeID)`

- *Description:* Get node identity by it's number.
- *The following properties should hold at call time:*

  `Node` is an integer. (basic_props:int/1)

  `NodeID` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Node` is an integer. (basic_props:int/1)

  `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

Usage 2: `dht_rpr_id_by_node(Node,NodeID)`

- *Description:* Lookup and fill ramaining id field.
- *The following properties should hold at call time:*

  `Node` is an integer. (basic_props:int/1)

  `NodeID` is a term of type `node_id/2` with first argument as free variable or integer and second an IP/DNS address (dht_rpr:dht_rpr_comp_node_id/1)
- *The following properties should hold upon exit:*

  `Node` is an integer. (basic_props:int/1)

  `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

Usage 3: `dht_rpr_id_by_node(Node,NodeID)`

- *Description:* Lookup and fill remainting address field.
- *The following properties should hold at call time:*

  `Node` is an integer. (basic_props:int/1)

  `NodeID` is a term of type `node_id/2` with first argument as integer and second as free variable or IP/DNS address (dht_rpr:dht_rpr_comp_node_addr/1)
- *The following properties should hold upon exit:*

  `Node` is an integer. (basic_props:int/1)

  `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

Usage 4: `dht_rpr_id_by_node(Node,NodeID)`

- *Description:* Check whether local database really has record about `NodeID` with `Node` as its node number.
- *The following properties should hold at call time:*

  `Node` is an integer. (basic_props:int/1)

  `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

dht_rpr_node_id/1: REGTYPE

Usage: `dht_rpr_node_id(NodeID)`

- *Description:* `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address.

dht_rpr_compose_id/3: PREDICATE

Compose identity structure out of arguments provided

Usage 1: `dht_rpr_compose_id(Node,NodeIP,NodeID)`

- *Description:* Compose an internal structure.
- *The following properties should hold at call time:*

  `Node` is an integer. (basic_props:int/1)

  `NodeIP` is ground. (basic_props:gnd/1)

  `NodeID` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Node` is an integer. (basic_props:int/1)

  `NodeIP` is ground. (basic_props:gnd/1)

  `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

Usage 2: `dht_rpr_compose_id(Node,NodeIP,NodeID)`

- *Description:* Check whether arguments correspond to structure supplied.
- *The following properties should hold at call time:*

  `Node` is an integer. (basic_props:int/1)

  `NodeIP` is ground. (basic_props:gnd/1)

  `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)
- *The following properties should hold upon exit:*

  `Node` is an integer. (basic_props:int/1)

  `NodeIP` is ground. (basic_props:gnd/1)

  `NodeID` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

dht_rpr_clear_by_node/1: PREDICATE

Write-interface (or more precisely, erase-interface) to DB of physical nodes (those that have IP-address). `dht_rpr_clear_node` is a dumb-wrapper around retraction operation over module-specific database. As usually, retraction may be performed when the argument is a free variable.

Usage 1: `dht_rpr_clear_by_node(Node)`

- *Description:* Erase any (possibly random) node information.
- *The following properties should hold at call time:*

  `Node` is a term of type `node_id/2` with first argument as integer and second as free variable or IP/DNS address (dht_rpr:dht_rpr_comp_node_addr/1)
- *The following properties should hold upon exit:*

  `Node` is ground. (basic_props:gnd/1)

Usage 2: `dht_rpr_clear_by_node(Node)`

- *Description:* Erase exact node.
- *The following properties should hold at call time:*

  `Node` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)
- *The following properties should hold upon exit:*

  `Node` is ground. (basic_props:gnd/1)

dht_rpr_node/1: PREDICATE

Generic read interface to DB of physical nodes.

Usage 1: `dht_rpr_node(Node)`

- *Description:* Checks for presence of any information on a node supplied as `Node`.
- *The following properties should hold at call time:*

  `Node` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

Usage 2: `dht_rpr_node(Node)`

- *Description:* Get node that matches given template.
- *The following properties should hold at call time:*

  `Node` is a term of type `node_id/2` with first argument is either a free variable or an integer and second is either a free variable or a IP/DNS address (dht_rpr:dht_rpr_comp_node/1)

dht_rpr_call/2: PREDICATE

`dht_rpr_call/2` execute a goal remotely. The platform for remote execution is specified by `HostId`. `Goal` might be a fully instantiated term as well as partially instantiated one (as used in any other goal).

Usage 1: `dht_rpr_call(HostId,Goal)`

- *Description:* Perform remote call of partially instantiated goal: e.g., a pattern search. Remote host for execution is specified via IP/DNS address of node identity, rest of identity is ignored
- *The following properties should hold at call time:*

  `HostId` is a term of type `node_id/2` with first argument as free variable or integer and second an IP/DNS address (dht_rpr:dht_rpr_comp_node_id/1)

  `Goal` is a free variable. (term_typing:var/1)

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
- *The following properties should hold upon exit:*

  `HostId` is a term of type `node_id/2` with first argument as free variable or integer and second an IP/DNS address (dht_rpr:dht_rpr_comp_node_id/1)

  `Goal` is ground. (basic_props:gnd/1)

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 2: `dht_rpr_call(HostId,Goal)`

- *Description:* Perform remote call of partially instantiated goal: e.g., a pattern search. Remote host for execution is specified via integer of node identity, IP/DNS address is searched through local database.
- *The following properties should hold at call time:*

  `HostId` is a term of type `node_id/2` with first argument as integer and second as free variable or IP/DNS address (dht_rpr:dht_rpr_comp_node_addr/1)

  `Goal` is a free variable. (term_typing:var/1)

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is a term of type `node_id/2` with first argument as integer and second as free variable or IP/DNS address (dht_rpr:dht_rpr_comp_node_addr/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 3: `dht_rpr_call(HostId,Goal)`

– *Description:* Perform remote call of partially instantiated goal: e.g., a pattern search. Remote host for execution is specified via IP/DNS address of node identity, rest of identity is ignored

– *The following properties should hold at call time:*

`HostId` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

`Goal` is a free variable. (term_typing:var/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 4: `dht_rpr_call(HostId,Goal)`

– *Description:* Perform remote call of partially instantiated goal: e.g., a pattern search.Remote host for execution is specified via integer, IP/DNS address is searched through local database using that integer as part of node identity.

– *The following properties should hold at call time:*

`HostId` is an integer. (basic_props:int/1)

`Goal` is a free variable. (term_typing:var/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is an integer. (basic_props:int/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 5: `dht_rpr_call(HostId,Goal)`

– *Description:* Perform remote call of partially instantiated goal: e.g., a pattern search. Finally make a try to use first argument as directly-specified IP/DNS address.

– *The following properties should hold at call time:*

`HostId` is an atom. (basic_props:atm/1)

`Goal` is a free variable. (term_typing:var/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is an atom. (basic_props:atm/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 6: `dht_rpr_call(HostId,Goal)`

– *Description:* Perform remote call of fully instantiated goal: e.g., a pattern search. Remote host for execution is specified via IP/DNS address of node identity, rest of identity is ignored

– *The following properties should hold at call time:*

`HostId` is a term of type `node_id/2` with first argument as free variable or integer and second an IP/DNS address (dht_rpr:dht_rpr_comp_node_id/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is a term of type `node_id/2` with first argument as free variable or integer and second an IP/DNS address (dht_rpr:dht_rpr_comp_node_id/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 7: `dht_rpr_call(HostId,Goal)`

– *Description:* Perform remote call of fully instantiated goal: e.g., a pattern search. Remote host for execution is specified via integer of node identity, IP/DNS address is searched through local database.

– *The following properties should hold at call time:*

`HostId` is a term of type `node_id/2` with first argument as integer and second as free variable or IP/DNS address (dht_rpr:dht_rpr_comp_node_addr/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is a term of type `node_id/2` with first argument as integer and second as free variable or IP/DNS address (dht_rpr:dht_rpr_comp_node_addr/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 8: `dht_rpr_call(HostId,Goal)`

– *Description:* Perform remote call of fully instantiated goal: e.g., a pattern search. Remote host for execution is specified via IP/DNS address of node identity, rest of identity is ignored

– *The following properties should hold at call time:*

`HostId` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is a term of type `node_id/2` with first argument as integer value and second as IP/DNS address. (dht_rpr:dht_rpr_node_id/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 9: `dht_rpr_call(HostId,Goal)`

– *Description:* Perform remote call of fully instantiated goal: e.g., a pattern search.Remote host for execution is specified via integer, IP/DNS address is searched through local database using that integer as part of node identity.

– *The following properties should hold at call time:*

`HostId` is an integer. (basic_props:int/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is an integer. (basic_props:int/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

Usage 10: `dht_rpr_call(HostId,Goal)`

– *Description:* Perform remote call of fully instantiated goal: e.g., a pattern search. Finally make a try to use first argument as directly-specified IP/DNS address.

– *The following properties should hold at call time:*

`HostId` is an atom. (basic_props:atm/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

– *The following properties should hold upon exit:*

`HostId` is an atom. (basic_props:atm/1)

`Goal` is ground. (basic_props:gnd/1)

`Goal` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

dht_rpr_call/3: PREDICATE

The only difference this predicate has with `dht_rpr_call/2` is debug-enabling switch. Third parameter is expected to be responsible for that. It takes one of two possible values 'debug' or 'nodebug'. The first one is default. If default value is used, the standard output stream is populated with various debugging information.

Usage 1: `dht_rpr_call(HostId,Goal,Debug)`

– *Description:* `dht_rpr_call/3` executes a `Goal` remotely and prints some debugging information locally. The platform for the remote execution is specified by `HostId`.`Debug` variable must be bound to value 'debug' in order for this case to fire.

– *The following properties should hold at call time:*

`HostId` is an integer. (basic_props:int/1)

`Goal` is any term. (basic_props:term/1)

`Debug` is ground. (basic_props:gnd/1)

Usage 2: `dht_rpr_call(HostId,Term,Anything)`

– *Description:* `dht_rpr_call/3` executes a `Goal` remotely without writing any information on the local output stream. The platform for the remote execution is specified by `HostId`.

– *The following properties should hold at call time:*

`HostId` is an integer. (basic_props:int/1)

`Term` is any term. (basic_props:term/1)

`Anything` is a free variable. (term_typing:var/1)

node_id/2: PREDICATE

`node_id/2`is an auxilary prediate for internal data structures hanling.

The predicate is of type *concurrent*.

197 Underlying data-storage module

Author(s): Arsen Kostenko.

This module contains very low-level utilities of data storage specific to a single node. Neither data sharing nor remote invocation is performed at this level. Note that no dedicated data manipulation is performed neither on this level. Also keep in mind that concept of `Key` should always meet the same constraints as the second argument of `functor/3` predicate. Important decision taken at this point is representation of all information stored in the DHT as usual Prolog facts. This behavior is implemented by representing relations of form `Key -> Value` in form of `Key(Value)` facts.

197.1 Usage and interface (dht_storage)

- **Library usage:**
  `:- use_module(library(dht_storage)).`
- **Exports:**
  - *Predicates:*
    `dht_store/3`, `dht_extract_b/2`, `dht_extract_nb/2`, `dht_consult_b/2`, `dht_consult_nb/2`, `dht_key_hash/2`.
- **Other modules used:**
  - *System library modules:*
    `concurrency/concurrency`.

197.2 Documentation on exports (dht_storage)

dht_store/3: PREDICATE

This predicate stores information into the local (module-local) database. The three arguments stand for key, value, and value of hash-function, when applied to the key. The third argument is needed for auxiliary database, which is used by reverse lookup.

Usage: `dht_store(Key,KeyHash,Value)`

- *Description:* The value provided in `Value` is stored under a key given as `Key`.
- *The following properties should hold at call time:*

`Key` is an atom.	(basic_props:atm/1)
`KeyHash` is an integer.	(basic_props:int/1)
`Value` is ground.	(basic_props:gnd/1)

dht_extract_b/2: PREDICATE

Looks up local database for fact of following type `Key/1`, that takes `Value` as argument. The pair is extracted from the database if there is at lease one match. Otherwise call is blocking once the fact is not found instantly.

Usage 1: `dht_extract_b(Key,Value)`

- *Description:* Search for exact fact.

– *The following properties should hold at call time:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)
– *The following properties should hold upon exit:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_extract_b(Key,Value)`
– *Description:* Search for fact matching pattern. Pattern is supplied as `Value`.
– *The following properties should hold at call time:*
`Key` is an atom. (basic_props:atm/1)
`Value` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)

dht_extract_nb/2: PREDICATE

Looks up the local database for a fact of type `Key`/1 that takes `Value` as argument. If a corresponding fact is found in database, it is extracted from it. With respect to behavior of `dht_extract_b/2`, this predicated has a useful difference - it does not block while searching.

Usage 1: `dht_extract_nb(Key,Value)`
– *Description:* Check that combination of `Key`/`Value` appears in database.
– *The following properties should hold at call time:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)
– *The following properties should hold upon exit:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_extract_nb(Key,Value)`
– *Description:* Search for combination of `Key`/`Value` matching pattern. Pattern is supplied as `Value`.
– *The following properties should hold at call time:*
`Key` is an atom. (basic_props:atm/1)
`Value` is a free variable. (term_typing:var/1)
– *The following properties should hold upon exit:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)

dht_consult_b/2: PREDICATE

Looks up local database for combination of `Key`/`Value` of following type `Key`/1 that takes `Value` as argument. The combination of `Key`/`Value` is only looked up. If there is no corresponding combination of `Key`/`Value` in local database, `dht_consult_b/2` blocks until such fact is inserted. Nothing is done neither to combination of `Key`/`Value` nor to local database.

Usage 1: `dht_consult_b(Key,Value)`

– *Description:* Search for exact combination of `Key/Value`.
– *The following properties should hold at call time:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)
– *The following properties should hold upon exit:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_consult_b(Key,Value)`
– *Description:* Search for combination of `Key/Value` matching pattern. Pattern is supplied as `Value`.
– *The following properties should hold at call time:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)
– *The following properties should hold upon exit:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)

dht_consult_nb/2: PREDICATE

Looks up local database for combination of `Key/Value` of following type `Key/1` that takes `Value` as argument. The combination of `Key/Value` is only looked up - no modifications are done in any case (whether a match was found or not). As in case with `dht_extract_nb/2`, this predicate does not block while searching for matching values.

Usage 1: `dht_consult_nb(Key,Value)`
– *Description:* Search for exact combination of `Key/Value`.
– *The following properties should hold at call time:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)
– *The following properties should hold upon exit:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)

Usage 2: `dht_consult_nb(Key,Value)`
– *Description:* Search for combination of `Key/Value` matching pattern. Pattern is supplied as `Value`.
– *The following properties should hold at call time:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)
– *The following properties should hold upon exit:*
`Key` is an atom. (basic_props:atm/1)
`Value` is ground. (basic_props:gnd/1)

dht_key_hash/2: PREDICATE

A general read-interface to auxiliary database, in order to perform reverse search: 'get set of keys by corresponding value of hash function'.

Usage 1: `dht_key_hash(Key,KeyHash)`

- *Description:* The most general case (when both arguments are free) is searching for any key-hash pair stored in auxiliary database.
- *The following properties should hold at call time:*

  `Key` is a free variable. (term_typing:var/1)

  `KeyHash` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Key` is ground. (basic_props:gnd/1)

  `KeyHash` is an integer. (basic_props:int/1)

Usage 2: `dht_key_hash(Key,KeyHash)`

- *Description:* Here `Key` is ground, which in turn leads to search for information on concrete predicate.
- *The following properties should hold at call time:*

  `Key` is ground. (basic_props:gnd/1)

  `KeyHash` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Key` is ground. (basic_props:gnd/1)

  `KeyHash` is an integer. (basic_props:int/1)

Usage 3: `dht_key_hash(Key,KeyHash)`

- *Description:* On the contrary to previous example, this one has only second argument `KeyHash` ground. Therefore, this type of call would search for keys, that where mapped into given value of hash-function.
- *The following properties should hold at call time:*

  `Key` is a free variable. (term_typing:var/1)

  `KeyHash` is an integer. (basic_props:int/1)
- *The following properties should hold upon exit:*

  `Key` is ground. (basic_props:gnd/1)

  `KeyHash` is an integer. (basic_props:int/1)

Usage 4: `dht_key_hash(Key,KeyHash)`

- *Description:* Finally, calling `dht_key_hash` with both arguments ground is similar to straight-forward check on auxiliary database, or to asking a question: "Does auxiliary database has any information on this key, which is mapped into that hash value?"
- *The following properties should hold at call time:*

  `Key` is ground. (basic_props:gnd/1)

  `KeyHash` is an integer. (basic_props:int/1)

198 Configuration module

Author(s): Arsen Kostenko.

This is the initial system-wide configuration storage module. All the configurations stored here are represented by command-line arguments or corresponding terms, depending on the server launching style.

198.1 Usage and interface (dht_config)

- **Library usage:**
  `:- use_module(library(dht_config)).`
- **Exports:**
  - *Predicates:*
    `hash_power/1`, `dht_set_hash_power/1`, `dht_s2c_port/1`, `dht_set_s2c_port/1`, `dht_s2c_threads/1`, `dht_set_s2c_threads/1`, `dht_s2s_port/1`, `dht_set_s2s_port/1`, `dht_s2s_threads/1`, `dht_set_s2s_threads/1`, `dht_join_host/1`, `dht_set_join_host/1`, `dht_server_id/1`, `dht_set_server_id/1`, `dht_server_host/1`, `dht_set_server_host/1`.

198.2 Documentation on exports (dht_config)

hash_power/1: PREDICATE

Get/check power of currently running DHT. Hash function has `(2**m)` values, therefore `hash_power/1` returns/checks `m`.

Usage 1: `hash_power(Power)`

- *Description:* Bound `Power` to value of currently running DHT power.
- *The following properties should hold at call time:*
  `Power` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `Power` is an integer. (basic_props:int/1)

Usage 2: `hash_power(Power)`

- *Description:* Check whether `Power` is equal to power of the currently running DHT.
- *The following properties should hold at call time:*
  `Power` is an integer. (basic_props:int/1)

dht_set_hash_power/1: PREDICATE

Set initial power of hash function.

Usage: `dht_set_hash_power(Power)`

- *Description:* Set `m` for `(2**m)` formula.
- *The following properties should hold at call time:*
  `Power` is an integer. (basic_props:int/1)

dht_s2c_port/1: PREDICATE

Get/check server to client communication port.

Usage 1: `dht_s2c_port(Port)`

- *Description:* Set value of `Port` to currently used port number for server-to-client communication.
- *The following properties should hold at call time:*

  `Port` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*

  `Port` is an integer. (basic_props:int/1)

Usage 2: `dht_s2c_port(Port)`

- *Description:* Check whether value of `Port` is equal to currently used port number for server-to-client communication.
- *The following properties should hold at call time:*

  `Port` is an integer. (basic_props:int/1)

dht_set_s2c_port/1: PREDICATE

Set port for server-to-client communication.

dht_s2c_threads/1: PREDICATE

Get/check number of threads for server-to-client communication.

dht_set_s2c_threads/1: PREDICATE

Set number of threads for server-to-client communication.

dht_s2s_port/1: PREDICATE

Get/check server-to-server communication port.

dht_set_s2s_port/1: PREDICATE

Set server-to-server communication port.

dht_s2s_threads/1: PREDICATE

Get/check number of threads for server-to-server communication.

dht_set_s2s_threads/1: PREDICATE

Set number of threads for server-to-server communication.

dht_join_host/1: PREDICATE

Get/check address of the host to join.

dht_set_join_host/1: PREDICATE
Set address of the host to join.

dht_server_id/1: PREDICATE
Get/check node number of current server.

dht_set_server_id/1: PREDICATE
Set node number of current server.

dht_server_host/1: PREDICATE
Get/check address of the current server

dht_set_server_host/1: PREDICATE
Set address of the current server

199 Tiny module with miscellaneous functions

Author(s): Arsen Kostenko.

This module holds just two predicates at the moment: `write_pr/2` and `read_pr`. In both of them the '_pr' suffix is standing for 'predicate', which in turn means that both of them are intended for transportation of predicates from one environment to another.

199.1 Usage and interface (`dht_misc`)

- **Library usage:**
  `:- use_module(library(dht_misc)).`
- **Exports:**
  - *Predicates:*
    `write_pr/2`, `read_pr/2`.
- **Other modules used:**
  - *System library modules:*
    `fastrw`.

199.2 Documentation on exports (`dht_misc`)

write_pr/2: PREDICATE

`write_pr/2` is a straight-forward wrapping around the `fast_write/2` predicate, without any checks on arguments The sole purpose is to allow usage of various ways of writing to streams without changing entire code of DHT.

Usage: `write_pr(Stream,Term)`

- *Description:* Write the value of the `Term` into stream provided by `Stream`.
- *The following properties should hold at call time:*

  `Stream` is ground. (basic_props:gnd/1)

  `Term` is any term. (basic_props:term/1)

read_pr/2: PREDICATE

Similarly to the previous predicate, this one serves currently as a wrap around the `fast_read/2` predicate, and was implemented with the same purpose - to allow transparent switching to different stream reading systems.

Usage 1: `read_pr(Stream,Term)`

- *Description:* Read stream represented by `Stream` looking for presence of pattern given by `Term`. If none found, the predicate does not block. Result found may be non-fully ground.
- *The following properties should hold at call time:*

  `Stream` is ground. (basic_props:gnd/1)

  `Term` is any term. (basic_props:term/1)

Usage 2: `read_pr(Stream,Term)`

- *Description:* Same as previous, with only modification - result found may be ground as well.
- *The following properties should hold at call time:*

  `Stream` is ground. (basic_props:gnd/1)

  `Term` is any term. (basic_props:term/1)
- *The following properties should hold upon exit:*

  `Stream` is ground. (basic_props:gnd/1)

  `Term` is ground. (basic_props:gnd/1)

Usage 3: `read_pr(Stream,Term)`

- *Description:* Scan stream `Stream` for presence of concrete (exact) predicate given by value of `Term`. `Term` is fully bound.
- *The following properties should hold at call time:*

  `Stream` is ground. (basic_props:gnd/1)

  `Term` is ground. (basic_props:gnd/1)
- *The following properties should hold upon exit:*

  `Stream` is ground. (basic_props:gnd/1)

  `Term` is ground. (basic_props:gnd/1)

200 Constraint programming over finite domains

Author(s): José Manuel Gómez Pérez, Manuel Carro.

This package is a very preliminary implementation of a finite domain solver. Examples can be found in the source and library directories.

- SEND + MORE = MONEY:

```
:- use_package(fd).
:- use_module(library(prolog_sys), [statistics/2]).
:- use_module(library(format)).


smm(SMM) :-
        statistics(runtime,_),
        do_smm(SMM),
        statistics(runtime,[_, Time]),
        format("Used ~d milliseconds~n", Time).

do_smm(X) :-
        X = [S,E,N,D,M,O,R,Y],
        X in 0 .. 9,
        all_different(X),
        M .>. 0,
        S .>. 0,
        1000*S + 100*E + 10*N + D + 1000*M + 100*O + 10*R + E
        .=. 10000*M + 1000*O + 100*N + 10*E + Y,
        labeling(X).
```

- Queens:

```
:- use_package(fd).
:- use_module(library(prolog_sys), [statistics/2]).
:- use_module(library(format)).
:- use_module(library(aggregates)).
:- use_module(library(lists), [length/2]).


queens(N, Qs) :-
        statistics(runtime,_),
        do_queens(N, Qs),
        statistics(runtime,[_, Time]),
        format("Used ~d milliseconds~n", Time).

do_queens(N, Qs):-
        constrain_values(N, N, Qs),
        all_different(Qs),!,
        labeling(Qs).

constrain_values(0, _N, []).
constrain_values(N, Range, [X|Xs]):-
        N > 0,
        X in 1 .. Range,
```

```
        N1 is N - 1,
        constrain_values(N1, Range, Xs),
        no_attack(Xs, X, 1).

no_attack([], _Queen, _Nb).
no_attack([Y|Ys], Queen, Nb):-
        Nb1 is Nb + 1,
        no_attack(Ys, Queen, Nb1),
        Queen .<>. Y + Nb,
        Queen .<>. Y - Nb.
```

200.1 Usage and interface (fd_doc)

- **Library usage:**
  `:- use_package(fd).`
  or
  `:- module(...,...,[fd]).`
- **Exports:**
  - *Predicates:*
    `labeling/1`, `pitm/2`, `choose_var/3`, `choose_free_var/2`, `choose_var_nd/2`, `choose_value/2`, `retrieve_range/2`, `retrieve_store/2`, `glb/2`, `lub/2`, `bounds/3`, `retrieve_list_of_values/2`.
  - *Regular Types:*
    `fd_item/1`, `fd_range/1`, `fd_subrange/1`, `fd_store/1`, `fd_store_entity/1`.
- **New operators defined:**
  `.=./2` [700,xfx], `.<>./2` [700,xfx], `.<./2` [700,xfx], `.=<./2` [700,xfx], `.>./2` [700,xfx], `.>=./2` [700,xfx], `../2` [500,yfx], `.&./2` [600,xfy], `in/2` [700,xfy].

200.2 Documentation on exports (fd_doc)

fd_item/1: REGTYPE

Usage: `fd_item(FD_item)`

- *Description:* `FD_item` is a finite domain entity, i.e. either a finite domains variable or an integer.

fd_range/1: REGTYPE

Usage: `fd_range(FD_range)`

- *Description:* `FD_range` is the range of a finite domain entity.

fd_subrange/1: REGTYPE

Usage:

- *Description:* A subrange is a pair representing a single interval.

fd_store/1: REGTYPE

Usage: `fd_store(FD_store)`

- *Description:* `FD_store` is a representation of the constraint store of a finite domain entity.

fd_store_entity/1: REGTYPE

Usage:

- *Description:* Representation of primitive constraints.

labeling/1: PREDICATE

Usage: `labeling(Vars)`

- *Description:* Implements the labeling process. Assigns values to the input variables `Vars`. On exit all variables are instantiated to a consistent value. On backtracking, the predicate returns all possible assignments. No labeling heuristics implemented so far, i.e. variables are instantiated in their order of appearance.
- *The following properties should hold at call time:*

  `Vars` is a list of `fd_items`. (basic_props:list/2)

pitm/2: PREDICATE

Usage: `pitm(V,MiddlePoint)`

- *Description:* Returns in `MiddlePoint` the intermediate value of the range of `V`. In case `V` is a ground integer value the returned value is `V` itself.
- *The following properties should hold at call time:*

  `V` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `MiddlePoint` is a free variable. (term_typing:var/1)

  `V` is a finite domain entity, i.e. either a finite domains variable or an integer. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_item/1)

  `MiddlePoint` is an integer. (basic_props:int/1)

choose_var/3: PREDICATE

Usage: `choose_var(ListOfVars,Var,RestOfVars)`

- *Description:* Returns a finite domain item `Var` from a list of fd items `ListOfVars` and the rest of the list `RestOfVars`in a deterministic way. Currently it always returns the first item of the list.
- *The following properties should hold at call time:*

  `ListOfVars` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Var` is a free variable. (term_typing:var/1)

  `RestOfVars` is a free variable. (term_typing:var/1)

  `ListOfVars` is a list of `fd_items`. (basic_props:list/2)

  `Var` is a finite domain entity, i.e. either a finite domains variable or an integer. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_item/1)

  `RestOfVars` is a list of `fd_items`. (basic_props:list/2)

choose_free_var/2: PREDICATE

Usage: `choose_free_var(ListOfVars,Var)`

- *Description:* Returns a free variable `Var` from a list of fd items `ListOfVars`. Currently it always returns the first free variable of the list.
- *The following properties should hold at call time:*

  `ListOfVars` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Var` is a free variable. (term_typing:var/1)

  `ListOfVars` is a list of `fd_items`. (basic_props:list/2)

  `Var` is a free variable. (term_typing:var/1)

choose_var_nd/2: PREDICATE

Usage: `choose_var_nd(ListOfVars,Var)`

- *Description:* Returns non deterministically an fd item `Var` from a list of fd items `ListOfVars` .
- *The following properties should hold at call time:*

  `ListOfVars` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Var` is a free variable. (term_typing:var/1)

  `ListOfVars` is a list of `fd_items`. (basic_props:list/2)

  `Var` is a finite domain entity, i.e. either a finite domains variable or an integer. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_item/1)

choose_value/2: PREDICATE

Usage: `choose_value(Var,Value)`

- *Description:* Produces an integer value `Value` from the domain of `Var`. On backtracking returns all possible values for `Var`.
- *The following properties should hold at call time:*

  `Var` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Value` is a free variable. (term_typing:var/1)

  `Var` is a finite domain entity, i.e. either a finite domains variable or an integer. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_item/1)

  `Value` is an integer. (basic_props:int/1)

retrieve_range/2: PREDICATE

Usage: `retrieve_range(Var,Range)`

- *Description:* Returns in `Range` the range of an fd item `Var`.
- *The following properties should hold at call time:*

  `Var` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Range` is a free variable. (term_typing:var/1)

  `Var` is a free variable. (term_typing:var/1)

  `Range` is the range of a finite domain entity. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_range/1)

retrieve_store/2: PREDICATE

Usage: `retrieve_store(Var,Store)`

- *Description:* Returns in `Store` a representation of the constraint store of an fd item `Var`.
- *The following properties should hold at call time:*

  `Var` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Store` is a free variable. (term_typing:var/1)

  `Var` is a free variable. (term_typing:var/1)

  `Store` is a representation of the constraint store of a finite domain entity. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_store/1)

glb/2: PREDICATE

Usage: `glb(Var,LowerBound)`

- *Description:* Returns in `LowerBound` the lower bound of the range of `Var`.
- *The following properties should hold at call time:*

  `Var` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `LowerBound` is a free variable. (term_typing:var/1)

  `Var` is a finite domain entity, i.e. either a finite domains variable or an integer. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_item/1)

  `LowerBound` is an integer. (basic_props:int/1)

lub/2: PREDICATE

Usage: `lub(Var,UpperBound)`

- *Description:* Returns in `UpperBound` the upper bound of the range of `Var`.
- *The following properties should hold at call time:*

  `Var` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `UpperBound` is a free variable. (term_typing:var/1)

  `Var` is a finite domain entity, i.e. either a finite domains variable or an integer. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_item/1)

  `UpperBound` is an integer. (basic_props:int/1)

bounds/3: PREDICATE

Usage: `bounds(Var,LowerBound,UpperBound)`

- *Description:* Returns in `LowerBound` and `UpperBound` the lower and upper bounds of the range of `Var`.
- *The following properties should hold at call time:*

  `Var` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `LowerBound` is a free variable. (term_typing:var/1)

  `UpperBound` is a free variable. (term_typing:var/1)

  `Var` is a finite domain entity, i.e. either a finite domains variable or an integer. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_item/1)

  `LowerBound` is an integer. (basic_props:int/1)

  `UpperBound` is an integer. (basic_props:int/1)

retrieve_list_of_values/2: PREDICATE

Usage: `retrieve_list_of_values(Var,ListOfValues)`

- *Description:* Returns in `ListOfValues` an enumeration of al the values in the range of `Var`
- *The following properties should hold at call time:*

  `Var` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ListOfValues` is a free variable. (term_typing:var/1)

  `Var` is a finite domain entity, i.e. either a finite domains variable or an integer. (user(/home/ciaotester/tests/auto/CiaoDE/ciao/contrib/fd/fd_doc):fd_item/1)

  `ListOfValues` is a list of `int`s. (basic_props:list/2)

201 Dot generator

Author(s): Claudio Ochoa.

This module generates a dot file representing a graph. Nodes and edges can contain labels

201.1 Usage and interface (gendot)

- **Library usage:**
  `:- use_module(library(gendot)).`
- **Exports:**
  - *Predicates:*
    `gendot/3`.
- **Other modules used:**
  - *System library modules:*
    `terms`, `format`.

201.2 Documentation on exports (gendot)

gendot/3: PREDICATE

Usage: `gendot(L,Filename,Type)`

- *Description:* Generates a dot file from a list `L` representing a graph. It receives the basename `Filename` (without extension) of the output .dot file. Each element of `L` is a node in the graph, represented by a tuple (Identifier, Label, Edges), where Edges is a list of the outgoing edges of the current node, and each element of Edges is either an Identifier ot a tuple (Identifier,Label). In all cases, Labels are atoms. `Type` indicates the type of graph. If the graph is a Tree, then final nodes are represented by boxes. In all other cases, nodes are represented by circles
- *The following properties should hold at call time:*

`L` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Filename` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Type` is currently a term which is not a free variable.	(term_typing:nonvar/1)

202 Printing graphs using gnuplot as auxiliary tool

Author(s): David Trallero Mena.

This library uses `gnuplot` for printing graphs.

User-friendly predicates to generate data plots are provided, as well as predicates to set the general options which govern the generation of such plots. If no options is specified, global ones are used for data plots generation.

Several files can be generated as temporary files. A BaseName is required for generating the temporaries files. Data files name will be created from BaseName `+` number `+` .dat. The BaseName `+` `".plot"` will be the name used for `gnuplot` tool.

A list of pairs of list of pairs of the from (X,Y) and Local Option value is provided to the main predicate as data. In other words DataList = [(CurveDataList,LocalOptions), (CurveDataList1,LocalOptions1) ...]. Additionaly (function(String) , LocalOptions) can be used for adding a curve to the plot (imagine you want to compare your result with 'x=y').

LocalOptions of the DataList are options that are applied to the curve, as for example, if we print the curve with lines, or the title in the legend, etc. GlobalOptions are referred to the plot options, like title in x or y axis, etc.

202.1 Usage and interface (`gnuplot`)

- **Library usage:**
  `:- use_module(library(gnuplot)).`
- **Exports:**
  - *Predicates:*
    `get_general_options/1`, `set_general_options/1`, `generate_plot/2`, `generate_plot/3`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `write`, `system`.

202.2 Documentation on exports (`gnuplot`)

get_general_options/1: PREDICATE

Usage: `get_general_options(X)`

- *Description:* Get the general options of the graphic that will be plotted
- *The following properties should hold at call time:*
  `X` is a free variable. (term_typing:var/1)
- *The following properties should hold upon exit:*
  `X` is a list. (basic_props:list/1)

set_general_options/1: PREDICATE

Usage: `set_general_options(X)`

– *Description:* Get the general options of the graphic that will be plotted. Possible options are:
  - format(A) Specify the format of points
  - nokey Legend is no represented
  - nogrid No grid
  - grid An smooth grid is shown
  - label(L , (X,Y)) Put Label L at point (X,Y)
  - xlabel(A) Label of X-Axis
  - ylabel(A) Label of Y-Axis
  - xrange(A,B) Define the X range representation
  - yrange(A,B) Define the Y range representation
  - title(A) Title of the plot
  - key(A) define the key (for example [left,box], left is the position, box indicates that a box should be around)
  - term_post(A) define the postscript terminal. A is a list of atoms.
  - size(A,B) specify the size of the plot (A,B float numbers)
  - autoscale autoscale the size of the plot
  - autoscale(A) autoscale the argument (for example: autoscale(x))
– *The following properties should hold at call time:*
  `X` is a list. (basic_props:list/1)

generate_plot/2: PREDICATE

Usage: `generate_plot(BaseName,DataList)`

– *Description:* This predicates generate a '`BaseName` + .ps' postscript file using each element of `DataList` as pair of list of pairs and local options, i.e., (list((X,Y)), LocalOptions), in which X is the position in X-Axis and Y is the position in Y-Axis. Nevertheless, each element of `DataList` can be a list of pairs instead of a pair for commodity. `gnuplot` is used as auxiliary tool. Temporary files '`BaseName` + N.dat' are generated for for every list of pairs, and '`BaseName` + .plot' is de file used by gnuplot. The local options can be:
  - with(Option) Tells how the curve will be represented. Option can b line, dots, boxes, impulses, linespoints. This option HAVE TO BE the last one
  - title(T) Put the name of the curve in the legend to T
– *The following properties should hold at call time:*
  `BaseName` is currently instantiated to an atom. (term_typing:atom/1)
  `DataList` is a list of `pair`s. (basic_props:list/2)
– *The following properties should hold upon exit:*
  `BaseName` is currently instantiated to an atom. (term_typing:atom/1)
  `DataList` is a list of `pair`s. (basic_props:list/2)

generate_plot/3: PREDICATE

Usage: `generate_plot(BaseName,DataList,GeneralOptions)`

– *Description:* It is the same as generate_plot/2 but `GeneralOptions` are used as the general options of the plot. Look at predicate set_general_options for detailed description of possible options

- *The following properties should hold at call time:*
  `BaseName` is currently instantiated to an atom. (term_typing:atom/1)
  `DataList` is a list of `pair`s. (basic_props:list/2)
  `GeneralOptions` is a list. (basic_props:list/1)
- *The following properties should hold upon exit:*
  `BaseName` is currently instantiated to an atom. (term_typing:atom/1)
  `DataList` is a list of `pair`s. (basic_props:list/2)
  `GeneralOptions` is a list. (basic_props:list/1)

203 Lazy evaluation

Author(s): Amadeo Casas (`http://www.cs.unm.edu/~amadeo`, University of New Mexico).

This library package allows the use of lazy evaluation in a Ciao module/program.

Lazy Evaluation is a program evaluation technique used particularly in functional languages. When using lazy evaluation, an expression is not evaluated as soon as it is assigned, but rather when the evaluator is forced to produce the value of the expression. Although the `when` or `freeze` control primitives present in many modern logic programming systems are more powerful than lazy evaluation, they lack the simplicity of use and cleaner semantics of functional lazy evaluation.

The objective of this package is to allow evaluating the functions lazily. Functions are the subset of relations (predicates) which have a designated argument through which a single output is obtained for any set of inputs (the other arguments). In logic programming systems which have syntactic support for functions (including Ciao), functions are typically translated to predicates whose `last` argument is designated as a (single value) output and the rest as inputs.

In our proposal, a function can be declared as lazy via the following declaration:

```
:- lazy fun_eval f/N.
```

This function could be represented as:

```
:- lazy fun_eval f(~_,_,_,_).
```

where ~ indicates the argument through which the single output will be obtained. Another possible representation may be:

```
:- lazy fun_return f(~_,_,_,_).
```

In order to achieve the intended behavior, the execution of each function declared as lazy is suspended until the return value of the function is needed.

A simple example of the use of lazy evaluation would be the definition of a function which returns the (potentially) infinite list of integers starting with a given one:

```
:- lazy fun_eval nums_from/1.
nums_from(X) := [X | nums_from(X+1)].
```

While lazy functions certainly increase the overhead in the execution, they also allow the user to develop in an easy way predicates which can handle infinite terms, and this is the main advantage of the proposed functionality.

Lazy evaluation can be also a better option than eager evaluation when a function in a different module is used and it returns a big amount of data. As an example, we have the following module `module1`:

```
:- module(module1, [test/1], [fsyntax, lazy, hiord]).

:- use_module(library(lazy(lazy_lib)), [nums_from/2, takeWhile/3]).
:- use_module(module2, [squares/2]).
:- use_module(library(arithpreds)).

:- fun_eval test/0.
test := ~takeWhile((''(X) :- X < 10000), ~squares(~nums_from(1))).
```

and another module `module2`:

```
:- module(module1, [test/1], [fsyntax, lazy, hiord]).

:- use_module(library(lazy(lazy_lib)), [nums_from/2, takeWhile/3]).
:- use_module(module2, [squares/2]).
```

```
:- use_module(library(arithpreds)).

:- fun_eval test/0.
test := ~takeWhile((''(X) :- X < 10000), ~squares(~nums_from(1))).
```

Function `test/0` in module `m1` needs to execute function `squares/1`, in module `m2`, which will return a very long list (in the case of this example this list will be infinite, but the conclusions also apply with finite but long lists). If `squares/1` were executed eagerly then the entire list would be returned, to immediately execute the `take/2` function with the entire list, but creating this intermediate result is wasteful in terms of memory requirements. In order to solve this problem, the `squares/1` function could be moved to module `m1` and merged with `take/2` (or, also, they could exchange a size parameter). But rearranging the program is not always possible and may perhaps complicate other aspects of the overall program design.

If instead the `squares/1` function is evaluated lazily, it is possible to keep the definitions unchanged and in different modules and there will be a smaller memory penalty for storing the intermediate result. As more values are needed by the `take/2` function, more values in the list returned by `squares/1` are built (in this example, only 10 values). These values that have been consumed and passed over will be recovered by the garbage collector and the corresponding memory freed. The query:

```
?- test(X).
```

will compute `X` = [1,4,9,16,25,36,49,64,81,100].

A library of useful functions has been added to this package to allow the programmer to develop lazy functions easily and with a well-defined syntax. This library is called **lazy_lib.pl** and it provides the following functions:

- nums_from(+X,-List): `List` is unified with an infinite list of successive numbers starting in `X`.
- nums_from_inc(+X,+Y,-List): `List` is unified with an infinite list of successive numbers starting in `X` with an increment of `Y`.
- repeat(+X,-List): `List` is unified with an infinite list of the term `Y`.
- cycle(+X,-List): `List` is unified with an infinite list of the term `Y` repeated infinite times.
- take(+X,+ListA,-ListR): `ListR` is unified with the first `X` elements of the infinite list `ListA`.
- takeWhile(+P,+ListA,-ListR): `ListR` is unified with the first elements of the infinite list `ListA` while the condition `P` is true.
- drop(+X,+ListA,-ListR): `ListR` is unified with the infinite list `ListA` dropping the first `X` elements.
- dropWhile(+P,+ListA,-ListR): `ListR` is unified with the infinite list `ListA` dropping the first elements while the condition `P` is true.
- splitAt(+X,+ListA,-Res): `Res` is unified with a tuple of lists where the first list is composed by the first `X` elements of the list `ListA` and the second list is composed by the rest of the elements of `ListA`.
- span(+P,+ListA,-Res): `Res` is unified with a tuple of lists where the first list is composed by the elements of `ListA` which verify the condition `P` and the second list is composed by the rest of the elements of the initial list.
- tail(+ListA,-ListR): `ListR` is unified with the tail of the infinite list `ListA`.
- lazy_map(+ListA,+P,-ListR): Version of the map/3 predicate to be executed lazily.
- lazy_foldl(+ListA,+X,+P,-ListR): Version of the foldl/3 predicate to be executed lazily.
- zipWith(+P,+ListA,+ListB,-ListR): `ListR` is a list whose elements are calculated from the function `P` and the elements of input lists `ListA` and `ListB` occuring at the same position in both lists.

203.1 Usage and interface (lazy_doc)

- **Library usage:**
  `:- use_package(lazy).`
  or
  `:- module(...,...,[lazy]).`
- **New operators defined:**
  `lazy/1` [1170,fx].
- **Other modules used:**
  - *System library modules:*
    `freeze/freeze`.

203.2 Other information (lazy_doc)

The translation of the code in order to execute it lazily is explained below.

A sentence translation is provided to handle the `lazy` directives. The translation of a lazy function into a predicate is done in two steps. First, the function is converted into a predicate (using the fsyntax package). Then, the resulting predicate is transformed to suspend its execution until the value of the last variable (i.e., the output variable) is needed. This suspension is achieved by the use of the `freeze/1` control primitive that many modern logic programming systems implement quite efficiently (`block` or `when` declarations can obviously also be used, but we explain the transformation in terms of `freeze` because it is more widespread). The translation will rename the original predicate to an internal name and add a bridge predicate with the original name which invokes the internal predicate through a call to `freeze/1`. This will delay the execution of the internal predicate until its result is required, which will be detected as a binding (i.e., demand) of its output variable.

We show now an example of the use of lazy evaluation, and how a lazy function is translated by this package. The following code returns an (infinite) list of fibonacci numbers:

```
:- lazy fun_eval fiblist/0.
fiblist := [0, 1 | ~zipWith(add, FibL, ~tail(FibL))]
        :- FibL = fiblist.
```

which is translated into:

```
fiblist(X) :-
          freeze(X, 'fiblist_$$lazy$$'(X)).

'fiblist_$$lazy$$'([0, 1 | Rest]) :-
          fiblist(FibL),
          tail(FibL, T),
          zipWith(add, FibL, T, Rest).
```

In the `fiblist` function defined, any element in the resulting infinite list of fibonacci numbers can be referenced, as for example, `nth(X, ~fiblist, Value).`. The other functions used in the definition are `tail/2` and `zipWith/3`. These two functions can be found in the **lazy_lib.pl** runtime file.

204 Programming MYCIN rules

Author(s): Angel Fernandez Pineda.

MYCIN databases are declared as Prolog modules containing mycin rules. Those rules are given a *certainty factor* (*CF*) which denotates an expert's credibility on that rule:

- A value of -1 stands for *surely not*.
- A value of 1 stands for *certainly*.
- A value of 0 stands for *I don't know*.

Intermediate values are allowed.

Mycin rules work on a different way as Prolog clauses: a rule will never fail (in the Prolog sense), it will return a certainty value instead. As a consequence **all** mycin rules will be explored during inference, so the order in which rules are written is not significant. For this reason, the usage of the Prolog *cut* (!) is discouraged.

204.1 Usage and interface (`mycin_doc`)

- **Library usage:**
  In order to declare a mycin database you must include the following declaration as the first one in your file:

  ```
  :- mycin(MycinDataBaseName).
  ```

- **New declarations defined:**
  `export/1`.

204.2 Documentation on new declarations (`mycin_doc`)

export/1: DECLARATION

This directive allows a given mycin predicate to be called from Prolog programs. The way in which mycin rules are called departs from Prolog ones. For instance, the followin mycin predicate:

```
:- export p/1.
```

must be called from Prolog Programs as: `mycin(p(X),CF)`, where CF will be binded to the resulting certainty factor. Obviously, the variables on *P/1* may be instantiated as you wish. Since the Prolog predicate *mycin/2* may be imported from several mycin databases, it is recommended to fully qualify those predicate goals. For example : `mydatabase:mycin(p(X),CF)`.

Usage: :- `export(Spec)`.

– *Description:* `Spec` will be a callable mycin predicate.

204.3 Known bugs and planned improvements (`mycin_doc`)

- Not fully implemented.
- Dynamic mycin predicates not implemented: open question.
- Importation of user-defined mycin predicates requires further design. This includes importation of mycin databases from another mycin database.

205 The Ciao Profiler

Author(s): Edison Mera.

The Ciao profiler provides a high-level, flexible way to mark a predicate (or a literal) for profiling. This is done by using declarations to indicate if a program element must be instrumented or not.

By default, if the user does not specify anything, no predicate inside the module will be instrumented as cost center for profiling. The use of at least one declaration saying that a specific predicate must be instrumented overrides this behavior.

The declaration is as follows:

```
:- cost_center pred1/Arity1, ... predN/ArityN.
```

where `pred1/Arity1`, ..., `predN/ArityN` are the predicates to be instrumented as cost centers. They can be separated by commas or the can be in a list.

By default the engine hooks of all defined cost center are active. The declaration:

```
(predN/ArityN,nohooks)
```

will deactivate them.

Another useful declaration makes possible to indicate that a given predicate is not going to be instrumented as cost center:

```
:- no_cost_center pred1/Arity1, ... predN/ArityN.
```

where `pred1/Arity1`, ..., `predN/ArityN` are the predicates that will not be instrumented as cost centers. There are two options (as in the previous case): write one assertion for each predicate or declare more than one predicate (separated by commas or in a list) in only one assertion.

The following assertions define the behavior of all the predicates of the module:

```
:- all_cost_center.
:- all_no_cost_center.
```

They specify respectively that all the predicates in the module will be instrumented as cost centers and that no predicate in the module will be instrumented as cost center. In the first assertion the engine hooks of all defined cost centers are active. The declaration `:- all_cost_center(nohooks).` will deactivate them.

Cost centers can be also defined at literal level replacing the literal by the declaration:

```
:- cost_center(name_cc, literal)
```

where `literal` is the program literal and `name_cc` is the name of its associated cost center. At predicate level the name of both cost center and predicate are equal.

205.1 Usage and interface (`profiler_doc`)

- **Library usage:**
  The Ciao profiler is used by including `profiler` in the package inclusion list of a module, or by means of an explicit `:- use_package(profiler).` directive.

206 ProVRML - a Prolog interface for VRML

Author(s): Göran Smedbäck, Manuel Carro (some changes), The CLIP Group.

`ProVRML` is Prolog library to handle VRML code. The library consists of modules to handle the tokenising, that is breaking the VRML code into smaller parts that can be analysed further. The further analysis will be the parsing. This is a complex part of the library and consists of several modules to handle errors and value check. When the parsing is done we have the Prolog terms of the VRML code. The terms are quite similar to the origin VRML code and can easily be read if you recognise that syntax.

This Prolog terms of the VRML code is then possible to use for analysis, reconstruction, reverse enginering, building blocks for automatic generation of VRML code. There are several possibilities and these are only some of them.

When you are done with the Prolog terms for the code, you would probably want to reverse the action and return to VRML code. This is done with the code generation modules. These are built up in more or less the same manner as the parser modules.

206.1 Usage and interface (`provrml`)

- **Library usage:**
  `:- use_module(library(provrml)).`
- **Exports:**
  - *Predicates:*
    `vrml_web_to_terms/2`, `vrml_file_to_terms/2`, `vrml_web_to_terms_file/2`, `vrml_file_to_terms_file/2`, `terms_file_to_vrml/2`, `terms_file_to_vrml_file/2`, `terms_to_vrml_file/2`, `terms_to_vrml/2`, `vrml_to_terms/2`, `vrml_in_out/2`, `vrml_http_access/2`.
- **Other modules used:**
  - *System library modules:*
    `pillow/http`, `pillow/html`, `provrml/provrml_io`, `provrml/provrml_parser`, `provrml/generator`.

206.2 Documentation on exports (`provrml`)

vrml_web_to_terms/2: PREDICATE

Usage: `vrml_web_to_terms(WEBAddress,Terms)`

- *Description:* Given a address to a VRML-document on the Internet, the predicate will return the prolog-terms.
- *Call and exit should be compatible with:*
  `WEBAddress` is an atom. (basic_props:atm/1)
  `Terms` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*
  `WEBAddress` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Terms` is a free variable. (term_typing:var/1)

vrml_file_to_terms/2: PREDICATE

Usage 1: `vrml_file_to_terms(FileName,Term)`

- *Description:* Given a filename containing a VRML-file the predicate returns the prolog terms corresponding.
- *Call and exit should be compatible with:*

  `FileName` is an atom. (basic_props:atm/1)

  `Term` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Term` is a free variable. (term_typing:var/1)

Usage 2: `vrml_file_to_terms(FileName,Terms)`

- *Description:* Given a filename containing a VRML-file and a filename, the predicate write the prolog terms corresponding to the filename.
- *Call and exit should be compatible with:*

  `FileName` is an atom. (basic_props:atm/1)

  `Terms` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Terms` is currently a term which is not a free variable. (term_typing:nonvar/1)

vrml_web_to_terms_file/2: PREDICATE

Usage: `vrml_web_to_terms_file(WEBAddress,FileName)`

- *Description:* Given a address to a VRML-document on the Internet and a filename, the predicate will write the prolog_terms to the file.
- *Call and exit should be compatible with:*

  `WEBAddress` is an atom. (basic_props:atm/1)

  `FileName` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `WEBAddress` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

vrml_file_to_terms_file/2: PREDICATE

No further documentation available for this predicate.

terms_file_to_vrml/2: PREDICATE

Usage: `terms_file_to_vrml(FileName,List)`

- *Description:* From a given filename with prologterms on the special format, the predicate returns the corresponding VRML-code.
- *Call and exit should be compatible with:*

  `FileName` is an atom. (basic_props:atm/1)

  `List` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `List` is a free variable. (term_typing:var/1)

terms_file_to_vrml_file/2: PREDICATE

Usage: `terms_file_to_vrml_file(Atom,Atom)`

- *Description:* From a given filename with prologterms on the special format, the predicate writes the corresponding VRML-code to second filename.
- *Call and exit should be compatible with:*

  `Atom` is an atom. (basic_props:atm/1)

  `Atom` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `Atom` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Atom` is currently a term which is not a free variable. (term_typing:nonvar/1)

terms_to_vrml_file/2: PREDICATE

Usage: `terms_to_vrml_file(Term,FileName)`

- *Description:* Given prolog-terms the predicate writes the corresponding VRML-code to the given file.
- *Call and exit should be compatible with:*

  `Term` is an atom. (basic_props:atm/1)

  `FileName` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

terms_to_vrml/2: PREDICATE

Usage: `terms_to_vrml(Term,VRMLCode)`

- *Description:* Given prolog-terms the predicate returns a list with the corresponding VRML-code.
- *Call and exit should be compatible with:*

  `Term` is an atom. (basic_props:atm/1)

  `VRMLCode` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `VRMLCode` is a free variable. (term_typing:var/1)

vrml_to_terms/2: PREDICATE

Usage: `vrml_to_terms(VRMLCode,Terms)`

- *Description:* Given a list with VRML-code the predicate will return the corresponding prolog-terms.
- *Call and exit should be compatible with:*

  `VRMLCode` is a string (a list of character codes). (basic_props:string/1)

  `Terms` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `VRMLCode` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Terms` is a free variable. (term_typing:var/1)

vrml_in_out/2: PREDICATE

Usage: `vrml_in_out(FileName,FileName)`

- *Description:* This is a controll-predicate that given a filename to a VRML-file and a filename, the predicate will read the VRML-code. Transform it to prolog-terms and then transform it back to VRRML-code and write it to the latter file.
- *Call and exit should be compatible with:*

  `FileName` is an atom. (basic_props:atm/1)

  `FileName` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

vrml_http_access/2: PREDICATE

Usage: `vrml_http_access(ReadFilename,BaseFilename)`

- *Description:* Given a web-address to a VRML-file the predicate will load the code, write it first to the second argument with extension '_first.wrl'. Then it transform the code to prolog terms and write it with the extension '.term'. Transform it back to VRML-code and write it to the filename with '.wrl. A good test-predicate.
- *Call and exit should be compatible with:*

  `ReadFilename` is an atom. (basic_props:atm/1)

  `BaseFilename` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `ReadFilename` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `BaseFilename` is currently a term which is not a free variable. (term_typing:nonvar/1)

206.3 Documentation on internals (`provrml`)

read_page/2: PREDICATE

Usage: `read_page(WEBAddress,Data)`

- *Description:* This routine reads a page on the web using pillow routines.
- *Call and exit should be compatible with:*

  `WEBAddress` is an atom. (basic_props:atm/1)

  `Data` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `WEBAddress` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Data` is a free variable. (term_typing:var/1)

207 boundary (library)

Author(s): Göran Smedbäck.

This module offers predicate to check values according to their boundaries and offers lists of possible node ascendents.

207.1 Usage and interface (boundary)

- **Library usage:**
  `:- use_module(library(boundary)).`
- **Exports:**
  - *Predicates:*
    `boundary_check/3`, `boundary_rotation_first/2`, `boundary_rotation_last/2`, `reserved_words/1`, `children_nodes/1`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `provrml/internal_types`, `provrml/provrmlerror`.

207.2 Documentation on exports (boundary)

boundary_check/3: PREDICATE

Usage: `boundary_check(Value_to_check,Init_value,Bound)`

- *Description:* This predicate check the boundaries of the given value according to the boudary values. If the value is wrong according to the boundaries, the value is checked according to the initial value given. If the value continues to be wrong, an error will be raised accordingly.
- *Call and exit should be compatible with:*
  `Value_to_check` is an atom. (basic_props:atm/1)
  `Init_value` is a list of `atm`s. (basic_props:list/2)
  `Bound` is a variable interval. (internal_types:bound/1)
- *The following properties should hold at call time:*
  `Value_to_check` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Init_value` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Bound` is currently a term which is not a free variable. (term_typing:nonvar/1)

boundary_rotation_first/2: PREDICATE

Usage: `boundary_rotation_first(Bound_double,Bound)`

- *Description:* The predicate will extract the first bounds from a double bound.
- *Call and exit should be compatible with:*
  `Bound_double` is a variable interval. (internal_types:bound_double/1)
  `Bound` is a variable interval. (internal_types:bound/1)

– *The following properties should hold at call time:*
`Bound_double` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Bound` is a free variable. (term_typing:var/1)

boundary_rotation_last/2: PREDICATE

Usage: `boundary_rotation_last(Bound_double,Bound)`

– *Description:* The predicate will extract the last bounds from a double bound.
– *Call and exit should be compatible with:*
`Bound_double` is a variable interval. (internal_types:bound_double/1)
`Bound` is a variable interval. (internal_types:bound/1)
– *The following properties should hold at call time:*
`Bound_double` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Bound` is a free variable. (term_typing:var/1)

reserved_words/1: PREDICATE

Usage: `reserved_words(List)`

– *Description:* Returns a list with the reserved words, words prohibited to use in cases not appropiated.
– *Call and exit should be compatible with:*
`List` is a list of `atm`s. (basic_props:list/2)
– *The following properties should hold at call time:*
`List` is a free variable. (term_typing:var/1)

children_nodes/1: PREDICATE

Usage: `children_nodes(List)`

– *Description:* Returns a list of all nodes possible as children nodes.
– *Call and exit should be compatible with:*
`List` is a list of `atm`s. (basic_props:list/2)
– *The following properties should hold at call time:*
`List` is a free variable. (term_typing:var/1)

208 dictionary (library)

Author(s): Göran Smedbäck.

This module contains the fixed dictionary. All the nodes in VRML with their associated fields.

208.1 Usage and interface (dictionary)

- **Library usage:**
  `:- use_module(library(dictionary)).`
- **Exports:**
  - *Predicates:*
    `dictionary/6`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `provrml/internal_types`.

208.2 Documentation on exports (dictionary)

dictionary/6: PREDICATE

Usage 1:
`dictionary(NodeTypeId,AccessType,FieldTypeId,FieldId,Init_value,Boundary)`

- *Description:* To lookup information about the nodes, getting their properties. Note that the type returned for the bound can be of two different types bound or bound_double. The rotation type have one bound for the directions and one for the degree of rotation.
- *Call and exit should be compatible with:*

`NodeTypeId` is an atom.	(basic_props:atm/1)
`AccessType` is an atom.	(basic_props:atm/1)
`FieldTypeId` is an atom.	(basic_props:atm/1)
`FieldId` is an atom.	(basic_props:atm/1)
`Init_value` is a list of `atm`s.	(basic_props:list/2)
`Boundary` is a variable interval.	(internal_types:bound/1)

- *The following properties should hold at call time:*

`Init_value` is a free variable.	(term_typing:var/1)
`Boundary` is a free variable.	(term_typing:var/1)

Usage 2:
`dictionary(NodeTypeId,AccessType,FieldTypeId,FieldId,Init_value,Boundary)`

- *Description:* To lookup information about the nodes, getting their properties. Note that the type returned for the bound can be of two different types bound or bound_double. The rotation type have one bound for the directions and one for the degree of rotation.

- *Call and exit should be compatible with:*
  `NodeTypeId` is an atom. (basic_props:atm/1)
  `AccessType` is an atom. (basic_props:atm/1)
  `FieldTypeId` is an atom. (basic_props:atm/1)
  `FieldId` is an atom. (basic_props:atm/1)
  `Init_value` is a list of `atm`s. (basic_props:list/2)
  `Boundary` is a variable interval. (internal_types:bound_double/1)
- *The following properties should hold at call time:*
  `Init_value` is a free variable. (term_typing:var/1)
  `Boundary` is a free variable. (term_typing:var/1)

209 dictionary_tree (library)

Author(s): Göran Smedbäck.

This module offers a dynamic tree structured dictionary a bit combined with predicates that gives it the useability to be the dictionary for the parser.

209.1 Usage and interface (dictionary_tree)

- **Library usage:**
  `:- use_module(library(dictionary_tree)).`
- **Exports:**
  - *Predicates:*
    `create_dictionaries/1`, `is_dictionaries/1`, `get_definition_dictionary/2`, `get_prototype_dictionary/2`, `dictionary_insert/5`, `dictionary_lookup/5`, `merge_tree/2`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`, `provrml/internal_types`.

209.2 Documentation on exports (dictionary_tree)

create_dictionaries/1: PREDICATE

Usage: `create_dictionaries(Dictionary)`

- *Description:* Returns a dictionary. A general name was used if the user would like to change the code to include more dictionaries.
- *Call and exit should be compatible with:*
  `Dictionary` is a dictionary. (internal_types:dictionary/1)
- *The following properties should hold at call time:*
  `Dictionary` is a free variable. (term_typing:var/1)

is_dictionaries/1: PREDICATE

Usage: `is_dictionaries(Dictionary)`

- *Description:* Is the argument a dictionary is solved by this predicate.
- *Call and exit should be compatible with:*
  `Dictionary` is a dictionary. (internal_types:dictionary/1)

get_definition_dictionary/2: PREDICATE

Usage: `get_definition_dictionary(Dictionary,Tree)`

- *Description:* Returns the definition dictionary (for the moment there is only one dictionary), which is a tree representation.

– *Call and exit should be compatible with:*

`Dictionary` is a dictionary. (internal_types:dictionary/1)

`Tree` is a tree structure. (internal_types:tree/1)

– *The following properties should hold at call time:*

`Dictionary` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Tree` is a free variable. (term_typing:var/1)

get_prototype_dictionary/2: PREDICATE

Usage: `get_prototype_dictionary(Dictionary,Tree)`

– *Description:* Returns the prototype dictionary (for the moment there is only one dictionary), which is a tree representation.

– *Call and exit should be compatible with:*

`Dictionary` is a dictionary. (internal_types:dictionary/1)

`Tree` is a tree structure. (internal_types:tree/1)

– *The following properties should hold at call time:*

`Dictionary` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Tree` is a free variable. (term_typing:var/1)

dictionary_insert/5: PREDICATE

Usage: `dictionary_insert(Key,Type,Field,Dictionary,Info)`

– *Description:* The predicate will search for the place for the Key and return Info, if the element inserted had a post before (same key value) multiple else new. The dictionary is dynamic and do not need output because of using unbinded variables.

– *Call and exit should be compatible with:*

`Key` is an atom. (basic_props:atm/1)

`Type` is an atom. (basic_props:atm/1)

`Field` is any term. (basic_props:term/1)

`Dictionary` is a tree structure. (internal_types:tree/1)

`Info` is an atom. (basic_props:atm/1)

– *The following properties should hold at call time:*

`Key` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Type` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Field` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Dictionary` is currently a term which is not a free variable. (term_typing:nonvar/1)

dictionary_lookup/5: PREDICATE

Usage: `dictionary_lookup(Key,Type,Field,Dictionary,Info)`

– *Description:* The predicate will search for the Key and return Info;defined or undefined accordingly. If defined the fields will be filled as well. The predicate do not insert the element.

– *Call and exit should be compatible with:*

`Key` is an atom. (basic_props:atm/1)

`Type` is an atom. (basic_props:atm/1)

`Field` is any term. (basic_props:term/1)

`Dictionary` is a dictionary. (internal_types:dictionary/1)

`Info` is an atom. (basic_props:atm/1)

– *The following properties should hold at call time:*

`Key` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Dictionary` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Info` is a free variable. (term_typing:var/1)

merge_tree/2: PREDICATE

Usage: `merge_tree(Tree,Tree)`

– *Description:* The predicate can be used for adding a tree dictionary to another one (the second). It will remove equal posts but posts with a slight difference will be inserted. The resulting tree will be the second tree.

– *Call and exit should be compatible with:*

`Tree` is a tree structure. (internal_types:tree/1)

`Tree` is a tree structure. (internal_types:tree/1)

– *The following properties should hold at call time:*

`Tree` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Tree` is currently a term which is not a free variable. (term_typing:nonvar/1)

210 provrmlerror (library)

Author(s): Göran Smedbäck.
This file implements error predicates of different types.

210.1 Usage and interface (provrmlerror)

- **Library usage:**
  `:- use_module(library(provrmlerror)).`
- **Exports:**
  - *Predicates:*
    `error_vrml/1`, `output_error/1`.
- **Other modules used:**
  - *System library modules:*
    `write`.

210.2 Documentation on exports (provrmlerror)

error_vrml/1: PREDICATE

Usage: `error_vrml(Structure)`

- *Description:* Given a structure with the error type as its head with possible arguments, it will write the associated error-text.
- *Call and exit should be compatible with:*
  `Structure` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*
  `Structure` is currently a term which is not a free variable. (term_typing:nonvar/1)

output_error/1: PREDICATE

Usage: `output_error(Message)`

- *Description:* This predicate will print the error message given as the argument. This predicate is used for warnings that only needs to be given as information and not necessarily give an error by the VRML browser.
- *Call and exit should be compatible with:*
  `Message` is a list of `atm`s. (basic_props:list/2)
- *The following properties should hold at call time:*
  `Message` is currently a term which is not a free variable. (term_typing:nonvar/1)

211 field_type (library)

Author(s): Göran Smedbäck.

211.1 Usage and interface (`field_type`)

- **Library usage:**
  `:- use_module(library(field_type)).`
- **Exports:**
  - *Predicates:*
    `fieldType/1`.

211.2 Documentation on exports (`field_type`)

fieldType/1: PREDICATE

Usage: `fieldType(FieldTypeId)`

- *Description:* Boolean predicate used to check the fieldTypeId with the defiened.
- *Call and exit should be compatible with:*
  `FieldTypeId` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*
  `FieldTypeId` is currently a term which is not a free variable. (term_typing:nonvar/1)

212 field_value (library)

Author(s): Göran Smedbäck.

212.1 Usage and interface (`field_value`)

- **Library usage:**
  `:- use_module(library(field_value)).`
- **Exports:**
  - *Predicates:*
    `fieldValue/6`, `mfstringValue/5`.
  - *Properties:*
    `parse/1`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `provrml/provrml_parser`, `provrml/parser_util`, `provrml/provrmlerror`.

212.2 Documentation on exports (`field_value`)

fieldValue/6: PREDICATE

Usage: `fieldValue(ParseIn,ParseOut,FieldTypeId,FieldValue,L,T)`

- *Description:* The predicate read the fieldValue from the input token stream and return the value of the parsing. The resulting list might be of numbers, strings or VRML code dependnig on the FieldTypeId.
- *Call and exit should be compatible with:*

field_value:parse(ParseIn)	(field_value:parse/1)
field_value:parse(ParseOut)	(field_value:parse/1)
`FieldTypeId` is an atom.	(basic_props:atm/1)
`FieldValue` is a list of `terms`.	(basic_props:list/2)
`L` is a list.	(basic_props:list/1)
`T` is a list.	(basic_props:list/1)

- *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`ParseOut` is a free variable.	(term_typing:var/1)
`FieldTypeId` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`FieldValue` is a free variable.	(term_typing:var/1)

mfstringValue/5: PREDICATE

Usage: `mfstringValue(ParseIn,ParseOut,Value,L,T)`

- *Description:* The predicate is exported for 'EXTERNPROTO' use, where names for locations are given. Reads one string value or multiple stringvalues from a list.

– *Call and exit should be compatible with:*

field_value:parse(ParseIn)	(field_value:parse/1)
field_value:parse(ParseOut)	(field_value:parse/1)
`Value` is a list of `string`s.	(basic_props:list/2)
`L` is a list.	(basic_props:list/1)
`T` is a list.	(basic_props:list/1)

– *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`ParseOut` is a free variable.	(term_typing:var/1)
`Value` is a free variable.	(term_typing:var/1)

parse/1: PROPERTY

A property, defined as follows:

```
parse(_1).
parse(parse(In,Out,Env,Dic)) :-
        list(In),
        list(Out),
        environment(Env),
        dictionary(Dic).
```

213 field_value_check (library)

Author(s): Göran Smedbäck.

213.1 Usage and interface (field_value_check)

- **Library usage:**
  `:- use_module(library(field_value_check)).`
- **Exports:**
  - *Predicates:*
    `fieldValue_check/8`, `mfstringValue/7`.
- **Other modules used:**
  - *System library modules:*
    `provrml/provrml_io`, `provrml/generator_util`, `provrml/boundary`, `provrml/tokeniser`, `provrml/generator`, `provrml/parser_util`.

213.2 Documentation on exports (field_value_check)

fieldValue_check/8: PREDICATE

Usage: `fieldValue_check(FieldTypeId,Value,ParseIn,ParseOut,InitValue,Boundary,L,T)`

- *Description:* The predicate read the fieldValue from the input token stream from the ParseIn. Checks of the values will be done in other module but initiated here. The values will be, if correct, collected via the DCG with the out/3 predicate for later output.

  All the predicates have the same meaning as the corresponding predicates in the input module field_value.pl. For more information about the different please see that module.
- *Call and exit should be compatible with:*

`FieldTypeId` is an atom.	(basic_props:atm/1)
`Value` is a list.	(basic_props:list/1)
field_value_check:parse(ParseIn)	(field_value_check:parse/1)
field_value_check:parse(ParseOut)	(field_value_check:parse/1)
`InitValue` is an atom.	(basic_props:atm/1)
`Boundary` is an atom.	(basic_props:atm/1)
`L` is a list.	(basic_props:list/1)
`T` is a list.	(basic_props:list/1)

- *The following properties should hold at call time:*

`FieldTypeId` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Value` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`ParseIn` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`ParseOut` is a free variable.	(term_typing:var/1)
`InitValue` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Boundary` is currently a term which is not a free variable.	(term_typing:nonvar/1)

mfstringValue/7: PREDICATE

No further documentation available for this predicate.

214 generator (library)

Author(s): Göran Smedbäck.

214.1 Usage and interface (generator)

- **Library usage:**
  `:- use_module(library(generator)).`
- **Exports:**
  - *Predicates:*
    `generator/2`, `nodeDeclaration/4`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `provrml/provrml_io`, `provrml/generator_util`, `provrml/parser_util`, `provrml/provrmlerror`, `provrml/internal_types`.

214.2 Documentation on exports (generator)

generator/2: PREDICATE

Usage: `generator(Terms,VRML)`

- *Description:* This predicate is the generator of VRML code. It accepts a list of terms that is correct VRML code, other kind of terms will be rejected will errormessage accordingly. The output is a string of correct VRML code, acceptable for VRML browsers.
- *Call and exit should be compatible with:*
  `Terms` is a list of `terms`. (basic_props:list/2)
  `VRML` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*
  `Terms` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `VRML` is a free variable. (term_typing:var/1)

nodeDeclaration/4: PREDICATE

Usage: `nodeDeclaration(ParseIn,ParseOut,L,T)`

- *Description:* The node declaration canbe constructed by a DEFinition, we then make a call to generator_util to make proper settings before continue. There can be a USE of a prior defined node or we can have a normal node declaration, one of the built ins.
- *Call and exit should be compatible with:*
  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*
`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)

215 generator_util (library)

Author(s): Göran Smedbäck.

215.1 Usage and interface (generator_util)

- **Library usage:**
  `:- use_module(library(generator_util)).`
- **Exports:**
  - *Predicates:*
    `reading/4`, `reading/5`, `reading/6`, `open_node/6`, `close_node/5`, `close_nodeGut/4`, `open_PROTO/4`, `close_PROTO/6`, `open_EXTERNPROTO/5`, `close_EXTERNPROTO/6`, `open_DEF/5`, `close_DEF/5`, `open_Script/5`, `close_Script/5`, `decompose_field/3`, `indentation_list/2`, `start_vrmlScene/4`, `remove_comments/4`.
- **Other modules used:**
  - *System library modules:*
    `provrml/provrmlerror`, `provrml/provrml_io`, `provrml/field_value`, `provrml/field_value_check`, `provrml/lookup`, `provrml/parser_util`.

215.2 Documentation on exports (generator_util)

reading/4: PREDICATE

Usage 1: `reading(DEF,Parse,L,T)`

- *Description:* This predicate will check if we have the special key word.
- *Call and exit should be compatible with:*

`DEF` is an atom.	(basic_props:atm/1)
`Parse` is a parse structure.	(internal_types:parse/1)
`L` is a list.	(basic_props:list/1)
`T` is a list.	(basic_props:list/1)

- *The following properties should hold at call time:*

`DEF` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`Parse` is currently a term which is not a free variable.	(term_typing:nonvar/1)

Usage 2: `reading(IS,NodeTypeId,ParseIn,ParseOut)`

- *Description:* This predicate will refer to a formerly introduced interface. We do a checkup of the access type and output the values.
- *Call and exit should be compatible with:*

`IS` is an atom.	(basic_props:atm/1)
`NodeTypeId` is an atom.	(basic_props:atm/1)
`ParseIn` is a parse structure.	(internal_types:parse/1)
`ParseOut` is a parse structure.	(internal_types:parse/1)

- *The following properties should hold at call time:*

`IS` is currently a term which is not a free variable.	(term_typing:nonvar/1)

`NodeTypeId` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)

Usage 3: `reading(Node,Parse,L,T)`

- *Description:* This predicate will read a node so we will check the properties of that one and then continue the progress in the generation.
- *Call and exit should be compatible with:*
  `Node` is an atom. (basic_props:atm/1)
  `Parse` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*
  `Node` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

Usage 4: `reading(Script,Parse,L,T)`

- *Description:* This predicate read a script and will then continue the generation.
- *Call and exit should be compatible with:*
  `Script` is an atom. (basic_props:atm/1)
  `Parse` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*
  `Script` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

Usage 5: `reading(NodeGut,NodeName,ParseIn,ParseOut)`

- *Description:* This predicate will read a node gut and will check the field according to the name.
- *Call and exit should be compatible with:*
  `NodeGut` is an atom. (basic_props:atm/1)
  `NodeName` is an atom. (basic_props:atm/1)
  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
- *The following properties should hold at call time:*
  `NodeGut` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `NodeName` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseOut` is a free variable. (term_typing:var/1)

Usage 6: `reading(PROTO,Parse,L,T)`

- *Description:* This predicate will read a prototype, check that the term name is the one, 'PROTO'.
- *Call and exit should be compatible with:*
  `PROTO` is an atom. (basic_props:atm/1)
  `Parse` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`PROTO` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

Usage 7: `reading(EXTERNPROTO,Parse,L,T)`

– *Description:* This predicate read a term with the name given as the first argument.

– *Call and exit should be compatible with:*

`EXTERNPROTO` is an atom. (basic_props:atm/1)

`Parse` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`EXTERNPROTO` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

reading/5: PREDICATE

Usage 1: `reading(Entrance,ParseIn,ParseOut,L,T)`

– *Description:* This predicate is a general predicate in this help module. The first argument is a key word to direct the input to the right entrance. When I say output in the following predicates I am refering to the out predicate which actually will use the features of DCG and we will add the output terms in a list for later output. The list is hidden to the user but is in this case the fourth argument will be the list and the fifth will be the resulting list, hopefully empty after the generation. Then we should have read all the terms.

– *Call and exit should be compatible with:*

`Entrance` is an atom. (basic_props:atm/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Entrance` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 2: `reading(Empty,ParseIn,ParseOut,L,T)`

– *Description:* This predicate check if we have ran out of input and is ready to terminate the reading.

– *Call and exit should be compatible with:*

`Empty` is an atom. (basic_props:atm/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Empty` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 3: `reading(Header,ParseIn,ParseOut,L,T)`

– *Description:* This predicate read the header and after the header we can have more information, that is comments.

– *Call and exit should be compatible with:*

`Header` is an atom. (basic_props:atm/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Header` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 4: `reading(NULL,ParseIn,ParseOut,L,T)`

– *Description:* This predicate accepts the special key word 'NULL' and will output that.

– *Call and exit should be compatible with:*

`NULL` is an atom. (basic_props:atm/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`NULL` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 5: `reading(Comment,ParseIn,ParseOut,L,T)`

– *Description:* This predicate will read a comment.

– *Call and exit should be compatible with:*

`Comment` is an atom. (basic_props:atm/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Comment` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 6: `reading(USE,ParseIn,ParseOut,L,T)`

– *Description:* This predicate will read the 'USE' key word.
– *Call and exit should be compatible with:*

`USE` is an atom. (basic_props:atm/1)
`ParseIn` is a parse structure. (internal_types:parse/1)
`ParseOut` is a parse structure. (internal_types:parse/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`USE` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)

Usage 7: `reading(MfstringValue,ParseIn,ParseOut,L,T)`

– *Description:* This predicate will read the term multi field string value. Then it will continue the generation in the field_value_check module. There it will read the string values and generate the code.
– *Call and exit should be compatible with:*

`MfstringValue` is an atom. (basic_props:atm/1)
`ParseIn` is a parse structure. (internal_types:parse/1)
`ParseOut` is a parse structure. (internal_types:parse/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`MfstringValue` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)

Usage 8: `reading(ExposedField,ParseIn,ParseOut,L,T)`

– *Description:* This predicate will read an exposedField and do the checkup for the interface with all its components.
– *Call and exit should be compatible with:*

`ExposedField` is an atom. (basic_props:atm/1)
`ParseIn` is a parse structure. (internal_types:parse/1)
`ParseOut` is a parse structure. (internal_types:parse/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`ExposedField` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)

Usage 9: `reading(RestrictedInterfaceDeclaration,ParseIn,ParseOut,L,T)`

– *Description:* This predicate will read the declaration for a restricted field and do the checkup accordingly if necessary.

– *Call and exit should be compatible with:*

`RestrictedInterfaceDeclaration` is an atom. (basic_props:atm/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`RestrictedInterfaceDeclaration` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 10: `reading(ExternInterfaceDeclaration,ParseIn,ParseOut,L,T)`

– *Description:* For reading an external interface declaration we see that we have three arguments in the term and that we have special access key word. We then outputs the declaration.

– *Call and exit should be compatible with:*

`ExternInterfaceDeclaration` is an atom. (basic_props:atm/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`ExternInterfaceDeclaration` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 11: `reading(ROUTE,ParseIn,ParseOut,L,T)`

– *Description:* Reading a ROUTE and we split the term into its parts. There might be comments in the different fields and therefore we have to strip_clean the fields to get them without a possible list containing comments, this for the checkup of the routing parameters. We then do an output of the values, then with the comments.

– *Call and exit should be compatible with:*

`ROUTE` is an atom. (basic_props:atm/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`ROUTE` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 12: `reading(Error_X,ParseIn,ParseOut,L,T)`

– *Description:* The predicate will call a proper error message after fetching some values like name.

– *Call and exit should be compatible with:*

`Error_X` is a compound term. (basic_props:struct/1)
`ParseIn` is a parse structure. (internal_types:parse/1)
`ParseOut` is a parse structure. (internal_types:parse/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Error_X` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)

reading/6: PREDICATE

No further documentation available for this predicate.

open_node/6: PREDICATE

Usage: `open_node(ParseIn,ParseOut,NodeGutsParseStruct,NodeNameId,L,T)`

– *Description:* The predicate will open a node to extract its name and its guts. The guts will then be added to a new parse structure to be emptied in the above module, generator.

– *Call and exit should be compatible with:*

`ParseIn` is a parse structure. (internal_types:parse/1)
`ParseOut` is a parse structure. (internal_types:parse/1)
`NodeGutsParseStruct` is a parse structure. (internal_types:parse/1)
`NodeNameId` is an atom. (basic_props:atm/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)
`NodeGutsParseStruct` is a free variable. (term_typing:var/1)
`NodeNameId` is a free variable. (term_typing:var/1)

close_node/5: PREDICATE

Usage: `close_node(ParseNodeStruct,ParseIn,ParseOut,L,T)`

– *Description:* The predicate will end the generation from the node and will do that by adding all the new posts in the dictionary, like new declarations and nodes, to the already used dictionary.

– *Call and exit should be compatible with:*

`ParseNodeStruct` is a parse structure. (internal_types:parse/1)
`ParseIn` is a parse structure. (internal_types:parse/1)
`ParseOut` is a parse structure. (internal_types:parse/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`ParseNodeStruct` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

close_nodeGut/4: PREDICATE

Usage: `close_nodeGut(ParseIn,ParseOut,L,T)`

– *Description:* The predicate will perform all the actions needed terminate the reading of the node guts.

– *Call and exit should be compatible with:*

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

open_PROTO/4: PREDICATE

Usage: `open_PROTO(Parse,ProtoParse,L,T)`

– *Description:* This predicate will construct a parse structure with the prototype information, the interface only. It can thereafter be used in further code generation. The scene will be opened afterwards.

– *Call and exit should be compatible with:*

`Parse` is a parse structure. (internal_types:parse/1)

`ProtoParse` is a parse structure. (internal_types:parse/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ProtoParse` is a free variable. (term_typing:var/1)

close_PROTO/6: PREDICATE

Usage: `close_PROTO(DeclParse,SceneParse,ParseIn,ParseOut,L,T)`

– *Description:* The predicate will push the dictionaries with its new information when gone through the scenery. The output parse structure will contain all the new information.

– *Call and exit should be compatible with:*

`DeclParse` is a parse structure. (internal_types:parse/1)

`SceneParse` is a parse structure. (internal_types:parse/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`SceneParse` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)

open_EXTERNPROTO/5: PREDICATE

Usage: `open_EXTERNPROTO(Parse,DeclParse,StringParse,L,T)`

– *Description:* This predicate will construct parse structures with the prototype information, the interface and the strings. It can thereafter be used in further code generation.

– *Call and exit should be compatible with:*

`Parse` is a parse structure. (internal_types:parse/1)
`DeclParse` is a parse structure. (internal_types:parse/1)
`StringParse` is a parse structure. (internal_types:parse/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
`DeclParse` is a free variable. (term_typing:var/1)
`StringParse` is a free variable. (term_typing:var/1)

close_EXTERNPROTO/6: PREDICATE

Usage: `close_EXTERNPROTO(ParseDeclIn,ParseStringIn,ParseIn,ParseOut,L,T)`

– *Description:* The predicate will end the generating of the external prototype and do checkup if there was correct.

– *Call and exit should be compatible with:*

`ParseDeclIn` is a parse structure. (internal_types:parse/1)
`ParseStringIn` is a parse structure. (internal_types:parse/1)
`ParseIn` is a parse structure. (internal_types:parse/1)
`ParseOut` is a parse structure. (internal_types:parse/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`ParseOut` is a free variable. (term_typing:var/1)

open_DEF/5: PREDICATE

Usage: `open_DEF(ParseIn,ParseOut,ParseNode,L,T)`

- *Description:* The predicate will open and do the settings to generate the code for a definition of a node.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
  `ParseNode` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseOut` is a free variable. (term_typing:var/1)
  `ParseNode` is a free variable. (term_typing:var/1)

close_DEF/5: PREDICATE

Usage: `close_DEF(ParseNode,ParseIn,ParseOut,L,T)`

- *Description:* The predicate will push the new dictionary information from the node definition to the output parse structure combining the information in the old parse structure with the newly received.
- *Call and exit should be compatible with:*

  `ParseNode` is a parse structure. (internal_types:parse/1)
  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `ParseNode` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseOut` is a free variable. (term_typing:var/1)

open_Script/5: PREDICATE

Usage: `open_Script(ParseIn,ParseOut,ScriptParse,L,T)`

- *Description:* The predicate will create a parse structure with the script guts.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
  `ScriptParse` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseOut` is a free variable. (term_typing:var/1)
  `ScriptParse` is a free variable. (term_typing:var/1)

close_Script/5: PREDICATE

Usage: `close_Script(ScriptParse,ParseIn,ParseOut,L,T)`

- *Description:* This predicate will update the dictionaries after generating code for the script.
- *Call and exit should be compatible with:*

  `ScriptParse` is a parse structure. (internal_types:parse/1)
  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `ScriptParse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseOut` is a free variable. (term_typing:var/1)

decompose_field/3: PREDICATE

No further documentation available for this predicate.

indentation_list/2: PREDICATE

Usage: `indentation_list(Parse,IndList)`

- *Description:* This predcate will construct a list with indentations to be output before text. The information of the indentations is inside the parse structure.
- *Call and exit should be compatible with:*

  `Parse` is a parse structure. (internal_types:parse/1)
  `IndList` is a list of `atm`s. (basic_props:list/2)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `IndList` is a free variable. (term_typing:var/1)

start_vrmlScene/4: PREDICATE

Usage: `start_vrmlScene(Parse,ParseScene,L,T)`

- *Description:* The predicate will construct a parse structure with the prototype scene and do the setups.
- *Call and exit should be compatible with:*

  `Parse` is a parse structure. (internal_types:parse/1)
  `ParseScene` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseScene` is a free variable. (term_typing:var/1)

remove_comments/4: PREDICATE

Usage: `remove_comments(Value,CommentsBefore,ValueClean,CommentsAfter)`

- *Description:* The predicate will remove comments and return the comments before and after the pure value.
- *Call and exit should be compatible with:*

  `Value` is a list of `atm`s. (basic_props:list/2)

  `CommentsBefore` is a list of `atm`s. (basic_props:list/2)

  `ValueClean` is an atom. (basic_props:atm/1)

  `CommentsAfter` is a list of `atm`s. (basic_props:list/2)
- *The following properties should hold at call time:*

  `Value` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `CommentsBefore` is a free variable. (term_typing:var/1)

  `ValueClean` is a free variable. (term_typing:var/1)

  `CommentsAfter` is a free variable. (term_typing:var/1)

215.3 Known bugs and planned improvements (`generator_util`)

- Run-time checks have been reported not to work with this code. That means that either the assertions here, or the code that implements the run-time checks are erroneous.

216 internal_types (library)

Author(s): Göran Smedbäck.

These are the internal data types used in the predicates. They are only used to simplify this documentation and make it more understandable.

Implemented by Göran Smedbäck

216.1 Usage and interface (internal_types)

- **Library usage:**
  `:- use_module(library(internal_types)).`
- **Exports:**
  - *Regular Types:*
    `bound/1`, `bound_double/1`, `dictionary/1`, `environment/1`, `parse/1`, `tree/1`, `whitespace/1`.

216.2 Documentation on exports (internal_types)

bound/1: REGTYPE

Min is a number or an atom that indicates the minimal value, Max indicates the maximal.

```
bound(bound(Min,Max)) :-
        atm(Min),
        atm(Max).
```

Usage: `bound(Bound)`

- *Description:* `Bound` is a variable interval.

bound_double/1: REGTYPE

Min is a number or an atom that indicates the minimal value, Max indicates the maximal. The first two for some value and the second pair for some other. Typically used for types that are compound, e.g., rotationvalue.

```
bound_double(bound(Min0,Max0,Min1,Max1)) :-
        atm(Min0),
        atm(Max0),
        atm(Min1),
        atm(Max1).
```

Usage: `bound_double(Bound)`

- *Description:* `Bound` is a variable interval.

dictionary/1: REGTYPE

Dic is a tree structure and is used as the internal representation of the dictionary.

```
dictionary(dic(Dic)) :-
        tree(Dic).
dictionary(X) :-
        term(X).
```

Usage: `dictionary(Dictionary)`

– *Description:* `Dictionary` is a dictionary.

environment/1: REGTYPE

EnvironmentType one of 'DEF','PROTO','EXTERNPROTO' with the name Name. Whitespace is a structure with whitespace information.

```
environment(env(Env,Name,WhiteSpace)) :-
        atm(Env),
        atm(Name),
        whitespace(WhiteSpace).
```

Usage: `environment(Environment)`

– *Description:* `Environment` is an environment structure.

parse/1: REGTYPE

In is the list of tokens to parse and Out is the resulting list after the parsing. Env is of type env and is the environment-structure.The dictinonary Dic contains created information and structures.

```
parse(parse(In,Out,Env,Dic)) :-
        list(In),
        list(Out),
        environment(Env),
        dictionary(Dic).
```

Usage: `parse(Parse)`

– *Description:* `Parse` is a parse structure.

tree/1: REGTYPE

Key is the search-key, Leaf is the information, Left and Right are more dictionary posts, where Left have less Key-value.

```
tree(tree(Key,Leaf,Left,Right)) :-
        atm(Key),
        leaf(Leaf),
        tree(Left),
        tree(Right).
```

Usage: `tree(Tree)`

– *Description:* `Tree` is a tree structure.

whitespace/1: REGTYPE

The Row and Indentation information. The row information used when parsing the VRML code to give accurate error position and the indentation is used when generating VRML code from terms.

```
whitespace(w(Row,Indentation)) :-
        number(Row),
        number(Indentation).
```

Usage: `whitespace(Whitespace)`

– *Description:* `Whitespace` is a whitespace structure.

217 provrml_io (library)

Author(s): Göran Smedbäck.
This file implements I/O predicates of different types.
Implemented by Göran Smedbäck

217.1 Usage and interface (provrml_io)

- **Library usage:**
  `:- use_module(library(provrml_io)).`
- **Exports:**
  - *Predicates:*
    `out/1`, `out/3`, `convert_atoms_to_string/2`, `read_terms_file/2`, `write_terms_file/2`, `read_vrml_file/2`, `write_vrml_file/2`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`.

217.2 Documentation on exports (provrml_io)

out/1: PREDICATE

Usage: `out(ListOfOutput)`

- *Description:* The predicate used is out/3 (DCG) where we will 'save' the output in the second argument. The tird argument is the rest, nil.
- *Call and exit should be compatible with:*
  `ListOfOutput` is a list of `atms`. (basic_props:list/2)
- *The following properties should hold at call time:*
  `ListOfOutput` is currently a term which is not a free variable. (term_typing:nonvar/1)

out/3: PREDICATE

No further documentation available for this predicate.

convert_atoms_to_string/2: PREDICATE

Usage: `convert_atoms_to_string(Atoms,String)`

- *Description:* The predicate transforms a list of atoms to a string.
- *Call and exit should be compatible with:*
  `Atoms` is a list of `atms`. (basic_props:list/2)
  `String` is a list of `nums`. (basic_props:list/2)
- *The following properties should hold at call time:*
  `Atoms` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `String` is a free variable. (term_typing:var/1)

read_terms_file/2: PREDICATE

Usage: `read_terms_file(Filename,Term)`

- *Description:* Given a filename to a file with terms, the predicate reads the terms and are returned in the second argument. `Filename` is an atom and `Term` is the read prolog terms.
- *Call and exit should be compatible with:*

  `Filename` is an atom. (basic_props:atm/1)

  `Term` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `Filename` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Term` is a free variable. (term_typing:var/1)

write_terms_file/2: PREDICATE

Usage: `write_terms_file(FileName,List)`

- *Description:* Given a filename and a list of terms the predicate will write them down to the file.
- *Call and exit should be compatible with:*

  `FileName` is an atom. (basic_props:atm/1)

  `List` is a list of `atm`s. (basic_props:list/2)
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `List` is currently a term which is not a free variable. (term_typing:nonvar/1)

read_vrml_file/2: PREDICATE

Usage: `read_vrml_file(FileName,Data)`

- *Description:* Given a filename, the predicate returns the substance.
- *Call and exit should be compatible with:*

  `FileName` is an atom. (basic_props:atm/1)

  `Data` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Data` is a free variable. (term_typing:var/1)

write_vrml_file/2: PREDICATE

Usage: `write_vrml_file(FileName,Data)`

- *Description:* Given a filename and data in form of a string, the predicate will write the data to the named file.
- *Call and exit should be compatible with:*

  `FileName` is an atom. (basic_props:atm/1)

  `Data` is a string (a list of character codes). (basic_props:string/1)
- *The following properties should hold at call time:*

  `FileName` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Data` is currently a term which is not a free variable. (term_typing:nonvar/1)

218 lookup (library)

Author(s): Göran Smedbäck.

218.1 Usage and interface (lookup)

- **Library usage:**
  `:- use_module(library(lookup)).`
- **Exports:**
  - *Predicates:*
    `create_proto_element/3`, `get_prototype_interface/2`, `get_prototype_definition/2`, `lookup_check_node/4`, `lookup_check_field/6`, `lookup_check_interface_fieldValue/8`, `lookup_field/4`, `lookup_route/5`, `lookup_fieldTypeId/1`, `lookup_get_fieldType/4`, `lookup_field_access/4`, `lookup_set_def/3`, `lookup_set_prototype/4`, `lookup_set_extern_prototype/4`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `provrml/provrmlerror`, `provrml/internal_types`, `provrml/provrml_io`, `provrml/parser_util`, `provrml/dictionary`, `provrml/dictionary_tree`, `provrml/field_value_check`, `provrml/boundary`, `provrml/generator_util`, `provrml/field_type`, `provrml/field_value`.

218.2 Documentation on exports (lookup)

create_proto_element/3: PREDICATE

Usage: `create_proto_element(Interface,Definition,Proto)`

- *Description:* The predicate will construct a proto structure containing the interface and the definition.
- *Call and exit should be compatible with:*
  `Interface` is any term. (basic_props:term/1)
  `Definition` is any term. (basic_props:term/1)
  `Proto` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*
  `Interface` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Definition` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Proto` is a free variable. (term_typing:var/1)

get_prototype_interface/2: PREDICATE

Usage: `get_prototype_interface(Proto,Interface)`

- *Description:* The predicate will return the interface from a proto structure.
- *Call and exit should be compatible with:*
  `Proto` is any term. (basic_props:term/1)
  `Interface` is any term. (basic_props:term/1)

– *The following properties should hold at call time:*
`Proto` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Interface` is a free variable. (term_typing:var/1)

get_prototype_definition/2: PREDICATE

Usage: `get_prototype_definition(Proto,Definition)`

– *Description:* The predicate will return the definition from a proto structure.
– *Call and exit should be compatible with:*
`Proto` is any term. (basic_props:term/1)
`Definition` is any term. (basic_props:term/1)
– *The following properties should hold at call time:*
`Proto` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Definition` is a free variable. (term_typing:var/1)

lookup_check_node/4: PREDICATE

Usage: `lookup_check_node(ParseIn,NodeTypeId,L,T)`

– *Description:* The predicate will check so that the node is of an acceptable type. If the node name is not found in the ordinary dictionary then the secondary dictionary is consulted, the personal one. Then the node have to be a Prototype, Externproto or a Defined one.
– *Call and exit should be compatible with:*
field_value:parse(ParseIn) (field_value:parse/1)
`NodeTypeId` is an atom. (basic_props:atm/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)
– *The following properties should hold at call time:*
`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
`NodeTypeId` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_check_field/6: PREDICATE

Usage: `lookup_check_field(ParseIn,ParseOut,NodeTypeId,Field,L,T)`

– *Description:* The predicate will create some output through the DCG and the output command out/3. There will be formatting and the most important part there will be a check of the field type and of its values so that they correspond to the type.
– *Call and exit should be compatible with:*
field_value:parse(ParseIn) (field_value:parse/1)
field_value:parse(ParseOut) (field_value:parse/1)
`NodeTypeId` is an atom. (basic_props:atm/1)
`Field` is any term. (basic_props:term/1)
`L` is a list. (basic_props:list/1)
`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

`NodeTypeId` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Field` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_check_interface_fieldValue/8: PREDICATE

Usage: `lookup_check_interface_fieldValue(ParseIn,ParseOut,AccessType,FieldType,Id,FieldValue,DCGIn,DCGOut)`

– *Description:* The predicate formats the output for the interface part of the prototype. It also checks the values for the fields.

– *Call and exit should be compatible with:*

field_value:parse(ParseIn) (field_value:parse/1)

field_value:parse(ParseOut) (field_value:parse/1)

`AccessType` is an atom. (basic_props:atm/1)

`FieldType` is any term. (basic_props:term/1)

`Id` is an atom. (basic_props:atm/1)

`FieldValue` is any term. (basic_props:term/1)

`DCGIn` is a string (a list of character codes). (basic_props:string/1)

`DCGOut` is a string (a list of character codes). (basic_props:string/1)

– *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

`AccessType` is currently a term which is not a free variable. (term_typing:nonvar/1)

`FieldType` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Id` is currently a term which is not a free variable. (term_typing:nonvar/1)

`FieldValue` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_field/4: PREDICATE

Usage: `lookup_field(Parse,FieldTypeId,FieldId0,FieldId1)`

– *Description:* The predicate will control that the two connected Fields are of the same type, e.g., SFColor - SFColor, MFVec3f - MFVec3f.

– *Call and exit should be compatible with:*

field_value:parse(Parse) (field_value:parse/1)

`FieldTypeId` is an atom. (basic_props:atm/1)

`FieldId0` is an atom. (basic_props:atm/1)

`FieldId1` is an atom. (basic_props:atm/1)

– *The following properties should hold at call time:*

`Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

`FieldTypeId` is currently a term which is not a free variable. (term_typing:nonvar/1)

`FieldId0` is currently a term which is not a free variable. (term_typing:nonvar/1)

`FieldId1` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_route/5: PREDICATE

Usage: `lookup_route(Parse,NodeTypeId0,FieldId0,NodeTypeId1,FieldId1)`

- *Description:* The predicate will check the routing behaviour for two given fields. They will be checked according to the binding rules, like name changes access proporties. The node types for the field must of course be given for the identification.
- *Call and exit should be compatible with:*

  field_value:parse(Parse) (field_value:parse/1)
  `NodeTypeId0` is an atom. (basic_props:atm/1)
  `FieldId0` is an atom. (basic_props:atm/1)
  `NodeTypeId1` is an atom. (basic_props:atm/1)
  `FieldId1` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `NodeTypeId0` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `FieldId0` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `NodeTypeId1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `FieldId1` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_fieldTypeId/1: PREDICATE

Usage: `lookup_fieldTypeId(FieldTypeId)`

- *Description:* The predicate just make a check to see if the given FieldType id is among the allowed. You can not construct own ones and the check is mearly a spellcheck.
- *Call and exit should be compatible with:*

  `FieldTypeId` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `FieldTypeId` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_get_fieldType/4: PREDICATE

Usage: `lookup_get_fieldType(Parse,NodeTypeId,FieldId,FieldType)`

- *Description:* The predicate will return the given field's type. It will start the search in the ordinar dictionary and then to the personal dictionary sarting off with 'PROTO'. After it will go for 'DEF' and 'EXTERNPROTO'.
- *Call and exit should be compatible with:*

  field_value:parse(Parse) (field_value:parse/1)
  `NodeTypeId` is an atom. (basic_props:atm/1)
  `FieldId` is an atom. (basic_props:atm/1)
  `FieldType` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `NodeTypeId` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `FieldId` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `FieldType` is a free variable. (term_typing:var/1)

lookup_field_access/4: PREDICATE

Usage: `lookup_field_access(Parse,NodenameId,FieldId,FieldId)`

- *Description:* The predicate will control that the access properties are correct according to the certain rules that we have. It makes a check to see if the fields are of the same access type or if one of them is an exposedField. It is not doing a route check up to control that behaviour entirely.
- *Call and exit should be compatible with:*

  field_value:parse(Parse) (field_value:parse/1)
  `NodenameId` is an atom. (basic_props:atm/1)
  `FieldId` is an atom. (basic_props:atm/1)
  `FieldId` is an atom. (basic_props:atm/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `NodenameId` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `FieldId` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `FieldId` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_set_def/3: PREDICATE

Usage: `lookup_set_def(Parse,Name,Node)`

- *Description:* The predicate will enter a new post in the personal dictionary for the node definition.
- *Call and exit should be compatible with:*

  field_value:parse(Parse) (field_value:parse/1)
  `Name` is an atom. (basic_props:atm/1)
  `Node` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Name` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Node` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_set_prototype/4: PREDICATE

Usage: `lookup_set_prototype(Parse,Name,Interface,Definition)`

- *Description:* The predicate will insert the prototype definition in the personal dictionary and will give a warning if there is a multiple name given.
- *Call and exit should be compatible with:*

  field_value:parse(Parse) (field_value:parse/1)
  `Name` is an atom. (basic_props:atm/1)
  `Interface` is any term. (basic_props:term/1)
  `Definition` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Name` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Interface` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Definition` is currently a term which is not a free variable. (term_typing:nonvar/1)

lookup_set_extern_prototype/4: PREDICATE

Usage: `lookup_set_extern_prototype(Parse,Name,Interface,Strings)`

- *Description:* The predicate will insert the external prototype definition in the personal dictionary and will give a warning if there is a multiple name given.
- *Call and exit should be compatible with:*

  field_value:parse(Parse) (field_value:parse/1)

  `Name` is an atom. (basic_props:atm/1)

  `Interface` is any term. (basic_props:term/1)

  `Strings` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Name` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Interface` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Strings` is currently a term which is not a free variable. (term_typing:nonvar/1)

219 provrml_parser (library)

Author(s): Göran Smedbäck.

219.1 Usage and interface (provrml_parser)

- **Library usage:**
  `:- use_module(library(provrml_parser)).`
- **Exports:**
  - *Predicates:*
    `parser/2`, `nodeDeclaration/4`.
  - *Properties:*
    `field_Id/1`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`, `provrml/lookup`, `provrml/field_value`, `provrml/tokeniser`, `provrml/parser_util`, `provrml/possible`, `provrml/provrmlerror`.

219.2 Documentation on exports (provrml_parser)

parser/2: PREDICATE

Usage: `parser(VRML,Terms)`

- *Description:* The parser uses a tokeniser to read the input text string of VRML code and returns a list with the corresponding terms. The tokens will be read in this parser as the grammar says. The parser is according to the specification of the VRML grammar, accept that it is performed over tokens in sted of the actual code.
- *Call and exit should be compatible with:*
  `VRML` is a string (a list of character codes). (basic_props:string/1)
  `Terms` is a list of `terms`. (basic_props:list/2)
- *The following properties should hold at call time:*
  `VRML` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Terms` is a free variable. (term_typing:var/1)

nodeDeclaration/4: PREDICATE

Usage: `nodeDeclaration(Parse_in,Parse_out,L,T)`

- *Description:* The predicate is also accepted as a node field as has to be accessed from the module that reads field values, i.e., field_value.pl
- *Call and exit should be compatible with:*
  `Parse_in` is a parse structure. (internal_types:parse/1)
  `Parse_out` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*
`Parse_in` is currently a term which is not a free variable. (term_typing:nonvar/1)
`Parse_out` is a free variable. (term_typing:var/1)

field_Id/1: PROPERTY

A property, defined as follows:

```
field_Id(_1).
```

220 parser_util (library)

Author(s): Göran Smedbäck.

220.1 Usage and interface (parser_util)

- **Library usage:**
  `:- use_module(library(parser_util)).`
- **Exports:**
  - *Predicates:*
    at_least_one/4, at_least_one/5, fillout/4, fillout/5, create_node/3, create_field/3, create_field/4, create_field/5, create_directed_field/5, correct_commenting/4, create_parse_structure/1, create_parse_structure/2, create_parse_structure/3, create_environment/4, insert_comments_in_beginning/3, get_environment_name/2, get_environment_type/2, get_row_number/2, add_environment_whitespace/3, get_indentation/2, inc_indentation/2, dec_indentation/2, add_indentation/3, reduce_indentation/3, push_whitespace/3, push_dictionaries/3, get_parsed/2, get_environment/2, inside_proto/1, get_dictionaries/2, strip_from_list/2, strip_from_term/2, strip_clean/2, strip_exposed/2, strip_restricted/2, strip_interface/2, set_parsed/3, set_environment/3, insert_parsed/3, reverse_parsed/2, stop_parse/2, look_first_parsed/2, get_first_parsed/3, remove_code/3, look_ahead/3.
- **Other modules used:**
  - *System library modules:*
    aggregates, dynamic, iso_misc, iso_byte_char, iso_incomplete, operators, read, write, lists, provrml/dictionary_tree, provrml/internal_types.

220.2 Documentation on exports (parser_util)

at_least_one/4: PREDICATE

Usage: `at_least_one(ParseIn,ParseOut,L,T)`

- *Description:* One or more whitespace or comment have to be read, for the moment there are no whitespaces to be read so we only stick with the comments.
- *Call and exit should be compatible with:*

`ParseIn` is a parse structure.	(internal_types:parse/1)
`ParseOut` is a parse structure.	(internal_types:parse/1)
`L` is a list.	(basic_props:list/1)
`T` is a list.	(basic_props:list/1)

- *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`ParseOut` is a free variable.	(term_typing:var/1)

at_least_one/5: PREDICATE

Usage: `at_least_one(ParseIn,ParseOut,ListOfRead,L,T)`

- *Description:* One or more whitespace or comment have to be read, the result will be given in the list.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
  `ListOfRead` is a list of `terms`. (basic_props:list/2)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseOut` is a free variable. (term_typing:var/1)
  `ListOfRead` is a free variable. (term_typing:var/1)

fillout/4: PREDICATE

Usage: `fillout(ParseIn,ParseOut,L,T)`

- *Description:* If there are whitespaces and comments, zero or more of each. This read all comments and all whitespace. The comments and whitespace will not be returned.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseOut` is a free variable. (term_typing:var/1)

fillout/5: PREDICATE

Usage: `fillout(ParseIn,ParseOut,ResultingList,L,T)`

- *Description:* If there are whitespaces and comments, zero or more of each, we add them to the resulting list. This read all comments and all whitespace.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)
  `ParseOut` is a parse structure. (internal_types:parse/1)
  `ResultingList` is a list of `terms`. (basic_props:list/2)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `ParseOut` is a free variable. (term_typing:var/1)
  `ResultingList` is a free variable. (term_typing:var/1)

create_node/3: PREDICATE

Usage: `create_node(NodeTypeId,Parse,Node)`

- *Description:* The predicate will construct a node term with the read guts which is inside the parse structure. A node consists of its name and one argument, a list of its fields.
- *Call and exit should be compatible with:*

  `NodeTypeId` is an atom. (basic_props:atm/1)

  `Parse` is a parse structure. (internal_types:parse/1)

  `Node` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `NodeTypeId` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Node` is a free variable. (term_typing:var/1)

create_field/3: PREDICATE

Usage: `create_field(FieldNameId,Arguments,Field)`

- *Description:* The predicate will construct a field with the Id as the fieldname and the arguments as they are, in a double list, which results in a single list or a single list which will result in free arguments.
- *Call and exit should be compatible with:*

  `FieldNameId` is an atom. (basic_props:atm/1)

  `Arguments` is any term. (basic_props:term/1)

  `Field` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `FieldNameId` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Arguments` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Field` is a free variable. (term_typing:var/1)

create_field/4: PREDICATE

Usage: `create_field(FieldAccess,FieldType,FieldId,Field)`

- *Description:* The predicate will construct a field with its access type as the name with type and id as arguments.
- *Call and exit should be compatible with:*

  `FieldAccess` is an atom. (basic_props:atm/1)

  `FieldType` is an atom. (basic_props:atm/1)

  `FieldId` is an atom. (basic_props:atm/1)

  `Field` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `FieldAccess` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `FieldType` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `FieldId` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Field` is a free variable. (term_typing:var/1)

create_field/5: PREDICATE

Usage: `create_field(FieldAccess,FieldType,FieldId,Fieldvalue,Field)`

- *Description:* The predicate will construct a field with its access type as the name with type, id and value as arguments.
- *Call and exit should be compatible with:*

  `FieldAccess` is an atom. (basic_props:atm/1)
  `FieldType` is an atom. (basic_props:atm/1)
  `FieldId` is an atom. (basic_props:atm/1)
  `Fieldvalue` is any term. (basic_props:term/1)
  `Field` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `FieldAccess` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `FieldType` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `FieldId` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Fieldvalue` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Field` is a free variable. (term_typing:var/1)

create_directed_field/5: PREDICATE

Usage: `create_directed_field(Access,Type,Id0,Id1,Field)`

- *Description:* The predicate will construct a directed field with the key word IS in the middle. Its access type as the name with type, from id0 and to id1 as arguments.
- *Call and exit should be compatible with:*

  `Access` is an atom. (basic_props:atm/1)
  `Type` is an atom. (basic_props:atm/1)
  `Id0` is an atom. (basic_props:atm/1)
  `Id1` is an atom. (basic_props:atm/1)
  `Field` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `Access` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Type` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Id0` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Id1` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Field` is a free variable. (term_typing:var/1)

correct_commenting/4: PREDICATE

Usage: `correct_commenting(Place,Comment,ParsedIn,ParsedOut)`

- *Description:* The predicate places the comment 'before' or 'after' the parsed term. This results in a list with the term and the comment or in just returning the term.
- *Call and exit should be compatible with:*

  `Place` is an atom. (basic_props:atm/1)
  `Comment` is a compound term. (basic_props:struct/1)
  `ParsedIn` is any term. (basic_props:term/1)
  `ParsedOut` is any term. (basic_props:term/1)

– *The following properties should hold at call time:*

`Place` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Comment` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParsedIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParsedOut` is a free variable. (term_typing:var/1)

create_parse_structure/1: PREDICATE

Usage: `create_parse_structure(Parse)`

– *Description:* The predicate will construct the parse structure with its three fields: the parsing list, the environment structure, and the dictionaries.

– *Call and exit should be compatible with:*

`Parse` is a parse structure. (internal_types:parse/1)

– *The following properties should hold at call time:*

`Parse` is a free variable. (term_typing:var/1)

create_parse_structure/2: PREDICATE

Usage 1: `create_parse_structure(ParseIn,ParseOut)`

– *Description:* The predicate will construct a parse structure with its three fields: the parsing list, the environment structure, and the dictionaries. It will reuse the environment and the dictionaries from the input.

– *Call and exit should be compatible with:*

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

– *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

Usage 2: `create_parse_structure(ParsedList,ParseOut)`

– *Description:* The predicate will construct a parse structure with its three fields: the parsing list, the environment structure, and the dictionaries. It will use the list of parsed items in its structure.

– *Call and exit should be compatible with:*

`ParsedList` is a list of `terms`. (basic_props:list/2)

`ParseOut` is a parse structure. (internal_types:parse/1)

– *The following properties should hold at call time:*

`ParsedList` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

create_parse_structure/3: PREDICATE

Usage: `create_parse_structure(ParsedList,ParseIn,ParseOut)`

– *Description:* The predicate will construct a parse structure with its three fields: the parsing list, the environment structure, and the dictionaries. It will use the list of parsed items in its structure and the environment and the dictionary from the parse structure given.

– *Call and exit should be compatible with:*

`ParsedList` is a list of `terms`. (basic_props:list/2)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

– *The following properties should hold at call time:*

`ParsedList` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

create_environment/4: PREDICATE

Usage: `create_environment(Parse,EnvType,Name,EnvStruct)`

– *Description:* The predicate will construct an environment structure based on the information in the parse structure. Well only the white- space information will be reused. The are three types of environments 'PROTO', 'EXTERNPROTO', and 'DEF'.

– *Call and exit should be compatible with:*

`Parse` is a parse structure. (internal_types:parse/1)

`EnvType` is an atom. (basic_props:atm/1)

`Name` is an atom. (basic_props:atm/1)

`EnvStruct` is an environment structure. (internal_types:environment/1)

– *The following properties should hold at call time:*

`Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

`EnvType` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Name` is currently a term which is not a free variable. (term_typing:nonvar/1)

`EnvStruct` is a free variable. (term_typing:var/1)

insert_comments_in_beginning/3: PREDICATE

Usage: `insert_comments_in_beginning(Comment,ParseIn,ParseOut)`

– *Description:* We add the comment in the beginneing of the parsed, to get the proper look.

– *Call and exit should be compatible with:*

`Comment` is a compound term. (basic_props:struct/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

– *The following properties should hold at call time:*

`Comment` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

get_environment_name/2: PREDICATE

Usage: `get_environment_name(Environment,Name)`

– *Description:* The predicate will return the enviroment name.

– *Call and exit should be compatible with:*
  `Environment` is an environment structure. (internal_types:environment/1)
  `Name` is an atom. (basic_props:atm/1)
– *The following properties should hold at call time:*
  `Environment` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Name` is a free variable. (term_typing:var/1)

get_environment_type/2: PREDICATE

Usage: `get_environment_type(Environment,Type)`

– *Description:* The predicate will return the enviroment type, one of the three: 'PROTO', 'EXTERNPROTO', and 'DEF'.
– *Call and exit should be compatible with:*
  `Environment` is an environment structure. (internal_types:environment/1)
  `Type` is an atom. (basic_props:atm/1)
– *The following properties should hold at call time:*
  `Environment` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Type` is a free variable. (term_typing:var/1)

get_row_number/2: PREDICATE

Usage: `get_row_number(Parse,Row)`

– *Description:* The predicate will return the row number from the parse structure. The row number is not fully implemented.
– *Call and exit should be compatible with:*
  `Parse` is a parse structure. (internal_types:parse/1)
  `Row` is a number. (basic_props:num/1)
– *The following properties should hold at call time:*
  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Row` is a free variable. (term_typing:var/1)

add_environment_whitespace/3: PREDICATE

Usage: `add_environment_whitespace(EnvIn,WhiteSpaceList,EnvOut)`

– *Description:* The predicate will add the new whitespace that is collected in a list of whitespaces to the environment.
– *Call and exit should be compatible with:*
  `EnvIn` is an environment structure. (internal_types:environment/1)
  `WhiteSpaceList` is a list of `atm`s. (basic_props:list/2)
  `EnvOut` is an environment structure. (internal_types:environment/1)
– *The following properties should hold at call time:*
  `EnvIn` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `WhiteSpaceList` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `EnvOut` is a free variable. (term_typing:var/1)

get_indentation/2: PREDICATE

Usage 1: `get_indentation(Whitespace,Indentation)`

- *Description:* The predicate will return the indentation depth from a whitespace structure.
- *Call and exit should be compatible with:*

  `Whitespace` is a whitespace structure. (internal_types:whitespace/1)

  `Indentation` is a number. (basic_props:num/1)
- *The following properties should hold at call time:*

  `Whitespace` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Indentation` is a free variable. (term_typing:var/1)

Usage 2: `get_indentation(Parse,Indentation)`

- *Description:* The predicate will return the indentation depth from a parse structure.
- *Call and exit should be compatible with:*

  `Parse` is a parse structure. (internal_types:parse/1)

  `Indentation` is a number. (basic_props:num/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Indentation` is a free variable. (term_typing:var/1)

inc_indentation/2: PREDICATE

Usage: `inc_indentation(ParseIn,ParseOut)`

- *Description:* Will increase the indentation with one step to a parse structure.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)

  `ParseOut` is a parse structure. (internal_types:parse/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ParseOut` is a free variable. (term_typing:var/1)

dec_indentation/2: PREDICATE

Usage: `dec_indentation(ParseIn,ParseOut)`

- *Description:* Will decrease the indentation with one step to a parse structure.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)

  `ParseOut` is a parse structure. (internal_types:parse/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ParseOut` is a free variable. (term_typing:var/1)

add_indentation/3: PREDICATE

No further documentation available for this predicate.

reduce_indentation/3: PREDICATE

No further documentation available for this predicate.

push_whitespace/3: PREDICATE

Usage: `push_whitespace(ParseWithWhitespace,ParseIn,ParseOut)`

- *Description:* The predicate will add the whitespace values from one parse structure to another one, resultin in the output, with the values from the second parse structure with the whitespace from the first added.
- *Call and exit should be compatible with:*

  `ParseWithWhitespace` is a parse structure. (internal_types:parse/1)

  `ParseIn` is a parse structure. (internal_types:parse/1)

  `ParseOut` is a parse structure. (internal_types:parse/1)
- *The following properties should hold at call time:*

  `ParseWithWhitespace` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ParseOut` is a free variable. (term_typing:var/1)

push_dictionaries/3: PREDICATE

Usage: `push_dictionaries(Parse,Parse,Parse)`

- *Description:* The predicate will set the first parse structure's directory to the second parsing structure argument. The resulting parsing structure will be returned.
- *Call and exit should be compatible with:*

  `Parse` is a parse structure. (internal_types:parse/1)

  `Parse` is a parse structure. (internal_types:parse/1)

  `Parse` is a parse structure. (internal_types:parse/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Parse` is a free variable. (term_typing:var/1)

get_parsed/2: PREDICATE

Usage 1: `get_parsed(ParseStructure,ListOfParsed)`

- *Description:* The predicate will return a list of the parsed terms that is inside the parse structure.
- *Call and exit should be compatible with:*

  `ParseStructure` is a parse structure. (internal_types:parse/1)

  `ListOfParsed` is a list of `terms`. (basic_props:list/2)
- *The following properties should hold at call time:*

  `ParseStructure` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ListOfParsed` is a free variable. (term_typing:var/1)

Usage 2: `get_parsed(ParseStructure,EnvironmentStructure)`

- *Description:* The predicate will return the environment of the parse structure.
- *Call and exit should be compatible with:*

  `ParseStructure` is a parse structure. (internal_types:parse/1)

  `EnvironmentStructure` is an environment structure. (internal_types:environment/1)
- *The following properties should hold at call time:*

  `ParseStructure` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `EnvironmentStructure` is a free variable. (term_typing:var/1)

Usage 3: `get_parsed(ParseStructure,Dictionaries)`

- *Description:* The predicate will return dictionary used within the parse structure.
- *Call and exit should be compatible with:*

  `ParseStructure` is a parse structure. (internal_types:parse/1)

  `Dictionaries` is a dictionary. (internal_types:dictionary/1)
- *The following properties should hold at call time:*

  `ParseStructure` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Dictionaries` is a free variable. (term_typing:var/1)

get_environment/2: PREDICATE

No further documentation available for this predicate.

inside_proto/1: PREDICATE

Usage: `inside_proto(Parse)`

- *Description:* The predicate will answer to the question: are we parsing inside a PROTO/EXTERNPROTO.
- *Call and exit should be compatible with:*

  `Parse` is a parse structure. (internal_types:parse/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

get_dictionaries/2: PREDICATE

No further documentation available for this predicate.

strip_from_list/2: PREDICATE

Usage: `strip_from_list(ListWithComments,CleanList)`

- *Description:* The predicate will strip the list from comments and return a list without any comments.
- *Call and exit should be compatible with:*

  `ListWithComments` is a list of `terms`. (basic_props:list/2)

  `CleanList` is a list of `terms`. (basic_props:list/2)

– *The following properties should hold at call time:*

`ListWithComments` is currently a term which is not a free variable. (term_typing:nonvar/1)

`CleanList` is a free variable. (term_typing:var/1)

strip_from_term/2: PREDICATE

Usage: `strip_from_term(Term,Stripped)`

– *Description:* The predicate will remove comments from a term, it will reduce its arguments if there are comments as arguments.

– *Call and exit should be compatible with:*

`Term` is any term. (basic_props:term/1)

`Stripped` is any term. (basic_props:term/1)

– *The following properties should hold at call time:*

`Term` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Stripped` is a free variable. (term_typing:var/1)

strip_clean/2: PREDICATE

Usage: `strip_clean(ParsedIn,ParsedOut)`

– *Description:* The predicate will return a striped list or a single atom if there was no comments and no more items in the list. It will also return a atom if there is comments and only one other element.

– *Call and exit should be compatible with:*

`ParsedIn` is any term. (basic_props:term/1)

`ParsedOut` is any term. (basic_props:term/1)

– *The following properties should hold at call time:*

`ParsedIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParsedOut` is a free variable. (term_typing:var/1)

strip_exposed/2: PREDICATE

No further documentation available for this predicate.

strip_restricted/2: PREDICATE

No further documentation available for this predicate.

strip_interface/2: PREDICATE

Usage: `strip_interface(Interface,StrippedInterface)`

– *Description:* The predicate will remove comments from the interface that we read for the PROTOtype. This will help us when setting the properties.

– *Call and exit should be compatible with:*

`Interface` is a list of `terms`. (basic_props:list/2)

`StrippedInterface` is a list of `terms`. (basic_props:list/2)

– *The following properties should hold at call time:*

`Interface` is currently a term which is not a free variable. (term_typing:nonvar/1)

`StrippedInterface` is a free variable. (term_typing:var/1)

set_parsed/3: PREDICATE

Usage: `set_parsed(ParseIn,NewParseList,ParseOut)`

– *Description:* The predicate will create a new parse structure from the first parse structure with the parse list from the second argument.

– *Call and exit should be compatible with:*

`ParseIn` is a parse structure. (internal_types:parse/1)

`NewParseList` is a list of `terms`. (basic_props:list/2)

`ParseOut` is a parse structure. (internal_types:parse/1)

– *The following properties should hold at call time:*

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`NewParseList` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

set_environment/3: PREDICATE

Usage: `set_environment(Environment,ParseIn,ParseOut)`

– *Description:* The modificator will return a parse structure with the environment given with the other properties from the first parse structure.

– *Call and exit should be compatible with:*

`Environment` is an environment structure. (internal_types:environment/1)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

– *The following properties should hold at call time:*

`Environment` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

insert_parsed/3: PREDICATE

Usage: `insert_parsed(ListOfParsed,ParseIn,ParseOut)`

– *Description:* The predicate will append the newly parsed terms to the old that we have in the parse structure.

– *Call and exit should be compatible with:*

`ListOfParsed` is a list of `terms`. (basic_props:list/2)

`ParseIn` is a parse structure. (internal_types:parse/1)

`ParseOut` is a parse structure. (internal_types:parse/1)

– *The following properties should hold at call time:*

`ListOfParsed` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

`ParseOut` is a free variable. (term_typing:var/1)

reverse_parsed/2: PREDICATE

Usage: `reverse_parsed(ParseIn,ParseOut)`

- *Description:* The returned parse structure is the same as the input with the difference that the parsed terms are in reverse order.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)

  `ParseOut` is a parse structure. (internal_types:parse/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ParseOut` is a free variable. (term_typing:var/1)

stop_parse/2: PREDICATE

Usage: `stop_parse(TermIn,TermOut)`

- *Description:* The predicate will bind the invalue to the outvalue, used to terminate a parsing.
- *Call and exit should be compatible with:*

  `TermIn` is any term. (basic_props:term/1)

  `TermOut` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `TermIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `TermOut` is a free variable. (term_typing:var/1)

look_first_parsed/2: PREDICATE

Usage: `look_first_parsed(Parse,First)`

- *Description:* Look at the first item in the parse structure.
- *Call and exit should be compatible with:*

  `Parse` is a parse structure. (internal_types:parse/1)

  `First` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `Parse` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `First` is a free variable. (term_typing:var/1)

get_first_parsed/3: PREDICATE

Usage: `get_first_parsed(ParseIn,ParseOut,First)`

- *Description:* Get the first item in the parse structure and return the parse structure with the item removed.
- *Call and exit should be compatible with:*

  `ParseIn` is a parse structure. (internal_types:parse/1)

  `ParseOut` is a parse structure. (internal_types:parse/1)

  `First` is any term. (basic_props:term/1)
- *The following properties should hold at call time:*

  `ParseIn` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `ParseOut` is a free variable. (term_typing:var/1)

  `First` is a free variable. (term_typing:var/1)

remove_code/3: PREDICATE

No further documentation available for this predicate.

look_ahead/3: PREDICATE

Usage: `look_ahead(Name,Parsed,Parsed)`

- *Description:* This predicate is used normally by the CDG and the two last arguments will therefore be the same because we don't remove the parsed. The name is the name inside a term, the first argument.
- *Call and exit should be compatible with:*

  `Name` is an atom. (basic_props:atm/1)

  `Parsed` is a list of `term`s. (basic_props:list/2)

  `Parsed` is a list of `term`s. (basic_props:list/2)
- *The following properties should hold at call time:*

  `Name` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Parsed` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Parsed` is a free variable. (term_typing:var/1)

221 possible (library)

Author(s): Göran Smedbäck.

221.1 Usage and interface (possible)

- **Library usage:**
  `:- use_module(library(possible)).`
- **Exports:**
  - *Predicates:*
    `continue/3`.

221.2 Documentation on exports (possible)

continue/3: PREDICATE

Usage: `continue(RuleName,L,T)`

- *Description:* The predicate will check the rule name's possible followers, that is the entrance in the grammar, to see if we have the possibility to contiue the generation in the asked direction. We will by using the DCG look one item ahead to see if we have the proper key name ahead. Then we check the possible alternatives for the rule name from the list and type we receive from the call to possible. As we can see there are different look ahead predicates depending if we have a token or a word, looking on the structure name(token name) or if we should read the first word beyond the structure name.
- *Call and exit should be compatible with:*
  `RuleName` is an atom. (basic_props:atm/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*
  `RuleName` is currently a term which is not a free variable. (term_typing:nonvar/1)

222 tokeniser (library)

Author(s): Göran Smedbäck.

222.1 Usage and interface (tokeniser)

- **Library usage:**
  `:- use_module(library(tokeniser)).`
- **Exports:**
  - *Predicates:*
    `tokeniser/2`, `token_read/3`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `provrml/provrmlerror`.

222.2 Documentation on exports (tokeniser)

tokeniser/2: PREDICATE

Usage: `tokeniser(VRML,Tokens)`

- *Description:* This predicate will perform the parsing of the VRML code. The result will be tokens that will be the source for producing the Prolog terms of the VRML code. This is done in the parser module. From these terms analysis, changing, and any thing that you want to do with VRML code from Prolog programming language. We perform the predicate with a catch call to be able to output error messages if encountered.
- *Call and exit should be compatible with:*
  `VRML` is a list of `atm`s. (basic_props:list/2)
  `Tokens` is a list of `term`s. (basic_props:list/2)
- *The following properties should hold at call time:*
  `VRML` is currently a term which is not a free variable. (term_typing:nonvar/1)
  `Tokens` is a free variable. (term_typing:var/1)

token_read/3: PREDICATE

Usage 1: `token_read(String,L,T)`

- *Description:* The predicate will return the token string with one argument the string. The string has some special properties according to the specification, but always starting with the string symbol.
- *Call and exit should be compatible with:*
  `String` is any term. (basic_props:term/1)
  `L` is a list. (basic_props:list/1)
  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*
  `String` is a free variable. (term_typing:var/1)

Usage 2: `token_read(Comment,L,T)`

- *Description:* The predicate will return a token for a comment. The comment symbol, the bracket will start the comment and go for a complete line.
- *Call and exit should be compatible with:*

  `Comment` is any term. (basic_props:term/1)

  `L` is a list. (basic_props:list/1)

  `T` is a list. (basic_props:list/1)
- *The following properties should hold at call time:*

  `Comment` is a free variable. (term_typing:var/1)

Usage 3: `token_read(Id,L,T)`

- *Description:* The predicate will return a token for a word, an identifier. there is a check whether the id starts with a capital or a low cap letter. There are tough no distinction made in the token, but made a bit more easy to change if needed.
- *Call and exit should be compatible with:*

  `Id` is any term. (basic_props:term/1)

  `L` is a list. (basic_props:list/1)

  `T` is a list. (basic_props:list/1)

Usage 4: `token_read(Exp,L,T)`

- *Description:* The predicate will return the token for an exponentional number. The number are according to the definitions of VRML and due to the normal Prolog standard. We allow integer and float exponents but not exponential exponents.
- *Call and exit should be compatible with:*

  `Exp` is any term. (basic_props:term/1)

  `L` is a list. (basic_props:list/1)

  `T` is a list. (basic_props:list/1)

Usage 5: `token_read(Float,L,T)`

- *Description:* The predicate will return a token for a floating point value.
- *Call and exit should be compatible with:*

  `Float` is currently instantiated to a float. (term_typing:float/1)

  `L` is a list. (basic_props:list/1)

  `T` is a list. (basic_props:list/1)

Usage 6: `token_read(Hex,L,T)`

- *Description:* The returned token is of type hexadecimal number according to the specifications.E.g., 0xabcd3ef where the 0x is essential.
- *Call and exit should be compatible with:*

  `Hex` is any term. (basic_props:term/1)

  `L` is a list. (basic_props:list/1)

  `T` is a list. (basic_props:list/1)

Usage 7: `token_read(Int,L,T)`

- *Description:* The token returned is the integer token and will contain the integer value read.
- *Call and exit should be compatible with:*

  `Int` is an integer. (basic_props:int/1)

  `L` is a list. (basic_props:list/1)

  `T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Int` is a free variable. (term_typing:var/1)

Usage 8: `token_read(Symbol,L,T)`

– *Description:* The symbol returned with this token is one of the symbols allowed according to the specification. The only symbol is dot for the moment.

– *Call and exit should be compatible with:*

`Symbol` is any term. (basic_props:term/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

Usage 9: `token_read(ListOfType,L,T)`

– *Description:* The token for whitespace returns a list with the encountered whitespaces. This is a better way because a whitespace are selldom found alone. The whitespaces considered are: space, tab, new-line, return, and comma.

– *Call and exit should be compatible with:*

`ListOfType` is any term. (basic_props:term/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

Usage 10: `token_read(Paren,L,T)`

– *Description:* There are four tokens returned with this prefix: node_open, node_close, list_open, list_close.

– *Call and exit should be compatible with:*

`Paren` is an atom. (basic_props:atm/1)

`L` is a list. (basic_props:list/1)

`T` is a list. (basic_props:list/1)

– *The following properties should hold at call time:*

`Paren` is a free variable. (term_typing:var/1)

223 Pattern (regular expression) matching

Author(s): The CLIP Group.

This library provides facilities for matching strings and terms against *patterns*. There are some prolog flags

- There is a prolog flag to case insensitive match. Its name is case_insensitive. If its value is on, matching is case insenseitive, but if its value is off matching isn't case insensitive. By default, its value is off.
- There is a syntax facility to use matching more or less like a unification. You can type, `" =~ "regexp" "` as an argument of a predicate. Thus, that argument must match with regexp. For example:

  ```
  pred ( =~ "ab*c", B) :- ...
  ```

  is equivalent to

  ```
  pred (X,B) :- match_posix("ab*c",X,R), ...
  ```

  So, there are two prolog flags about this. One of this prolog flags is `"format"`. Its values are shell, posix, list and pred, and sustitute in the example match_posix by match_shell, match_posix, match_struct and macth_pred respectivly. By default its value is posix. The other prolog flag is exact. Its values are on and off. If its value is off sustitute in the example R by []. If its value is on, R is a variable. By default, its value is on.

223.1 Usage and interface (`regexp_doc`)

- **Library usage:**
  `:- use_package(regexp).`
  or
  `:- module(...,...,[regexp]).`
- **New operators defined:**
  `=~/1` [200,fy].
- **Other modules used:**
  - *System library modules:*
    `regexp/regexp_code`.

223.2 Documentation on internals (`regexp_doc`)

match_shell/3: PREDICATE

Usage: `match_shell(Exp,IN,Rest)`

- *Description:* Matches `IN` against `Exp`. `Rest` is the longest remainder of the string after the match. For example, `match_shell("??*","foo.pl",Tail)` succeeds, instantiating `Tail` to `"o.pl"`.
- *The following properties should hold at call time:*

  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)
  `IN` is a string (a list of character codes). (basic_props:string/1)
  `Rest` is a string (a list of character codes). (basic_props:string/1)

match_shell/2: PREDICATE

Usage: `match_shell(Exp,IN)`

- *Description:* Matches completely `IN` (no tail can remain unmatched) against `Exp` similarly to `match_shell/3`.
- *The following properties should hold at call time:*

  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)

  `IN` is a string (a list of character codes). (basic_props:string/1)

match_posix/2: PREDICATE

Usage: `match_posix(Exp,IN)`

- *Description:* Matches completely `IN` (no tail can remain unmatched) against `Exp` similarly to `match_posix/3`.
- *The following properties should hold at call time:*

  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)

  `IN` is a string (a list of character codes). (basic_props:string/1)

match_posix/4: PREDICATE

Usage: `match_posix(Exp,In,Match,Rest)`

- *The following properties should hold at call time:*

  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)

  `In` is a string (a list of character codes). (basic_props:string/1)

  `Match` is a list of `string`s. (basic_props:list/2)

  `Rest` is a string (a list of character codes). (basic_props:string/1)

match_posix_rest/3: PREDICATE

Usage: `match_posix_rest(Exp,IN,Rest)`

- *Description:* Matches `IN` against `Exp`. `Tail` is the remainder of the string after the match. For example, `match_posix("ab*c","abbbbcdf",Tail)` succeeds, instantiating `Tail` to `"df"`.
- *The following properties should hold at call time:*

  `Exp` is a posix regular expression to match against. (regexp_code:posix_regexp/1)

  `IN` is a string (a list of character codes). (basic_props:string/1)

  `Rest` is a string (a list of character codes). (basic_props:string/1)

match_posix_matches/3: PREDICATE

Usage: `match_posix_matches(Exp,IN,Matches)`

- *Description:* Matches completely `IN` against `Exp`. `Exp` can contain *anchored expressions* of the form `\(regexp\)`. `Matches` will contain a list of the *anchored expression* which were matched on success. Note that since POSIX expressions are being read inside a string, backslashes will have to be doubled. For example,

```
?- match_posix_matches("\\(aa|bb\\)\\(bb|aa\\)", "bbaa", M).
M = ["bb","aa"] ? ;
no

?- match_posix_matches("\\(aa|bb\\)\\(bb|aa\\)", "aabb", M).
M = ["aa","bb"] ? ;
no
```

– *The following properties should hold at call time:*

`Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)

`IN` is a string (a list of character codes). (basic_props:string/1)

`Matches` is a list of `strings`. (basic_props:list/2)

match_struct/4: PREDICATE

Usage: `match_struct(Exp,IN,Rest,Tail)`

– *Description:* Matches `IN` against `Exp`. `Tail` is the remainder of the list of atoms `IN` after the match. For example, `match_struct([a,*(b),c],[a,b,b,b,c,d,e],Tail)` succeeds, instantiating `Tail` to `[d,e]`.

– *Call and exit should be compatible with:*

`Exp` is a struct regular expression to match against. (regexp_code:struct_regexp/1)

`IN` is a string (a list of character codes). (basic_props:string/1)

`Rest` is a string (a list of character codes). (basic_props:string/1)

match_pred/2: PREDICATE

Usage: `match_pred(Pred1,Pred2)`

– *Description:* Tests if two predicates `Pred1` and `Pred2` match using posix regular expressions.

replace_first/4: PREDICATE

Usage: `replace_first(IN,Old,New,Resul)`

– *Description:* Replace the first ocurrence of the `Old` by `New` in `IN` and copy the result in `Resul`.

– *The following properties should hold at call time:*

`IN` is a string (a list of character codes). (basic_props:string/1)

`Old` is a posix regular expression to match against. (regexp_code:posix_regexp/1)

`New` is a string (a list of character codes). (basic_props:string/1)

`Resul` is a string (a list of character codes). (basic_props:string/1)

replace_all/4: PREDICATE

Usage: `replace_all(IN,Old,New,Resul)`

– *Description:* Replace all ocurrences of the `Old` by `New` in `IN` and copy the result in `Resul`.

– *The following properties should hold at call time:*
`IN` is a string (a list of character codes). (basic_props:string/1)
`Old` is a posix regular expression to match against. (regexp_code:posix_regexp/1)
`New` is a string (a list of character codes). (basic_props:string/1)
`Resul` is a string (a list of character codes). (basic_props:string/1)

224 regexp_code (library)

224.1 Usage and interface (regexp_code)

- **Library usage:**
  `:- use_module(library(regexp_code)).`
- **Exports:**
  - *Predicates:*
    `match_shell/3`, `match_shell/2`, `match_posix/2`, `match_posix/4`, `match_posix_rest/3`, `match_posix_matches/3`, `match_struct/4`, `match_pred/2`, `replace_first/4`, `replace_all/4`.
  - *Regular Types:*
    `shell_regexp/1`, `posix_regexp/1`, `struct_regexp/1`.
  - *Multifiles:*
    `define_flag/3`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

224.2 Documentation on exports (regexp_code)

match_shell/3: PREDICATE

Usage: `match_shell(Exp,IN,Rest)`

- *Description:* Matches `IN` against `Exp`. `Rest` is the longest remainder of the string after the match. For example, `match_shell("??*","foo.pl",Tail)` succeeds, instantiating `Tail` to `"o.pl"`.
- *The following properties should hold at call time:*
  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)
  `IN` is a string. (regexp_code:string/1)
  `Rest` is a string. (regexp_code:string/1)

match_shell/2: PREDICATE

Usage: `match_shell(Exp,IN)`

- *Description:* Matches completely `IN` (no tail can remain unmatched) against `Exp` similarly to `match_shell/3`.
- *The following properties should hold at call time:*
  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)
  `IN` is a string. (regexp_code:string/1)

match_posix/2: PREDICATE

Usage: `match_posix(Exp,IN)`

- *Description:* Matches completely `IN` (no tail can remain unmatched) against `Exp` similarly to `match_posix/3`.
- *The following properties should hold at call time:*

  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)

  `IN` is a string. (regexp_code:string/1)

match_posix/4: PREDICATE

Usage: `match_posix(Exp,In,Match,Rest)`

- *The following properties should hold at call time:*

  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)

  `In` is a string. (regexp_code:string/1)

  `Match` is a list of `strings`. (basic_props:list/2)

  `Rest` is a string. (regexp_code:string/1)

match_posix_rest/3: PREDICATE

Usage: `match_posix_rest(Exp,IN,Rest)`

- *Description:* Matches `IN` against `Exp`. `Tail` is the remainder of the string after the match. For example, `match_posix("ab*c","abbbbcdf",Tail)` succeeds, instantiating `Tail` to `"df"`.
- *The following properties should hold at call time:*

  `Exp` is a posix regular expression to match against. (regexp_code:posix_regexp/1)

  `IN` is a string. (regexp_code:string/1)

  `Rest` is a string. (regexp_code:string/1)

match_posix_matches/3: PREDICATE

Usage: `match_posix_matches(Exp,IN,Matches)`

- *Description:* Matches completely `IN` against `Exp`. `Exp` can contain *anchored expressions* of the form `\(regexp\)`. `Matches` will contain a list of the *anchored expression* which were matched on success. Note that since POSIX expressions are being read inside a string, backslashes will have to be doubled. For example,

```
?- match_posix_matches("\\(aa|bb\\)\\(bb|aa\\)", "bbaa", M).
M = ["bb","aa"] ? ;
no

?- match_posix_matches("\\(aa|bb\\)\\(bb|aa\\)", "aabb", M).
M = ["aa","bb"] ? ;
no
```

- *The following properties should hold at call time:*

  `Exp` is a shell regular expression to match against. (regexp_code:shell_regexp/1)

  `IN` is a string. (regexp_code:string/1)

  `Matches` is a list of `strings`. (basic_props:list/2)

match_struct/4: PREDICATE

Usage: `match_struct(Exp,IN,Rest,Tail)`

- *Description:* Matches `IN` against `Exp`. `Tail` is the remainder of the list of atoms `IN` after the match. For example, `match_struct([a,*(b),c],[a,b,b,b,c,d,e],Tail)` succeeds, instantiating `Tail` to `[d,e]`.
- *Call and exit should be compatible with:*

  `Exp` is a struct regular expression to match against. (regexp_code:struct_regexp/1)

  `IN` is a string. (regexp_code:string/1)

  `Rest` is a string. (regexp_code:string/1)

match_pred/2: PREDICATE

Usage: `match_pred(Pred1,Pred2)`

- *Description:* Tests if two predicates `Pred1` and `Pred2` match using posix regular expressions.

replace_first/4: PREDICATE

Usage: `replace_first(IN,Old,New,Resul)`

- *Description:* Replace the first ocurrence of the `Old` by `New` in `IN` and copy the result in `Resul`.
- *The following properties should hold at call time:*

  `IN` is a string. (regexp_code:string/1)

  `Old` is a posix regular expression to match against. (regexp_code:posix_regexp/1)

  `New` is a string. (regexp_code:string/1)

  `Resul` is a string. (regexp_code:string/1)

replace_all/4: PREDICATE

Usage: `replace_all(IN,Old,New,Resul)`

- *Description:* Replace all ocurrences of the `Old` by `New` in `IN` and copy the result in `Resul`.
- *The following properties should hold at call time:*

  `IN` is a string. (regexp_code:string/1)

  `Old` is a posix regular expression to match against. (regexp_code:posix_regexp/1)

  `New` is a string. (regexp_code:string/1)

  `Resul` is a string. (regexp_code:string/1)

shell_regexp/1: REGTYPE

Usage: `shell_regexp(P)`

- *Description:* `P` is a shell regular expression to match against.

posix_regexp/1: REGTYPE

Usage: `posix_regexp(P)`

- *Description:* `P` is a posix regular expression to match against.

struct_regexp/1: REGTYPE

Usage: `struct_regexp(P)`

– *Description:* `P` is a struct regular expression to match against.

224.3 Documentation on multifiles (`regexp_code`)

define_flag/3: PREDICATE

The predicate is *multifile*.

Usage: `define_flag(Flag,FlagValues,Default)`

– *The following properties hold upon exit:*

`Flag` is an atom. (basic_props:atm/1)

Define the valid flag values (basic_props:flag_values/1)

225 Automatic tester

Author(s): David Trallero Mena.

This module have been created to automate the test that a predicate should pass hopefully. With that intention we have to provide a set of test and its correct answers. The predicate `run_tester/10` will execute every test and compare it with its answer, generating two traces, one with detailed information, and another with the summary of executions of the tests.

225.1 Usage and interface (tester)

- **Library usage:**
  `:- use_module(library(tester)).`
- **Exports:**
  - *Predicates:*
    `run_tester/10`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `write`, `io_alias_redirection`.

225.2 Documentation on exports (tester)

run_tester/10: PREDICATE

Meta-predicate with arguments: `run_tester(?,?,(pred 0),(pred 1),?,(pred 1),?,(pred 0),?,?)`.

Usage: `run_tester(LogFile,ResultFile,Begin,Test,TestList,Check,CheckList,End,GoodExamples,Slider`

- *Description:* run_tester is a predicate for automatizate testers. It get 2 file names as entry (`LogFile` and `ResultFile`) for saving the trace and the short result scheme respectevely. `Being` and `End` are called at the beginning and at the end of the test. `Test` is called which each element of `TestList` and after, `Check` is called with the corresponding element in `CheckList` for checking the results of `Test` predicate. `GoodExample` is ground(int) at the exit and tells the number of examples that passed the test correctly. `Slider` can take the values slider(no) or slider(Title) and slider will be shown everytime a new test is called
- *The following properties should hold at call time:*

  `LogFile` is a string (a list of character codes). (basic_props:string/1)

  `ResultFile` is a string (a list of character codes). (basic_props:string/1)

  `Begin` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `Test` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `TestList` is a list. (basic_props:list/1)

  `Check` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `CheckList` is a list. (basic_props:list/1)

`End` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`GoodExamples` is a free variable. (term_typing:var/1)

`Slider` is any term. (basic_props:term/1)

225.3 Other information (tester)

Two simple examples of the use of the run_tester are provided.

225.3.1 Understanding run_test predicate

```
:- module( tester_test2 , _ , _ ).


:- use_module('..'(tester)).
%:- use_module( library(tester) ).
:- use_module(library(lists)).
:- use_module(library(write)).

init_func :-
        write( 'Starting the test\n' ).

tester_func( (X,X,_) ) :-
        write( 'The argument is correct ' ),
        write( X ) , nl.

checker_func( (_,X,X) ) :-
        write( 'check is fine\n\n' ).


end_func :-
        write( 'Test ended\n' ).


main :-
        L = [ (1,1,1),   % CORRECT
              (2,2,1),   % Test CORRECT , CHECK FALSE
              (1,2,2)    % Test FALSE
            ],

         run_tester(
                      'test.log',
                      'result.log',
                      init_func ,
                      tester_func ,
                      L,
                      checker_func,
                      L,
                      end_func,
                      Res,
                      slider( 'Tester2: ' )
```

```
                 ),

          length( L , LL ),
          Op is (Res / LL) * 100,
          message( note , [ 'Analysis result: ' , Op , '%' ] ).
```

225.3.2 More complex example

In this example we just want to test if the output of Ciaopp is readable by CIAO.
Tester function succeds if it is able to write the output file.
Checker function succeds if it is able to load the written file.

```
:- module( tester_test1 , _ , [] ).

%:- use_module( library(tester) , [run_tester/10] ).
:- use_module('..'(tester), [run_tester/10]).


:- use_module(library(ciaopp)).
:- use_module(library(compiler)).

:- use_module(library(filenames)).

:- use_module(library(write)).

:- use_module(library(lists)).

init_func.


test_files( '/home/dtm/Ciaopp/Benchmarks/ciaopp/modes/' ).

tester_func( FileArg ) :-
        test_files( Path ),
        atom_concat( Path , FileArg , File0 ),

        message( note ,
         [ '++++++++++++++++++++++++++++++++++++++++++++++++\n' ] ),
        (unload( File0 )->true;true),
        module( File0 ),

        atom_concat( TFile , '.pl', File0 ),
        atom_concat( TFile , '_test.pl' , TestFile ),

        output( TestFile ).


get_module( Path , Module ) :-
        no_path_file_name( Path , File ),
        (atom_concat( Module , '.pl' , File )
        -> true ; Module = File ).
```

```
checker_func( FileArg ) :-
        get_module( FileArg , Module ),
        (unload( Module )->true;true),

        atom_concat(RawFile, '.pl'     , FileArg ),
        atom_concat(RawFile, '_test.pl' , OptFile ),

        test_files( Path ),
        atom_concat( Path , OptFile, OptFilePath ),

        message( note , [ 'Cargando ' , OptFilePath ] ),
        use_module( OptFilePath ).

end_func.




main :-
        L = [
                'aiakl.pl',
                'query.pl',
                'mmatrix.pl',
                'ann.pl',
                'bid.pl',
                'rdtok.pl',
                'myread.pl',
                'boyer.pl',
                'read.pl',
                'occur.pl',
                'serialize.pl',
                'browse.pl',
                'peephole.pl',
                'tak.pl',
                'deriv.pl',
                'progeom.pl',
                'warplan.pl',
                'fib.pl',
                'qplan.pl',
                'witt.pl',
                'grammar.pl',
                'zebra.pl',
                'qsortapp.pl',
                'hanoiapp.pl'
              ],

        run_tester(
                       'test.log',
                       'result.log',
```

```
                init_func ,
                tester_func ,
                L,
                checker_func,
                L,
                end_func,
                Res,
                slider( 'Tester1: ' )
            ),
length( L , LL ),
Op is (Res / LL) * 100,
message( note , [ 'Analysis result: ' , Op , '%' ] ).
```

226 Measuring features from predicates (time cost or memory used)

Author(s): David Trallero Mena.

This library has been done for measuring or compare execution features (currently only time) of predicates. This module relys on gnuplot, an auxiliary module which use the tool `gnuplot`, for representing results graphically

226.1 Usage and interface (`time_analyzer`)

- **Library usage:**
  `:- use_module(library(time_analyzer)).`
- **Exports:**
  - *Predicates:*
    `performance/3`, `benchmark/6`, `compare_benchmark/7`, `generate_benchmark_list/7`, `benchmark2/6`, `compare_benchmark2/7`, `generate_benchmark_list2/7`, `sub_times/3`, `div_times/2`, `cost/3`.
- **Other modules used:**
  - *System library modules:*
    `gnuplot/gnuplot`, `prolog_sys`, `lists`, `write`, `hiordlib`.

226.2 Documentation on exports (`time_analyzer`)

performance/3: PREDICATE

Meta-predicate with arguments: `performance(goal,?,?)`.

Usage: `performance(P,M,Times)`

- *Description:* performance accepts a goal, `P`, as a first argument. The aim of this predicate is to call `P` several times and meassure some feature (in this version, only time, that is reason because no extra parameter has been added). `M` defines how many times `P` should be called. Usually, calling the predicate in some succesion (10,100,1000) and dividing by the number of times it is executed we can obtain the "execution time" of the predicate (if we are measuring time).

  The result of executions are returned in the list `Times`

  The diferent modes are:
  - graph(Start , End , Increment). It defines arithmetic succesion starting in Start and ending in End, by increment of Increment. So `P` is called Start times on the first time, Start+Increment on the second, etc.
  - graph The same as graph/3 but with default options
  - graph_exp(Start , End , Exp). It defines geometric succesion. Start is multiplied by Exp till it gets End. So `P` is called Start times on the first time, Start*Exp on the second, etc.
  - graph_exp The same as graph_exp/3 but with default options
- *The following properties should hold at call time:*

  `P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`M` is any term. (basic_props:term/1)

`Times` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`M` is any term. (basic_props:term/1)

`Times` is a list of `nums`. (basic_props:list/2)

benchmark/6: PREDICATE

Usage: `benchmark(P,BenchList,NumTimes,Method,Reserved,OutList)`

– *Description:* The predicate `P`, which accepts ONE argument, is called with the first member of each pair of the `BenchList` list `NumTimes`. The entry list have pairs because the second member of the pair express the meaning of the first one in the X-Axis. For example, if we are doing a benchmark of qsort function, the first member will be a list for being ordered and the second one will be the length of the unordered list. The output is a list of (X,Y) points where Y means the time needed for its entry of "cost" X. `OutList` can be used as TimeList in predicate generate_plot. `Reserved` is reserved for future implementations (it will take the value of runtime, memory_used...)

– *The following properties should hold at call time:*

`P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`BenchList` is a list of `pairs`. (basic_props:list/2)

`NumTimes` is an integer. (basic_props:int/1)

time_analyzer:average_mode(Method) (time_analyzer:average_mode/1)

`Reserved` is any term. (basic_props:term/1)

`OutList` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

`BenchList` is a list of `pairs`. (basic_props:list/2)

`NumTimes` is an integer. (basic_props:int/1)

time_analyzer:average_mode(Method) (time_analyzer:average_mode/1)

`Reserved` is any term. (basic_props:term/1)

`OutList` is a list of `pairs`. (basic_props:list/2)

compare_benchmark/7: PREDICATE

Usage: `compare_benchmark(ListPred,BenchList,Method,NumTimes,BaseName,Reserved,GeneralOptions)`

– *Description:* It is the generalization of execute predicate `benchmark/6` with several predicates. `benchmark/6` predicate is called with each predicate in `ListPred`, and `BaseName` is used for the temporaries basename file. `GeneralOptions` are aplied to the plot

– *The following properties should hold at call time:*

`ListPred` is a list of `callables`. (basic_props:list/2)

`BenchList` is a list. (basic_props:list/1)

time_analyzer:average_mode(Method) (time_analyzer:average_mode/1)
`NumTimes` is an integer. (basic_props:int/1)
`BaseName` is currently instantiated to an atom. (term_typing:atom/1)
`Reserved` is any term. (basic_props:term/1)
`GeneralOptions` is a list. (basic_props:list/1)

generate_benchmark_list/7: PREDICATE

No further documentation available for this predicate.

benchmark2/6: PREDICATE

Usage: `benchmark2(P,BenchList,Method,NumTimes,What,OutList)`

– *Description:* The predicate `P`, which accepts TWO arguments, is called `NumTimes` with the first member of each pair of the `BenchList` list and a free variable as the second. The time of execution (in the future, the desired featured for be measured) is expected to be the second argument, that is because it is a variable. The entry list, `BenchList` have pairs because the second member of the pair express the cost of the first (in X-Axis). For example, if we are doing a benchmark of qsort function, the first member will be a list for being ordered and the second one will represent the lenght of the unordered list. The output is a list of (X,Y) points where Y express the time needed for they entry of "cost" X. `OutList` can be used as TimeList in predicate generate_plot. `What` is reserved for future use

– *The following properties should hold at call time:*

`P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
`BenchList` is a list of `pair`s. (basic_props:list/2)
time_analyzer:average_mode(Method) (time_analyzer:average_mode/1)
`NumTimes` is an integer. (basic_props:int/1)
`What` is currently instantiated to an atom. (term_typing:atom/1)
`OutList` is a free variable. (term_typing:var/1)

– *The following properties should hold upon exit:*

`P` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)
`BenchList` is a list of `pair`s. (basic_props:list/2)
time_analyzer:average_mode(Method) (time_analyzer:average_mode/1)
`NumTimes` is an integer. (basic_props:int/1)
`What` is currently instantiated to an atom. (term_typing:atom/1)
`OutList` is a list of `pair`s. (basic_props:list/2)

compare_benchmark2/7: PREDICATE

Usage: `compare_benchmark2(ListPred,BenchList,Method,NumTimes,BaseName,Reserved,GeneralOptions)`

– *Description:* It is the generalization of execute predicate `benchmark2/6` with several predicates. `benchmark2/6` is called with each predicate in `ListPred` and `BaseName` is used for the temporaries basename file. `GeneralOptions` are applied to the plot ('default' can be used for default General options)

– *The following properties should hold at call time:*

`ListPred` is a list of `callable`s. (basic_props:list/2)

`BenchList` is a list. (basic_props:list/1)

time_analyzer:average_mode(Method) (time_analyzer:average_mode/1)

`NumTimes` is an integer. (basic_props:int/1)

`BaseName` is currently instantiated to an atom. (term_typing:atom/1)

`Reserved` is currently instantiated to an atom. (term_typing:atom/1)

`GeneralOptions` is a list. (basic_props:list/1)

– *The following properties should hold upon exit:*

`ListPred` is a list of `callable`s. (basic_props:list/2)

`BenchList` is a list. (basic_props:list/1)

time_analyzer:average_mode(Method) (time_analyzer:average_mode/1)

`NumTimes` is an integer. (basic_props:int/1)

`BaseName` is currently instantiated to an atom. (term_typing:atom/1)

`Reserved` is currently instantiated to an atom. (term_typing:atom/1)

`GeneralOptions` is a list. (basic_props:list/1)

generate_benchmark_list2/7: PREDICATE

No further documentation available for this predicate.

sub_times/3: PREDICATE

Usage: `sub_times(A,B,C)`

– *Description:* C is the result of doing A - B, where A, B, C are a list of pairs as (Time,_)

– *Call and exit should be compatible with:*

`A` is a list of `pair`s. (basic_props:list/2)

`B` is a list of `pair`s. (basic_props:list/2)

`C` is a list of `pair`s. (basic_props:list/2)

div_times/2: PREDICATE

Usage: `div_times(A,B)`

– *Description:* `A` is a list of pairs (P1,P2). `B` is a list of pairs with the form (P1,P2/P1) for each (P1,P2) that belongs to `A`

– *Call and exit should be compatible with:*

`A` is a list of `pair`s. (basic_props:list/2)

`B` is a list of `pair`s. (basic_props:list/2)

cost/3: PREDICATE

Meta-predicate with arguments: `cost(goal,?,?)`.

Usage: `cost(A,T,What)`

- *Description:* This pred is thought for measuring constant complexity predicates. `T` is the expected measured feature. `What` is reserved for future implementations, just put 'runtime'
- *Call and exit should be compatible with:*

  `A` is a term which represents a goal, i.e., an atom or a structure. (basic_props:callable/1)

  `T` is an integer. (basic_props:int/1)

  `What` is any term. (basic_props:term/1)

generate_plot/3: (UNDOC_REEXPORT)
Imported from `gnuplot` (see the corresponding documentation for details).

generate_plot/2: (UNDOC_REEXPORT)
Imported from `gnuplot` (see the corresponding documentation for details).

set_general_options/1: (UNDOC_REEXPORT)
Imported from `gnuplot` (see the corresponding documentation for details).

get_general_options/1: (UNDOC_REEXPORT)
Imported from `gnuplot` (see the corresponding documentation for details).

227 XDR handle library

Author(s): José Manuel Gómez Pérez.

This library offers facilities to enable users to setup preferences on the values an eventual XML document may take. XML documents are specified by XDR documents (eXternal Data Representation standard), in a way conceptually similar to that of objects and classes in object oriented programming. These facilities allow to take as input an XDR Schema defining the class of documents of interest, and establish a dialogue with the user via an HTML form that allows the user to setup preferences to select sub-classes of documents (those which satisfy the preferences). The preferences are the output of the process and may be in the form of XPath expressions, for example, as can be seen in the example attached in the "examples" directory.

227.1 Usage and interface (xdr_handle)

- **Library usage:**
  `:- use_module(library(xdr_handle)).`
- **Exports:**
  - *Predicates:*
    `xdr_tree/3`, `xdr_tree/1`, `xdr2html/4`, `xdr2html/2`, `unfold_tree/2`, `unfold_tree_dic/3`, `xdr_xpath/2`.
  - *Regular Types:*
    `xdr_node/1`.
- **Other modules used:**
  - *System library modules:*
    `pillow/http`, `pillow/html`, `pillow/pillow_types`, `xdr_handle/xdr_types`, `aggregates`, `lists`, `terms`.

227.2 Documentation on exports (xdr_handle)

xdr_tree/3: PREDICATE

Usage: `xdr_tree(XDR_url,XDR_tree,XDR_id)`

- *Description:* Parses an XDR (External Data Representation Standard) located at an url `XDR_url` into a tree structured Prolog term `XDR_tree`. It also returns an identifier of the XDR_tree `XDR_id` corresponding to the sequence of nodes in the tree (this is intended to be a hook to use in CGI applications).
- *The following properties should hold at call time:*

`XDR_url` is currently a term which is not a free variable.	(term_typing:nonvar/1)
`XDR_tree` is a free variable.	(term_typing:var/1)
`XDR_id` is a free variable.	(term_typing:var/1)
`XDR_url` specifies a URL.	(pillow_types:url_term/1)
`XDR_tree` specifies an XDR document.	(xdr_types:xdr/1)
`XDR_id` is an integer.	(basic_props:int/1)

xdr_tree/1: PREDICATE

Usage: `xdr_tree(XDR_tree)`

- *Description:* Checks the correctness of an XDR tree `XDR_tree`.
- *The following properties should hold at call time:*

  `XDR_tree` specifies an XDR document. (xdr_types:xdr/1)

xdr_node/1: REGTYPE

Usage: `xdr_node(XDR_node)`

- *Description:* `XDR_node` is a XDR tree node.

xdr2html/4: PREDICATE

Usage: `xdr2html(XDRTree,HTMLOutput,UnfoldedTree,Dic)`

- *Description:* Receives an XDR tree `XDRTree` and produces the corresponding HTML code `HTMLOutput`, an equivalente unfolded plain tree `UnfoldedTree` and a control dictionary `Dic` to hold a reference the evenutal fom objects.
- *The following properties should hold at call time:*

  `XDRTree` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `HTMLOutput` is a free variable. (term_typing:var/1)

  `UnfoldedTree` is a free variable. (term_typing:var/1)

  `Dic` is a free variable. (term_typing:var/1)

  `XDRTree` specifies an XDR document. (xdr_types:xdr/1)

  `HTMLOutput` is a term representing HTML code. (pillow_types:html_term/1)

  `UnfoldedTree` specifies an XDR document. (xdr_types:xdr/1)

  `Dic` is a dictionary of values of the attributes of a form. It is a list of `form_assignment` (pillow_types:form_dict/1)

xdr2html/2: PREDICATE

Usage: `xdr2html(XDRTree,HTMLOutput)`

- *Description:* Receives an XDR tree `XDRTree` and produces the corresponding HTML code `HTMLOutput`. This html code is intended to be part of a form used as a means by which an eventual user can give value to an instance of the XDR, i.e. an XML element.
- *The following properties should hold at call time:*

  `XDRTree` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `HTMLOutput` is a free variable. (term_typing:var/1)

  `XDRTree` specifies an XDR document. (xdr_types:xdr/1)

  `HTMLOutput` is a term representing HTML code. (pillow_types:html_term/1)

unfold_tree/2: PREDICATE

Usage: `unfold_tree(XDRTree,UFT)`

- *Description:* Obtains an unfolded XDR tree `UFT` from a standard XDR tree `XDRTree`, i.e. an XDR tree where all references to XDR elements have been substituted with the elements themselves. Especially useful for eventual generation of equivalent XPATH expressions, (see example).
- *The following properties should hold at call time:*

  `XDRTree` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `UFT` is a free variable. (term_typing:var/1)

  `XDRTree` specifies an XDR document. (xdr_types:xdr/1)

  `UFT` specifies an XDR document. (xdr_types:xdr/1)

unfold_tree_dic/3: PREDICATE

Usage: `unfold_tree_dic(XDRTree,UFT,Dic)`

- *Description:* Obtains an unfolded XDR tree `UFT` and a form dictionary `Dic` from a standard XDR tree `XDRTree`. Especially useful for HTML form data exchange (see example).
- *The following properties should hold at call time:*

  `XDRTree` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `UFT` is a free variable. (term_typing:var/1)

  `Dic` is a free variable. (term_typing:var/1)

  `XDRTree` specifies an XDR document. (xdr_types:xdr/1)

  `UFT` specifies an XDR document. (xdr_types:xdr/1)

  `Dic` is a dictionary of values of the attributes of a form. It is a list of `form_assignment` (pillow_types:form_dict/1)

xdr_xpath/2: PREDICATE

Usage: `xdr_xpath(XDRTree,XPath)`

- *Description:* Produces an XPATH expression `XPath` from an XDR tree `XDRTree`. If the given XDR tree has no definite value the xpath expression produced will be empty
- *The following properties should hold at call time:*

  `XDRTree` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `XPath` is a free variable. (term_typing:var/1)

  `XDRTree` specifies an XDR document. (xdr_types:xdr/1)

  `XPath` is an atom. (basic_props:atm/1)

228 XML query library

Author(s): José Manuel Gómez Pérez.

This package provides a language suitable for querying XML documents from a Prolog program. Constraint programming expresions can be included in order to prune search as soon as possible, i.e. upon constraint unsatisfability, improving efficiency. Also, facilities are offered to improve search speed by transforming XML documents into Prolog programs, hence reducing search to just running the program and taking advantage of Prolog's indexing capabilities.

Queries in an XML document have a recursive tree structructure that permits to detail the search on the XML element sought, its attributes, and its children. As a suffix, a constraint programming expression can be added. Queries return value for the free variables included (in case of success), and checks whether the XML document structure matches that depicted by the query itself.

The operators introduced are described below:

- `@` Delimits a subquery on an elment's attribute, such as `product@val(product_name, "car")`, the first argument being the attribute name and the second its value. Any of them can be free variables, being possible to write queries like `product@val(Name, "car")`, intended to find the 'Name' of attributes of element product whose value is the string `"car"`.
- *::* The right-hand side of the subexpression delimited by this operator is a query on the children elements of the element described on its left-hand side.
- *with* Declares the constraints the items sought must satisfy.

Some examples of this query language (more can be found in the examples directory):

- Example A:

```
product@val(product_name,"car")::(quantity(X),
                                  'time-left'(Y),
                                  negotiation::preference::price(Z))
       with X * Z .>. Y
```

- Example B:

```
nitf::head::docdata::'doc-id'@val('id-string',"020918050")::(Y),
                     body::'body.head'::abstract::p(X)
```

228.1 Usage and interface (`xml_path_doc`)

- **Library usage:**

  `:- use_package(xml_path).`

  or

  `:- module(...,...,[xml_path]).`
- **Exports:**
  - *Predicates:*

    `xml_search/3`, `xml_parse/3`, `xml_parse_match/3`, `xml_search_match/3`, `xml_index_query/3`, `xml_index_to_file/2`, `xml_index/1`, `xml_query/3`.
- **Other modules used:**
  - *System library modules:*

    `xml_path/xml_path_types`.

228.2 Documentation on exports (xml_path_doc)

xml_search/3: PREDICATE

Usage: `xml_search(Query,Source,Doc)`

- *Description:* Checks a high level query `Query` against an XML document `Source`. If the query is successful it retuns in `Doc` the whole xml element(s) of the document that matched it.
- *The following properties should hold at call time:*

  `Query` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Source` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Doc` is a free variable. (term_typing:var/1)

  `Query` is a primitive XML query. (xml_path_types:canonic_xml_query/1)

  `Source` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

  `Doc` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

xml_parse/3: PREDICATE

Usage: `xml_parse(Query,Source,Doc)`

- *Description:* Checks a high level query `Query` against an XML document `Source`. If the query is successful it retuns in `Doc` the whole xml element(s) of the document that matched it. On the contrary as `xml_search/3`, the query can start at any level of the XML document, not necessarily at the root node.
- *The following properties should hold at call time:*

  `Query` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Source` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Doc` is a free variable. (term_typing:var/1)

  `Query` is a primitive XML query. (xml_path_types:canonic_xml_query/1)

  `Source` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

  `Doc` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

xml_parse_match/3: PREDICATE

Usage: `xml_parse_match(Query,Source,Match)`

- *Description:* Checks a high level query `Query` against an XML document `Source`. If the query is successful it retuns in `Doc` the exact subtree of the xml document that matched it. On the contrary as `'$xml_search_match/3`, the query can start at any level of the XML document, not necessarily at the root node.
- *The following properties should hold at call time:*

  `Query` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Source` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Match` is a free variable. (term_typing:var/1)

  `Query` is a primitive XML query. (xml_path_types:canonic_xml_query/1)

`Source` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

`Match` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

xml_search_match/3: PREDICATE

Usage: `xml_search_match(BasicQuery,SourceDoc,Match)`

– *Description:* Checks query `Query` against an XML document `Source`. If the query is successful it retuns in `Doc` the exact subtree of the xml document that matched it.

– *The following properties should hold at call time:*

`BasicQuery` is currently a term which is not a free variable. (term_typing:nonvar/1)

`SourceDoc` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Match` is a free variable. (term_typing:var/1)

`BasicQuery` is a primitive XML query. (xml_path_types:canonic_xml_query/1)

`SourceDoc` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

`Match` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

xml_index_query/3: PREDICATE

Usage: `xml_index_query(Query,Id,Match)`

– *Description:* Matches a high level query `Query` against an XML document previously transformed into a Prolog program. `Id` identifies the resulting document `Match`, which is the exact match of the query against the XML document.

– *The following properties should hold at call time:*

`Query` is currently a term which is not a free variable. (term_typing:nonvar/1)

`Id` is a free variable. (term_typing:var/1)

`Match` is a free variable. (term_typing:var/1)

`Query` is a primitive XML query. (xml_path_types:canonic_xml_query/1)

`Id` is an atom. (basic_props:atm/1)

`Match` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

xml_index_to_file/2: PREDICATE

Usage: `xml_index_to_file(SourceDoc,File)`

– *Description:* Transforms the XML document `SourceDoc` in a Prolog program which is output to file `File`.

– *The following properties should hold at call time:*

`SourceDoc` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

`File` is an atom. (basic_props:atm/1)

xml_index/1: PREDICATE

Usage: `xml_index(SourceDoc)`

- *Description:* Transforms the XML document `SourceDoc` in a Prolog program, generating the associated clauses, which are stored dynamically into the current process memory space.
- *The following properties should hold at call time:*

  `SourceDoc` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

xml_query/3: PREDICATE

Usage: `xml_query(Query,Doc,Match)`

- *Description:* Checks that XML document `Doc` is compliant with respect to the query `Query` expressed in the low level query language. The exact mapping of the query over the document is returned in `Match`
- *The following properties should hold at call time:*

  `Query` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Doc` is currently a term which is not a free variable. (term_typing:nonvar/1)

  `Match` is a free variable. (term_typing:var/1)

  `Query` is a primitive XML query. (xml_path_types:canonic_xml_query/1)

  `Doc` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

  `Match` is either a XML attribute, a XML element or a line break. (xml_path_types:canonic_xml_item/1)

228.3 Documentation on internals (`xml_path_doc`)

canonic_xml_term/1: REGTYPE

Usage: `canonic_xml_term(XMLTerm)`

- *Description:* `XMLTerm` is a term representing XML code in canonical form.

canonic_xml_item/1: REGTYPE

Usage: `canonic_xml_item(XMLItem)`

- *Description:* `XMLItem` is either a XML attribute, a XML element or a line break.

tag_attrib/1: REGTYPE

Usage: `tag_attrib(Att)`

- *Description:* `Att` is a XML attribute.

canonic_xml_query/1: REGTYPE

Usage: `canonic_xml_query(Query)`

- *Description:* `Query` is a primitive XML query.

canonic_xml_subquery/1: REGTYPE

Usage: `canonic_xml_subquery(SQuery)`

– *Description:* `SQuery` defines a XML subquery.

PART XII - Appendices

Author(s): The CLIP Group.

These appendices describe the installation of the Ciao environment on different systems and some other issues such as reporting bugs, signing up on the Ciao user's mailing list, downloading new versions, limitations, etc.

229 Installing Ciao from the source distribution

Author(s): Manuel Carro, Daniel Cabeza, Manuel Hermenegildo.

This describes the installation procedure for the Ciao system, including libraries and manuals, from a *source* distribution. This applies primarily to Unix-type systems (Linux, Mac OS X, Solaris, SunOS, etc.). However, the sources can also be compiled if so desired on Windows systems – see Section 229.6 [Installation and compilation under Windows], page 1105 for details.

If you find any problems during installation, please refer to Section 229.8 [Troubleshooting (nasty messages and nifty workarounds)], page 1106. See also Section 231.3 [Downloading new versions], page 1113 and Section 231.4 [Reporting bugs], page 1114.

229.1 Un*x installation summary

Note: It is recommended that you read the full installation instructions (specially if the installation will be shared by different architectures). However, in many cases it suffices to follow this summary:

1. Uncompress and unpackage (using `gunzip` and `tar -xpf`) the distribution. This will put everything in a new directory whose name reflects the Ciao version.
2. Type `./ciaosetup configure`. This will autodetect and configure the system for your specific platform. If you need more control about what configure does, just add the option `--help` to see more arguments.

   The option `--menu` show a menu with configurable options. You must follow the instructions that appears on it.

   Note that the GNU implementation of the make Un*x command is used internally in some specific parts. It is available in many systems (including all Linux systems and Mac OS X) simply as `make`. If this or next steps stop right away with `make` error messages it is probably an older version and you need to install `gmake`.
3. Type `./ciaosetup build`. This will build executables and compile libraries.
4. Type `./ciaosetup install`. This will install everything in the specified directories.
5. The system will do the right modifications in your startup scripts. This will make the documentation accessible, set the correct mode when opening Ciao source files in `emacs`, etc. The modified files are tagged with the names \'DOTBASHRC\', \'DOTCSHRC\' and \'DOTEMACS\', which are the startup files for bash, csh and emacs respectively.

   The following modifications are done automatically in your startup scripts, and you don't need to do it manually. This will make the documentation accessible, set the correct mode when opening Ciao source files in `emacs`, etc. Note that `<v>libroot</v>` must be replaced with the appropriate value:

   - For users a *csh-compatible shell* (`csh`, `tcsh`, ...), add to `~/.cshrc`:

     ```
     if ( -e <v>libroot</v>/ciao/DOTcshrc ) then
        source <v>libroot</v>/ciao/DOTcshrc
     endif
     ```

     Note: while this is recognized by the terminal shell, and therefore by the text-mode Emacs which comes with Mac OS X, the Aqua native Emacs 21 does not recognize that initialization. It is thus necessary, at this moment, to set manually the Ciao shell (ciaosh) and Ciao library location by hand. This can be done from the Ciao menu within Emacs after a Ciao file has been loaded. We believe that the reason is that Mac OS X does not actually consult the per-user initialization files on startup. It should also be possible to put the right initializations in the .emacs file using the `setenv` function of Emacs-lisp, as in

```
(setenv "CIAOLIB" "<v>libroot</v>/ciao")
```

The same can be done for the rest of the variables initialized in `<v>libroot</v>/ciao/DOTcshrc`

- For users of an *sh-compatible shell* (`sh`, `bash`, ...), the installer will add to `~/.bashrc` the next lines:

```
if [ -f <v>libroot</v>/ciao/DOTprofile ]; then
   . <v>libroot</v>/ciao/DOTprofile
fi
```

  This will set up things so that the Ciao executables are found and you can access the Ciao system manuals using the `info` command. Note that, depending on your shell, *you may have to log out and back in* for the changes to take effect.

- Also, if you use `emacs` (highly recommended) the install will add the next line to your `~/.emacs` file:

```
(load-file "<v>libroot</v>/ciao/ciao-mode-init.el")
(if (file-exists-p "<v>libroot</v>/ciao/ciao-mode-init.el")
  (load-file "<v>libroot</v>/ciao/ciao-mode-init.el")
)
```

If you are installing Ciao globally in a multi-user machine, make sure that you instruct all users to do the same. If you are the system administrator, the previous steps can be done once and for all, and globally for all users by including the lines above in the central startup scripts (e.g., in Linux `/etc/bashrc`, `/etc/csh.login`, `/etc/csh.cshrc`, `/etc/skel`, `/usr/share/emacs/.../lisp/site-init.pl`, etc.).

6. Finally, if the (freely available) `emacs` editor/environment is not installed in your system, we *highly recommend* that you also install it at this point (see Section 229.2 [Un*x full installation instructions], page 1100 for instructions). While it is easy to use Ciao with any editor of your choice, the Ciao distribution includes a very powerful *application development environment* which is based on `emacs` and which enables, e.g., source-level debugging, syntax coloring, context-sensitive on-line help, etc.
7. You may want now want to check your installation (see Section 229.3 [Checking for correct installation on Un*x], page 1103) and read the documentation, which is stored in `DOCDIR` (copied from `CIAOSRC/doc/reference`) and can be easily accessed as explained in that same section. There are special "getting started" sections at the beginning of the manual.
8. If you have any problems you may want to check the rest of the instructions. The system can be *uninstalled* by typing `./ciaosetup uninstall`.

229.2 Un*x full installation instructions

1. **Uncompress and unpackage:** (using `gunzip` and `tar -xpf`) the distribution in a suitable directory. This will create a new directory called `ciao-X.Y`, where `X.Y` is the version number of the distribution. The `-p` option in the `tar` command ensures that the relative dates of the files in the package are preserved, which is needed for correct operation of the Makefiles.
2. **Select installation options:** Run the `./ciaosetup configure` command and answer the questions that appears in the menu. The meaning of some important options in the menu is as follows:

   %

   - `CIAOSRC`: directory where the sources are % stored.
   - `BINROOT`: directory where the Ciao executables will go. For example, if `BINROOT=/usr/local/bin`, then the Ciao compiler (`ciaoc`) will be stored at

/usr/local/bin/ciaoc. Actually, it will be a link to ciaoc-*VersionNumber*. This applies also to other executables below and is done so that several versions of Ciao can coexist on the same machine. Note that the *version installed latest* will be the one started by default when typing ciao, ciaoc, etc.

- LIBROOT: directory where the run-time libraries will be installed. The Ciao installation procedure will create a new subdirectory ciao below LIBROOT and a subdirectory below this one for each Ciao version installed. For example, if LIBROOT=/usr/local/lib and you have Ciao version x.y, then the libraries will be installed under /usr/local/lib/ciao/ciao-x.y. This allows you to install site-specific programs under /usr/local/lib/ciao and they will not be overwritten if a new version of Ciao is installed. It also again allows having several Ciao versions installed simultaneously.
- DOCDIR: directory where the manuals will be installed. It is often convenient if this directory is accessible via WWW (DOCDIR=/home/httpd/html/ciao, or something like that).

For network-based installations, it is of *utmost importance* that the configured paths be reachable in all the networked machines. Different machines with different architectures can share the same physical source directory during installation, since compilations for different architectures take place in dedicated subdirectories. Also, different machines/architectures can share the same LIBROOT directory (LIBROOT is configured in the menu). This saves space since the architecture-independent libraries will be shared. See Section 229.5 [Multiarchitecture support], page 1104 below.

3. **Compile Ciao:** At the ciao top level directory type ./ciaosetup build.

   This will:

   - Build an engine in $(CIAOSRC)/bin/$(CIAOARCH), where $(CIAOARCH) depends on the architecture. The engine is the actual interpreter of the low level code into which Ciao programs are compiled.
   - Build a new Ciao standalone compiler (ciaoc), with the default paths set for your local configuration (nonetheless, these can be overridden by environment variables, as described below).
   - Precompile all the libraries under $(CIAOSRC)/lib and $(CIAOSRC)/library using this compiler.
   - Compile a toplevel Ciao shell and a shell for Ciao scripts, under the $(CIAOSRC)/shell directory.
   - Compile some small, auxiliary applications (contained in the etc directory, and documented in the part of the manual on 'Miscellaneous Standalone Utilities').

   This step can be repeated successively for several architectures in the same source directory. Only the engine and some small parts of the libraries (those written in C) differ from one architecture to the other. Standard Ciao code compiles into bytecode object files (.po) and/or executables which are portable among machines of different architecture, provided there is an executable engine accessible in every such machine. See more details below under Section 229.5 [Multiarchitecture support], page 1104.

4. **Check compilation:** If the above steps have been satisfactorily finished, the compiler has compiled itself and all the distribution modules, and very probably everything is fine.
5. **Install Ciao:** To install Ciao in the directories selected in the configuration script during step 2 above, type ./ciaosetup justinstall. This will:

   - Install the executables of the Ciao program development tools (i.e., the general driver/top-level ciao, the standalone compiler ciaoc, the script interpreter ciao-shell, miscellaneous utilities, etc.) in BINROOT (see below). In order to use these tools, the PATH environment variable of users needs to contain the path BINROOT.

- Install the Ciao libraries under `LIBROOT/ciao` (these will be automatically found).
- Install under `DOCDIR` the Ciao manuals in several formats (such as GNU `info`, `html`, `postscript`, etc.), depending on the distribution. In order for these manuals to be found when typing `M-x info` within `emacs`, or by the standalone `info` and `man` commands, the `MANPATH` and `INFOPATH` environment variables of users both need to contain the path `DOCDIR`.
- Install under `LIBROOT/ciao` the Ciao GNU `emacs` interface (`ciao.el`, which provides an interactive interface to the Ciao program development tools, as well as some other auxiliary files) and a file `ciao-mode-init` containing the `emacs` initialization commands which are needed in order to use the Ciao `emacs` interface.

6. **Set up user environments:** In order to automate the process of setting the variables above, the installation process leaves the files `LIBROOT/ciao/DOTcshrc` (for `csh`-like shells), `LIBROOT/ciao/DOTprofile` (for `sh`-like shells), and `LIBROOT/ciao/ciao-mode-init` (for emacs) with appropriate definitions which will take care of all needed environment variable definitions and emacs mode setup. If you has indicated in the menu that the startup files must be modified, then the install process will do it for you, otherwise you can modify by hand these files making the following modifications in your startup scripts, so that these files are used (`<v>libroot</v>` must be replaced with the appropriate value):
   - For users a *csh-compatible shell* (`csh`, `tcsh`, ...), add to `~/.cshrc`:

     ```
     if ( -e <v>libroot</v>/ciao/DOTcshrc ) then
        source <v>libroot</v>/ciao/DOTcshrc
     endif
     ```

     Note: while this is recognized by the terminal shell, and therefore by the text-mode Emacs which comes with Mac OS X, the Aqua native Emacs 21 does not recognize that initialization. It is thus necessary, at this moment, to set manually the Ciao shell (ciaosh) and Ciao library location by hand. This can be done from the Ciao menu within Emacs after a Ciao file has been loaded. We believe that the reason is that Mac OS X does not actually consult the per-user initialization files on startup. It should also be possible to put the right initializations in the .emacs file using the `setenv` function of Emacs-lisp, as in

     ```
     (setenv "CIAOLIB" "<v>libroot</v>/ciao")
     ```

     The same can be done for the rest of the variables initialized in `<v>libroot</v>/ciao/DOTcshrc`
   - For users of an *sh-compatible shell* (`sh`, `bash`, ...), the installer will add to `~/.bashrc` the next lines:

     ```
     if [ -f <v>libroot</v>/ciao/DOTprofile ]; then
        . <v>libroot</v>/ciao/DOTprofile
     fi
     ```

     This will set up things so that the Ciao executables are found and you can access the Ciao system manuals using the `info` command. Note that, depending on your shell, *you may have to log out and back in* for the changes to take effect.
   - Also, if you use `emacs` (highly recommended) the install will add the next line to your `~/.emacs` file:

     ```
     (load-file "<v>libroot</v>/ciao/ciao-mode-init.el")
     (if (file-exists-p "<v>libroot</v>/ciao/ciao-mode-init.el")
       (load-file "<v>libroot</v>/ciao/ciao-mode-init.el")
     )
     ```

   If you are installing Ciao globally in a multi-user machine, make sure that you instruct all users to do the same. If you are the system administrator, the previous steps can be done once and for all, and globally for all users by including the lines above in the

central startup scripts (e.g., in Linux `/etc/bashrc`, `/etc/csh.login`, `/etc/csh.cshrc`, `/etc/skel`, `/usr/share/emacs/.../lisp/site-init.pl`, etc.).

7. **Download and install Emacs (highly recommended):** If the (freely available) `emacs` editor is not installed in your system, its installation is *highly recommended* (if you are installing in a multi-user machine, you may want to do it in a general area so that it is available for other users, even if you do not use it yourself). While it is easy to use Ciao with any editor of your choice, the Ciao distribution includes a very powerful *application development environment* which is based on `emacs` and which enables, e.g., source-level debugging, syntax coloring, context-sensitive on-line help, etc.

   The emacs editor (in all its versions: Un*x, Windows, etc.) can be downloaded from, for example, `http://www.emacs.org/`, and also from the many GNU mirror sites worldwide (See `http://www.gnu.org/` for a list), in the `gnu/emacs` and `gnu/windows/emacs` directories. You can find answers to frequently asked questions (FAQ) about `emacs` in general at `http://www.gnu.org/software/emacs/emacs-faq.text` and about the Windows version at `http://www.gnu.org/software/emacs/windows/ntemacs.html` (despite the `ntemacs` name it runs fine also as is on Win9X and Win2000 machines).
8. **Check installation / read documentation:** You may now want to check your installation (see Section 229.3 [Checking for correct installation on Un*x], page 1103) and read the documentation, which is stored in `DOCDIR` (copied from `CIAOSRC/doc/reference`) and can be easily accessed as explained that same section. There are special "getting started" sections at the beginning of the manual.

If you have any problems you may want to check Section 229.8 [Troubleshooting (nasty messages and nifty workarounds)], page 1106.

The system can be *uninstalled* by typing `./ciaosetup uninstall` in the top directory. Configuration should have not changed since installation, so that the same directories are cleaned (i.e. the variables in `SETTINGS` should have the same value as when the install was performed).

229.3 Checking for correct installation on Un*x

If everything has gone well, several applications and tools should be available to a normal user. Try the following while logged in as a *normal user* (important in order to check that permissions are set up correctly):

- Typing `ciao` (or `ciaosh`) should start the typical Prolog-style top-level shell.
- In the top-level shell, Ciao library modules should load correctly. Type for example `use_module(library(dec10_io))` –you should get back a prompt with no errors reported.
- To exit the top level shell, type `halt.` as usual, or ⟨^D⟩.
- Typing `ciaoc` should produce the help message from the Ciao standalone compiler.
- Typing `ciao-shell` should produce a message saying that no code was found. This is a Ciao application which can be used to write scripts written in Ciao, i.e., files which do not need any explicit compilation to be run.

Also, the following documentation-related actions should work:

- If the `info` program is installed, typing `info` should produce a list of manuals which *should include Ciao manual(s) in a separate area* (you may need to log out and back in so that your shell variables are reinitialized for this to work).
- Opening with a WWW browser (e.g., `netscape`) the directory or `URL` corresponding to the `DOCDIR` setting should show a series of Ciao-related manuals. Note that *style sheets* should be activated for correct formatting of the manual.
- Typing `man ciao` should produce a man page with some very basic general information on Ciao (and pointing to the on-line manuals).

- The `DOCDIR` directory should contain the manual also in the other formats such as `postscript` or `pdf` which specially useful for printing. See Section 2.3.7 [Printing manuals (Un*x)], page 24 for instructions.

Finally, if `emacs` is installed, after starting it (typing `emacs`) the following should work:

- Typing ⟨^H⟩ ⟨i⟩ (or in the menus `Help->Manuals->Browse Manuals with Info`) should open a list of manuals in info format in which the Ciao manual(s) should appear.
- When opening a Ciao file, i.e., a file with `.pl` or `.pls` ending, using ⟨^X⟩⟨^F⟩`filename` (or using the menus) the code should appear highlighted according to syntax (e.g., comments in red), and `Ciao/Prolog` menus should appear in the menu bar on top of the `emacs` window.
- Loading the file using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨l⟩) should start in another emacs buffer the Ciao toplevel shell and load the file. You should now be able to switch the the toplevel shell and make queries from within `emacs`.

Note: when using `emacs` it is *very convenient* to swap the locations of the (normally not very useful) ⟨Caps Lock⟩ key and the (very useful in `emacs`) ⟨Ctrl⟩ key on the keyboard. How to do this is explained in the `emacs` frequently asked questions FAQs (see the `emacs` download instructions for their location).

229.4 Cleaning up the source directory

After installation, the source directory can be cleaned up in several ways:

- `./ciaosetup uninstall` removes the installation but does not touch the source directories.
- `./ciaosetup totalclean` leaves the distribution is its original form, throwing away any intermediate files (as well as any unneeded files left behind by the Ciao developers), while still allowing recompilation.

229.5 Multiarchitecture support

As mentioned before, Ciao applications (including the compiler and the top level) can run on several machines with different architectures without any need for recompiling, provided there is one Ciao engine (compiled for the corresponding architecture) accessible in each machine. Also, the Ciao libraries (installed in `LIBROOT`, which contain also the engines) and the actual binaries (installed in `BINROOT`) can themselves be shared on several machines with different architectures, saving disk space.

For example, assume that the compiler is installed as:

`/usr/local/share/bin/ciaoc`

and the libraries are installed under

`/usr/local/share/lib`

Assume also that the `/usr/local/share` directory is mounted on, say, a number of Linux and a number of Solaris boxes. In order for `ciaoc` to run correctly on both types of machines, the following is needed:

1. Make sure you that have done `./ciaosetup install` on one machine of each architecture (once for Linux and once for Solaris in our example). This recompiles and installs a new engine and any architecture-dependent parts of the libraries for each architecture. The engines will have names such as `ciaoengine.LINUXi86`, `ciaoengine.SolarisSparc`, and so on.
2. In multi-architecture environments it is even more important to make sure that users make the modifications to their startup scripts using `<v>libroot</v>/ciao/DOTcshrc` etc. The selection of the engine (and architecture-dependent parts of libraries) is done in these scripts by setting the environment variable `CIAOARCH`, using the `ciao_get_arch` command, which

is installed automatically when installing Ciao. This will set `CIAOARCH` to, say, `LINUXi86`, `SolarisSparc`, respectively, and `CIAOENGINE` will be set to `ciaoengine.`*CIAOARCH*.

However, note that this is not strictly necessary if running on only one architecture: if `CIAOARCH` is not set (i.e., undefined), the Ciao executables will look simply for `ciaoengine`, which is always a link to the latest engine installed in the libraries. But including the initialization files provided has the advantage of setting also paths for the manuals, etc.

229.6 Installation and compilation under Windows

There are two possibilities in order to install Ciao on Windows machines:

- Installing from the Windows *precompiled* distribution. This is the easiest since it requires no compilation and is highly recommended. This is described in Chapter 230 [Installing Ciao from a Win32 binary distribution], page 1109.
- Installing the standard Ciao (Un*x) system source distribution and compiling it under Windows. This is somewhat more complex and currently requires the (freely available) Cygnus Win32 development libraries –described below.

In order to compile Ciao for Win32 environments you need to have the (public domain) *Cygnus Win32* and development libraries installed in your system. Compilation should be performed preferably under Windows NT-type systems.

- Thus, the first step, if Cygnus Win32 is not installed in your system, is to download it (from, e.g., `http://www.cygnus.com/misc/gnu-win32`) and install it. The compilation process also requires that the executables `rm.exe`, `sh.exe`, and `uname.exe` from the Cygnus distribution be copied under `/bin` prior to starting the process (if these executables are not available under `/bin` the compilation process will produce a number of errors and eventually stop prematurely).
- Assuming all of the above is installed, type `./ciaosetup allwin32`. This will compile both the engine and the Ciao libraries. In this process, system libraries that are normally linked dynamically under Un*x (i.e., those for which `.so` dynamically loadable files are generated) are linked statically into the engine (this is done instead of generating `.dll`s because of a limitation in the current version of the Cygnus Win32 environment). No actual installation is made at this point, i.e., this process leaves things in a similar state as if you had just downloaded and uncompressed the precompiled distribution. Thus, in order to complete the installation you should now:
- Follow now the instructions in Chapter 230 [Installing Ciao from a Win32 binary distribution], page 1109.

A further note regarding the executables generated by the Ciao compiler and top-level: the same considerations given in Chapter 230 [Installing Ciao from a Win32 binary distribution], page 1109 apply regarding `.bat` files, etc. However, in a system in which Cygnus Win32 is installed these executables can also be used in a very simple way. In fact, the executables can be run as in Un*x by simply typing their name at the `bash` shell command line without any associated `.bat` files. This only requires that the `bash` shell which comes with Cygnus Win32 be installed and accessible: simply, make sure that `/bin/sh.exe` exists.

229.7 Porting to currently unsupported operating systems

If you would like to port Ciao to a currently unsupported platform, there are several issues to take into account. The main one is to get the *engine* to compile in that platform, i.e., the C code under the `engine` directory. The procedure currently followed by Ciao to decide the various flags needed to compile is as follows:

- The shell script `$(CIAOSRC)/etc/ciao_get_arch` is executed; it returns a string describing the operating system and the processor architecture (e.g., LINUXi86, SolarisSparc, SolarisAlpha, etc.). You should make sure it returns a correct (and meaningful) string for your setup. This string is used trhoughout the compilation to create several architecture-dependant flags.
- In the directory `$(CIAOSRC)/makefile-sysdep` there are files called mkf-<OS><ARCH> for every combination of operating system and architecture in which Ciao is know to (and how to) compile. They set several flags regarding, for example, whether to use or not threads, which threads library to use, the optimization flags to use, the compiler, linker, and it also sets separately the architecture name (ARCHNAME variable) and the operating system (OSNAME). You should create a new mkf file for your machine, starting from the one which is closest to you.
- Most times the porting problems happen in the use of locks and threads. You can either disable them, or have a look at the files `$(CIAOSRC)/engine/locks.h` and `$(CIAOSRC)/engine/threads.h`. If you know how to implement native (assembler) locks for your architecture, enable HAVE_NATIVE_SLOCKS for your architecture and add the definitions. Otherwise, if you have library-based locks, enable them. The mechanism in `threads.h` is similar.

Once a working engine is achieved, it should be possible to continue with the standard installation procedure, which will try to use a completely static version of the standalone compiler (`ciaoc.sta` in the `ciaoc` directory) to compile the interactive top-level (`ciaosh`) and a new version of the standalone compiler (`ciaoc`). These in turn should be able to compile the Ciao libraries. You may also need to look at some libraries (such as, for example, `sockets`) which contain C code. If you do succeed in porting to a platform that is currently unsupported please send the `mkf-CIAOARCH` and any patches to `ciao@clip.dia.fi.upm.es`, and we will include them (with due credit, of course) in the next distribution.

229.8 Troubleshooting (nasty messages and nifty workarounds)

The following a list of common installation problems reported by users:

- **Problem:** Compilation errors appear when trying a new installation/compilation after the previous one was aborted (e.g., because of errors).

  Possible reason and solution: It is a good idea to clean up any leftovers from the previous compilation using `./ciaosetup engclean` before restarting the installation or compilation process.
- **Problem:**

  During engine compilation, messages such as the following appear: `tasks.c:102:PTHREAD_CANCEL_ASYNCHRONOUS undeclared (first use of this function)`.

  Possible reason and solution:

  Your (Linux?) system does not have (yet) the Posix threads library installed. You can upgrade to one which does have it, or download the library from

  `http://pauillac.inria.fr/~xleroy/linuxthreads/index.html`

  and install it, or disable the use of threads in Linux: for this, edit the `SETTINGS` file and specify `USE_THREADS=no`, which will avoid linking against thread libraries (it will disable the use of thread-related primitives as well). Clean the engine with `./ciaosetup engclean` and restart compilation.

  If you have any alternative threads library available, you can tinker with `engine/threads.h` and the files under `makefile-sysdep` in order to get the task managing macros right for your system. Be sure to link the right library. If you succeed, we (`ciao@clip.dia.fi.upm.es`) will be happy of knowing about what you have done.

- **Problem:**

  `-lpthread: library not found` (or similar)

  Possible reason and solution:

  Your (Linux?) system seems to have Posix threads installed, but there is no threads library in the system. In newer releases (e.g., RedHat 5.0), the Posix threads system calls have been included in `glibc.so`, so specifying `-lpthread` in `makefile-sysdep/mkf-LINUX` is not needed; remove it. `./ciaosetup engclean` and restart installation.

  Alternatively, you may have made a custom installation of Posix threads in a non-standard location: be sure to include the flag `-L/this/is/where/the/posix/libraries/are` **before** `-lpthread`, and to update `/etc/ld.so.conf` (see `man ldconfig`).

- **Problem:**

  `Segmentation Violation` (when starting the first executable)

  Possible reason and solution:

  This has been observed with certain older versions of `gcc` which generated erroneous code under full optimization. The best solution is to upgrade to a newer version of `gcc`. Alternatively, lowering the level of optimization (by editing the `SETTINGS` file in the main directory of the distribution) normally solves the problem, at the cost of reduced execution speed.

- **Problem:** `ciaoc: /home/clip/lib/ciao/ciao-X.Y/engine/ciaoengine: not found`

  Possible reason and solution:

  - The system was not fully installed and the variable `CIAOENGINE` was not set.
  - The system was installed, the variable `CIAOENGINE` is set, but it is does not point to a valid ciaoengine.

  See the file `LIBROOT/ciao/DOTcshrc` for user settings for environment variables.

- **Problem:**

  `ERROR: File library(compiler) not found - aborting...` (or any other library is not found)

  Possible reason and solution:

  - The system was not installed and the variable `CIAOLIB` was not set.
  - The system is installed and the variable `CIAOLIB` is wrong.

  See the file `LIBROOT/ciao/DOTcshrc` for user settings for environment variables.

- **Problem:**

  `ERROR: File <some_directory>/<some_file>.itf not found - aborting...`

  Possible reason and solution:

  Can appear when compiling `.pl` files. The file to compile (<some_file>.pl) is not in the directory <some_directory>. You gave a wrong file name or you are in the wrong directory.

- **Problem:**

  `*ERROR*: /(write_option,1) is not a regular type` (and similar ones)

  Possible reason and solution:

  This is not a problem, but rather the type checker catching some minor inconsistencies which may appear while compiling the libraries. Bug us to remove it, but ignore it for now.

- **Problem:**

  `WARNING: Predicate <some_predicate>/<N> undefined in module <some_module>`

  Possible reason and solution:

  It can appear when the compiler is compiling Ciao library modules. If so, ignore it (we will fix it). If it appears when compiling user programs or modules, you may want to check your program for those undefined predicates.

- **Problem:**

  `gmake[1]: execve: /home/clip/mcarro/ciao-0.7p2/etc/collect_modules: No such file or directory`

  Possible reason and solution:

  Check if collect_modules is in $(CIAOSRC)/etc and is executable. If it is not here, your distribution is incorrect: please let us know.

- **Problem:**

  `make: Fatal error in reader: SHARED, line 12: Unexpected end of line seen`

  Possible reason and solution:

  You are using standard Un*x make, not GNU's make implementation (gmake).

- **Problem:**

  `WARNING`s or `ERROR`s while compiling the Ciao libraries during installation.

  Possible reason and solution:

  It is possible that you will see some such errors while compiling the Ciao libraries during installation. This is specially the case if you are installing a Beta or Alpha release of Ciao. These releases (which have "odd" version numbers such as 1.5 or 2.1) are typically snapshots of the development directories, on which many developers are working simultaneously, which may include libraries which have typically not been tested yet as much as the "official" distributions (those with "even" version numbers such as 1.6 or 2.8). Thus, minor warnings may not have been eliminated yet or even errors can sneak in. These warnings and errors should not affect the overall operation of the system (e.g., if you do not use the affected library).

230 Installing Ciao from a Win32 binary distribution

Author(s): Daniel Cabeza, Manuel Carro, Manuel Hermenegildo.

This describes the installation of Ciao after downloading the Windows *binary* (i.e., *precompiled*) distribution. It includes the installation of libraries and manuals and applies to Windows 95/98/NT/2000/XP systems. This is the simplest Windows installation, since it requires no compilation and is highly recommended. However, it is also possible to compile Ciao from the source distribution on these systems (please refer to Chapter 229 [Installing Ciao from the source distribution], page 1099 for details).

If you find any problems during installation, please refer to Section 229.8 [Troubleshooting (nasty messages and nifty workarounds)], page 1106. See also Section 231.3 [Downloading new versions], page 1113 and Section 231.4 [Reporting bugs], page 1114.

230.1 Win32 binary installation summary

Please follow these steps (below we use the terms *folder* and *directory* interchangeably):

1. Download the precompiled distribution and unpack it into any suitable folder, such as, e.g., `C:\Program Files`.

   This will create there a folder whose name reflects the Ciao version. Due to limitations of Windows related to file associations, do not put Ciao too deep in the folder hierarchy. For unpacking you will need a recent version of a zip archive manager – there are many freely available such as `WinZip`, `unzip`, `pkunzip`, etc. (see for example `www.winzip.com`). Some users have reported some problems with version 6.2 of WinZip, but no problems with, e.g., version 7. With WinZip, simply click on "Extract" and select the extraction folder as indicated above.
2. Stop any Ciao-related applications.

   If you have a previous version of Ciao installed, make sure you do not have any Ciao applications (including, e.g., a toplevel shell) running, or the extraction process may not be able to complete. You may also want to delete the entire folder of the previous installation to save space.
3. Open the Ciao source directory created during extraction and run (e.g. by double-clicking on it) the `install(.bat)` script. Answer "yes" to the dialog that pops up and type any character in the installation window to finish the process. You may need to reboot for the changes in the registry to take effect.

   This will update the windows registry (the file `ciao(.reg)` lists the additions) and also create some `.bat` files which may be useful for running Ciao executables from the command line. It also creates initialization scripts for the `emacs` editor. The actions performed by the installation script are reported in the installation window.
4. You may want to add a *windows shortcut* in a convenient place, such as the desktop, to `ciaosh.cpx`, the standard interactive toplevel shell. It is located inside the `shell` folder (e.g., click on the file `ciaosh.cpx` with the right mouse button and select the appropriate option, `Send to->Desktop as shortcut`).
5. You may also want to add another shortcut to the file `ciao(.html)` located inside `doc\reference\ciao_html` so that you can open the Ciao manual by simply double-clicking on this shortcut.
6. Finally, if the (freely available) `emacs` editor/environment is not installed in your system, we *highly recommend* that you also install it at this point. While it is easy to use Ciao with any editor of your choice, the Ciao distribution includes a very powerful *application development environment* which is based on `emacs` and which enables, e.g., source-level debugging, syntax coloring, context-sensitive on-line help, etc. If you are not convinced, consider that many programmers inside Micros*ft use `emacs` for developing their programs.

The emacs editor (in all its versions: Un*x, Windows, etc.) can be downloaded from, for example, `http://www.emacs.org/`, and also from the many GNU mirror sites worldwide (See `http://www.gnu.org/` for a list), in the `gnu/emacs` and `gnu/windows/emacs` directories. You can find answers to frequently asked questions (FAQ) about `emacs` in general at `http://www.gnu.org/software/emacs/emacs-faq.text` and about the Windows version at `http://www.gnu.org/software/emacs/windows/ntemacs.html` (despite the `ntemacs` name it runs fine also as is on Win9X and Win2000 machines).

You need to tell `emacs` how to load the Ciao mode automatically when editing and how to access the on-line documentation:

- Start `emacs` (double click on the icon or from the `Start` menu). Open (menu `Files->Open File` or simply ⟨^X⟩⟨^F⟩) the file `ForEmacs.txt` that the installation script has created in directory where you installed the Ciao distribution.
- Copy the lines in the file (select with the mouse and then menu `Edit->Copy`). Open/Create using `emacs` (menu `Files->Open File` or simply ⟨^X⟩⟨^F⟩) the file `~/.emacs` (or, if this fails, `c:/.emacs`).
- Paste the two lines (menu `Edit->Paste` or simply ⟨^Y⟩) into the file and save (menu `Files->Save Buffer` or simply ⟨^X⟩⟨^S⟩).
- Exit `emacs` and start it again.

`emacs` should not report any errors (at least related to Ciao) on startup. At this point the `emacs` checks in the following section should work.

230.2 Checking for correct installation on Win32

After the actions and registry changes performed by the installation procedure, you should check that the following should work correctly:

- Ciao-related file types (`.pl` source files, `.cpx` executables, `.itf,.po,.asr` interface files, `.pls` scripts, etc.) should have specific icons associated with them (you can look at the files in the folders in the Ciao distribution to check).
- Double-clicking on the shortcut to `ciaosh(.cpx)` on the desktop should start the typical Prolog-style top-level shell in a window. If this shortcut has not been created on the desktop, then double-clicking on the `ciaosh(.cpx)` icon inside the `shell` folder within the Ciao source folder should have the same effect.
- In the top-level shell, Ciao library modules should load correctly. Type for example `use_module(library(dec10_io)).` at the Ciao top-level prompt –you should get back a prompt with no errors reported.
- To exit the top level shell, type `halt.` as usual, or ⟨^D⟩.

Also, the following documentation-related actions should work:

- Double-clicking on the shortcut to `ciao(.html)` which appears on the desktop should show the Ciao manual in your default WWW browser. If this shortcut has not been created you can double-click on the `ciao(.html)` file in the `doc\reference\ciao_html` folder inside the Ciao source folder. Make sure you configure your browser to use *style sheets* for correct formatting of the manual (note, however, that some older versions of Explorer did not support style sheets well and will give better results turning them off).
- The `doc\reference` folder contains the manual also in the other formats present in the distribution, such as `info` (very convenient for users of the `emacs` editor/program development system) and `postscript` or `pdf`, which are specially useful for printing. See Section 3.2.7 [Printing manuals (Win32)], page 29 for instructions.

Finally, if `emacs` is installed, after starting it (double-clicking on the `emacs` icon or from the `Start` menu) the following should work:

- Typing ⟨^H⟩ ⟨i⟩ (or in the menus `Help->Manuals->Browse Manuals with Info`) should open a list of manuals in info format in which the Ciao manual(s) should appear.
- When opening a Ciao file, i.e., a file with `.pl` or `.pls` ending, using ⟨^X⟩⟨^F⟩`filename` (or using the menus) the code should appear highlighted according to syntax (e.g., comments in red), and `Ciao/Prolog` menus should appear in the menu bar on top of the `emacs` window.
- Loading the file using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨l⟩) should start in another emacs buffer the Ciao toplevel shell and load the file. You should now be able to switch the the toplevel shell and make queries from within `emacs`.

Note: when using `emacs` it is *very convenient* to swap the locations of the (normally not very useful) ⟨Caps Lock⟩ key and the (very useful in `emacs`) ⟨Ctrl⟩ key on the keyboard. How to do this is explained in the `emacs` frequently asked questions FAQs (see the `emacs` download instructions for their location).

If you find that everything works but `emacs` cannot start the Ciao toplevel you may want to check if you can open a normal Windows shell within `emacs` (just do ⟨M-x⟩ `shell`). If you cannot, it is possible that you are using some anti-virus software which is causing problems. See `http://www.gnu.org/software/emac/windows/faq3.html#anti-virus` for a workaround.

In some Windows versions it is possible that you had to change the *first* backslashes in the ciao-mode-init.el file in the Ciao Directory. E.g., assuming you have installed in drive `c:`, instances of `c:\` need to be changed to `c:/`. For example: `c:\prolog/ciao-1.7p30Win32/shell/ciaosh.bat` should be changed to `c:/prolog/ciao-1.7p30Win32/shell/ciaosh.bat`.

230.3 Compiling the miscellaneous utilities under Windows

The `etc` folder contains a number of utilities, documented in the manual in *PART V - Miscellaneous Standalone Utilities*. In the Win32 distribution these utilities are not compiled by the installation process. You can create the executable for each of them when needed by compiling the corresponding `.pl` file.

230.4 Server installation under Windows

If you would like to install Ciao on a server machine, used by several clients, the following steps are recommended:

- Follow the standard installation procedure on the server. When selecting the folder in which Ciao is installed make sure you select a folder that is visible by the client machines. Also make sure that the functionality specified in the previous sections is now available on the server.
- Perform a *client installation* on each client, by running (e.g., double-click on it) the `client.bat` script. This should update the registry of each client. At this point all the functionality should also be available on the clients.

230.5 CGI execution under IIS

The standard installation procedure updates the windows registry so that Ciao executables (ending in `.cpx`) are directly executable as CGIs under Microsoft's IIS, i.e., so that you make applications written in Ciao available on the WWW (see the `pillow` library for specific support for this task). In the event you re-install IIS, you probably would lose the entries in the registry which allow this. In that case, processing the file `ciao.reg` produced during the installation (or simply reinstalling Ciao) will add those entries again.

230.6 Uninstallation under Windows

To uninstall Ciao under Windows, simply delete the directory in which you put the Ciao distribution. If you also want to delete the registry entries created by the Ciao installation (not strictly needed) this must currently be done by hand. The installation leaves a list of these entries in the file `ciao.reg` to aid in this task. Also, all the register entries contain the word *ciao*. Thus, to delete all Ciao entries, run the application `regedit` (for example, by selecting `Run` from the Windows `Start` menu), search (⟨⇧F⟩) for *ciao* in all registry entries (i.e., select all of `Keys`, `Values`, and `Data` in the `Edit->Find` dialog), and delete each matching key (click on the left window to find the matching key for each entry found).

%% Local Variables: %% mode: CIAO %% update-version-comments: "off" %% End:

231 Beyond installation

Author(s): Manuel Carro, Daniel Cabeza, Manuel Hermenegildo.

231.1 Architecture-specific notes and limitations

Ciao makes use of advanced characteristics of modern architectures and operating systems such as multithreading, shared memory, sockets, locks, dynamic load libraries, etc., some of which are sometimes not present in a given system and others may be implemented in very different ways across the different systems. As a result, currently not all Ciao features are available in all supported operating systems. Sometimes this is because not all the required features are present in all the OS flavors supported and sometimes because we simply have not had the time to port them yet.

The current state of matters is as follows:

LINUX: multithreading, shared DB access, and locking working.

Solaris: multithreading, shared DB access, and locking working.

IRIX: multithreading, shared DB access, and locking working.

SunOS 4: multithreading, shared DB access, and locking NOT working.

Win 95/98/NT/2000/XP:
multithreading, shared DB access, and locking working. Dynamic linking of object code (C) libraries NOT working.

Mac OS X (Darwin):
multithreading, shared DB access, and locking working.

The features that do not work are disabled at compile time.

231.2 Keeping up to date with the Ciao users mailing list

We recommend that you join the Ciao *users mailing list* (`ciao-users@clip.dia.fi.upm.es`), in order to receive information on new versions and solutions to problems. Simply send a message to `ciao-users-request@clip.dia.fi.upm.es`, containing in the body only the word:

```
subscribe
```

alone in one line. Messages in the list are strictly limited to issues directly related to Ciao and your email address will of course be kept strictly confidential. You mail also want to subscribe to the `comp.lang.prolog` newsgroup.

There is additional info available on the Ciao system, other CLIP group software, publications on the technology underlying these systems, etc. in the CLIP group's WWW site `http://clip.dia.fi.upm.es`.

231.3 Downloading new versions

Ciao and its related libraries and utilities are under constant improvement, so you should make sure that you have the latest versions of the different components, which can be dowloaded from:

```
http://clip.dia.fi.upm.es/Software
```

231.4 Reporting bugs

If you still have problems after downloading the latest version and reading the installation instructions you can send a message to `ciao-bug@clip.dia.fi.upm.es`. Please be as informative as possible in your messages, so that we can reproduce the bug.

- For *installation problems* we typically need to have the version and patch number of the Ciao package (e.g., the name of the file downloaded), the output produced by the installation process (you can capture it by redirecting the output into a file or cutting and pasting with the mouse), and the exact version of the Operating System you are using (as well as the C compiler, if you took a source distribution).
- For *problems during use* we also need the Ciao and OS versions and a small example of code which we can run to reproduce the bug.

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