BNR Prolog
Reference Manual

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BNR Prolog Reference Manual
BNR Prolog is an extended version of Prolog for the Macintosh family of computers. Users not familiar with Prolog should read one of the textbooks listed at the end of this chapter. The user guide accompanying BNR Prolog covers the standard Prolog language. However, emphasis is placed on the extensions, such as constraints and relational arithmetic not covered in standard Prolog textbooks. The user guide also provides tutorial-style material to help users get started on the BNR Prolog system.

About This Manual

The reference manual is organized to facilitate quick access to information on language features. Each chapter covers a particular topic, with the relevant predicates presented in alphabetical order within the chapter.

Chapter 2 covers the syntax of BNR Prolog.

Chapters 3 through 9 cover the essential language predicates.

Chapter 10 describes the debugging facilities.

Chapters 11 through 20 describe the predicates associated with file and window input and output, graphics, and Macintosh system specifics.

Chapter 21 covers the external language interface.

The Appendices include a list of error messages and a list of differences (including extensions) between BNR Prolog and other Prologs.
The Layout of the Predicate Descriptions

Predicates within a chapter are listed in alphabetical order for quick reference. The first entry is the format of the predicate followed by a short verbal description. The format is the calling template and consists of the name of the predicate followed by its arguments. The layout adopted for predicate descriptions is as follows:

**Arguments:** A description of the arguments (if any). Special key words are used to denote the type of the arguments. These key words generally correspond to the BNR Prolog types or to compound types constructed from those types. The instantiation state of the variable is denoted by a prefix. The convention for prefixes is as follows:

"+" means "completely instantiated" (input argument).
The term is not changed during evaluation of the goal.

"-" means "variable" (output argument).
The argument is unified with a term produced during the evaluation of a goal.

"?" means either "instantiated" or "variable".

This section is always present.

**Succeeds:** Definition of the success semantics.
This section is always present.

**Fails:** Definition of the failure semantics.
This section is always present. It includes all exceptions due to type violations.

**Errors:** Abort semantics.
This section is optional.

**Notes:** Interesting or useful bits of information including caveats.
This section is optional.

**Examples:** A query or a sample of Prolog code that demonstrates the use of the predicate. Some tips on using the examples are given in the section below titled "Using the Examples".
This section is optional.
See Also: Gives the names of other predicates which are related to the one being described. The user is also referred to other appropriate background information. This section is optional.

Using the Examples

The following should be noted when trying the examples:

- Information the user types in is presented in boldface and may take the form of a query, fact or rule.
- When entering facts or rules, remember to backspace over the question prompt (?-) before typing.
- Queries, facts and rules are terminated by a period (.).
- the ":-" symbol preceding a goal indicates a command.
- Pressing the enter key after the period "submits" the information to the system.
- Pressing the return key takes you to a new line.
- System responses are presented in plain text. These generally include answers to the queries. The system responds with the first answer. Press the return key to obtain all the remaining answers or press semicolon (;) to obtain the next answer. Press any key to terminate the question.
- Comments are delimited by /* and */. Single line comments are occasionally used. These begin with a percent sign (%) and terminate with an end of line character (that is, a return character). For example,

        /* this is a comment */

and

        % this is a single line comment.

Refer to the tutorial "Using a BNR Prolog Document" in the BNR Prolog User Guide if you need further instructions on interacting with the Prolog system.
### Typographic Conventions

The following typographical conventions are used throughout this manual:

| **Typewriter** | Examples are displayed in this typeface. It is used to display any text which appears on the screen or in a program listing. BNR Prolog built-in predicate names and their corresponding arguments also appear in this special typeface. |
| **User Input** | Input that the user types in is shown in boldface, while the output generated by the system is shown in *typewriter* as demonstrated by the following example. |
| **keycaps** | This typeface denotes a key on the Macintosh keyboard. For example, |
| **Italics** | Italics are occasionally used to emphasize words in the text, particularly the first time a word is defined. Italics are also used when making explicit references to titles of books. |

```prolog
?- concat(one, two, _X).
    ?- concat(one, two, onetwo).
    Yes
```
"Quotation marks" Quotation marks are used when making cross-references to other sections of the manual or when making cross-references to chapter titles.

Quotation marks are occasionally used to highlight words in text.

The Prolog basic type symbol can be enclosed in either double or single quotation marks. Single quotation marks rather than double quotations marks have been used throughout the text when used with symbols. For example, the following is a Prolog symbol:

'A_Symbol'.
Suggested Prolog References

Readers who are new to Prolog may find it useful to read one of the following text books:


Readers who will be using the interactive interface facilities provided by BNR Prolog will find it useful to refer to:

Chapter 2: Basic Language Elements

Syntactic Context

To permit the extended feature set of BNR Prolog to be expressed, additional syntactic forms must be provided. Rather than attempt to add these piecemeal to a traditional Prolog syntax, a uniform, canonical syntax was developed with two objectives in mind. First, maintain a one to one relationship between the canonical syntax and the internal representation. Second, use the Edinburgh syntax model whenever possible. This second objective was included to facilitate learning of the canonical syntax by those who had been exposed to Edinburgh style Prologs, and to permit relatively straight forward porting of Edinburgh Prolog programs.

The standard output routines always write Prolog expressions in canonical form. To ease the programming task, certain license is allowed on input, but conversion to the standard canonical representation is always done.

Sentences

Prolog input streams from files or windows are sequences of sentences. Sentences consist of a Prolog term followed by a period (.), and either a space or newline.

Separators

Spaces are only significant in the following cases:
- A space is used to delimit symbols.
- A space between a name and a left parenthesis "(" is significant.
Comments

*Comments* may consist of any sequence of characters delimited by "/*" and "*/". For example

```plaintext
/* This is a comment */
```

Comments may be nested

```plaintext
/* This is a /* nested */ comment */
```

or they may be on multiple lines

```plaintext
/* This is a
   multiline comment */
```

Within a single line, any text between a percent sign (%) and the end of line is a comment:

```plaintext
% This is a one line comment.
```

This type of comment may not be nested.
Terms

Terms are either basic or compound. Basic terms consist of constants and logic variables. Compound terms are collections of terms and may be classified as lists or structures. Figure 2-1 shows the types of terms in BNR Prolog.

Figure 2-1. Types of BNR Prolog terms
1O

Chapter 2: Basic Language Elements

Symbols
Symbols in BNR Prolog may be composed of any one of the following
sequences:
A sequence of alphanumerics which do not begin either with
an underscore U or an uppercase letter, and are not valid
numerics. The underscore and the dollar sign ($) are
included as alphanumerics. Some examples of symbols
composed of alphanumerics follow:
9Xl4
fred 100

A sequence of special characters from the following set:

*&

= - ~A\/ • ; :
The comment sequence /* and */ is invalid in this form.
Examples of this type of symbol are as follows:
<> + *@

<>++
-->
&

(Note that a-->b is a sequence of three symbols and is
equivalent to a --> b)
An arbitrary sequence of alphanumerics, containing at least
one character, enclosed in single(') or double quotation
marks ("). A zero length sequence is represented by either a
pair of single quotation marks (") or a pair of double
quotation marks (""). Examples of this type of symbol
include the following:
'123-45'
'Kim\'s'
"Any_name"

An escape notation is supported for handling special ASCII
characters including single and double quotation marks and for
placing hexadecimal values in strings. Table 2-1 summarizes the
escape sequences.

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Table 2-1. Escape sequences for special characters

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<th>Special Character</th>
<th>Escape Sequence</th>
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<tbody>
<tr>
<td>new line/line feed</td>
<td>\n</td>
</tr>
<tr>
<td>horizontal tab</td>
<td>\t</td>
</tr>
<tr>
<td>backspace</td>
<td>\b</td>
</tr>
<tr>
<td>carriage return</td>
<td>\r</td>
</tr>
<tr>
<td>form feed</td>
<td>\f</td>
</tr>
<tr>
<td>backslash</td>
<td>\ \</td>
</tr>
<tr>
<td>single quote</td>
<td>'</td>
</tr>
<tr>
<td>double quote</td>
<td>&quot;</td>
</tr>
<tr>
<td>hexadecimal constant</td>
<td>\hh</td>
</tr>
</tbody>
</table>

The escape sequence \hh, where h is a character in the range 0..9 or A..F allows a hexadecimal byte value to be specified.

The Macintosh extended character set is presented in tabular form in Appendix A of this manual. The following extended ASCII characters values (shown in that table) are treated as uppercase letters:

- 065 - 090
- 128 - 134
- 174, 175, 184
- 203 - 206
- 217
- 229 - 239
- 241 - 244
The following ASCII character values are treated as lowercase letters:

- 036
- 097 - 122
- 135 - 139
- 185, 190, 191, 207, 216

The remaining ASCII character values are treated as special characters:

- 035, 038
- 058 - 062
- 064, 094, 096, 126
- 160 - 164
- 166 - 173
- 176 - 183
- 186 - 189
- 192 - 202
- 208 - 215
- 218 - 228
- 240
- 245 - 255

The maximum size of a symbol is 255 characters.

Symbols are case exact. For example, the symbol fred is not the same as fred and the symbol "fred" is not the same as "Fred".

Symbols beginning with a dollar sign ($) are local to the context in which they are defined. (Contexts are discussed the chapter titled "State Space Management" in this manual.)

Although single and double quotes are used interchangeably as symbol delimiters on input, only single quotes are used on output (as required).
Integers

An integer is a contiguous sequence of digits, optionally preceded by a minus sign (-). There should be no spaces between the sign character and the first digit. Examples of integers follow:

0
12344
-66311

Integers have a range of \(-2^{28}\) to \(2^{28} - 1\).

Floating Point Numbers

Floating point numbers (also called floats) are input in the following format:

\[-] <digits>.<digits> [E [<sign>] <digits>]

Expressions appearing in square brackets are optional. The format is

- an optional minus sign character (-),
- followed by at least one digit in the range 0..9,
- followed by a decimal point,
- followed by one or more digits in the range 0..9,
- followed by an optional exponent.

The exponent, if present, is either an "E" or "e" followed by a sign character ("+" or "-"), followed by at least one digit. No spaces may occur anywhere within the floating point number.

Floating point numbers use a modified IEEE 32 bit format; the least significant 3 bits of the mantissa have been dropped providing 5 digits of precision.

Floating point numbers are output in the following exponential format:

\[-] <integer part>. <fractional part> e <exponent>

where

- the minus sign (-) is optional,
- <integer part> is in the range 1..9,
— <fractional part> is a sequence of 4 digits,
— <exponent> is in the range -128 to +127.

If -3 <= <exponent> <= 4, then non-scientific (non-exponential) notation will be used on output. Leading and trailing zeros are omitted except for those adjacent to the decimal point.

Table 2-2 gives examples of the valid input form of some floating point numbers and their corresponding output form:

Table 2-2. Floating point input and output formats

<table>
<thead>
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<th>Input Format</th>
<th>Output Format</th>
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<tr>
<td>9.12345</td>
<td>9.1234</td>
</tr>
<tr>
<td>0.00091</td>
<td>9.10004e-4</td>
</tr>
<tr>
<td>9.1234e-1</td>
<td>0.91234</td>
</tr>
</tbody>
</table>

The following are not valid floating point numbers:

.9 /* No digit before the decimal point */
9. /* No digit after the decimal point */
99e2 /* No decimal point */
-.9 /* No digit after the sign character*/

Intervals

An interval is a range of values on the real number line delimited by two 32 bit floating point numbers. They provide support for relational arithmetic. (See the chapter titled "Arithmetic" in this manual for further information on interval arithmetic.)

Intervals are printed in the form _Interval_instance where instance is an instance number, for example, _Interval_366236.
Buckets

_Buckets_ are containers for 32 bit quantities, typically pointers or handles to user defined data structures. Bucket contents only have meaning to user defined external procedures, but the containers may be unified and passed to external procedures by means of standard Prolog mechanisms. (See the chapter titled "External Language Interface" in this manual.)

Buckets are printed in the form _Bucket_hexvalue_ where hexvalue is the current value of the bucket contents, for example, 89AB.

Variables

Variable names are symbols that begin either with an underscore (_) or an uppercase letter. Variable names may be up to 255 characters long and are case sensitive. The following are examples of variables:

Fred
_X100
_John_Doe

The underscore on its own denotes an anonymous or unnamed variable. Every occurrence of an anonymous variable in a clause represents a distinct variable.

The name _$ is a reserved name and will be rejected as a syntax error.

Variables are always scoped within a single fact or rule. The use of _x in one rule is independent of the use of _x in any other rule.

Variable names are preserved by the system throughout computations and are used by the standard print routines. If distinct variables in any expression have the same name, for example in recursive calls, a suffix consisting of an underscore followed by digits is appended to the variable name to differentiate between them.
Lists

A list consists of zero or more terms (called the elements of the list) separated by commas and enclosed in square brackets. The simplest type of list is the empty list which contains zero terms. The following are examples of lists:

```
[]
[a]
[a, b]
[a, []]
```

A list is often split into the initial element and the tail (the following sequence of elements). A tail variable specifies the tail of a list and is written as a variable name immediately followed by an ellipsis (..). A tail variable must always appear as the last element of a list. Indefinite lists are expressed using tail variables:

```
[_X..]
[a, _X..]
[_A, _B, _X..]
```

Tail variables are made uniform on input; that is, if a variable, _X is used as a tail variable anywhere in an expression, then all non-tail variable uses of it are transformed to [_X..].

Note: The Edinburgh list, [_H|_T] is converted on input to [_H, _T..].
Structures

Structures have the form of a symbol or a variable name, immediately followed (that is, no intervening spaces) by a parenthesized list of terms:

\[
\begin{align*}
&\text{fred()} \\
&\text{Fred(2, [] )} \\
&\text{f(2, _X..)} \\
&\text{(_..)}
\end{align*}
\]

The symbol or variable name is called the principal functor of the structure. The terms in the list are the arguments of the structure. The number of arguments in a structure is referred to as the arity of the functor.

Note: A structure may have an unspecified number of arguments by using tail variables.

Constraints

Syntactically, constraints are represented as one or more terms separated by commas and enclosed in braces (\{}\):

\[
\{\text{integer(_X), real(_Y), _X =< _Y}\}
\]

Regarded as a data structure, a constraint is simply a structure whose functor is "\". Constraints are described in the chapters titled "Passive Constraints" and "Control" in the User Manual and in the chapter titled "Control" in this manual.)
Operators

Symbols defined as operators can be used to modify the parsing rules in order to improve the readability of programs. The name, type and precedence of an operator is defined by an assertion to the op predicate:

    op(_Precedence, _Type, _Name).

Such an assertion succeeds only if all the arguments are instantiated as described below.

Any symbol can be used as an operator name. However, the tokenization rules make it easier to use symbols composed entirely of special characters. (Refer to the earlier discussion in this chapter on special characters in the extended Macintosh character set.)

These rules ensure, for example, that p->q is parsed as the expression

    p -> q

and not as single symbol. Operator names not entirely composed of special characters must be separated from adjacent names by blanks or some other separator, such as a newline character.

The precedence determines the order in which operators are translated into operations. The precedence of an operator is defined by an integer in the range 0 to 1200. The lower the number the tighter the binding. If an expression contains two operators, the operation specified by the operator with the lower precedence value is executed first.

The type specifies the position and the associativity of the operator. The position may be either prefix, postfix or infix. A prefix operator appears before its operands, a postfix operator appears after its operands and an infix operator appears between its operands.

The associativity determines how operators of the same precedence are translated. The associativity of an operator can be left to right (like "+" or "-"), right to left (like "-">"), or nonassociative (like "+"). For example, "+" and "+" have equal precedence and associate from left to right. Thus the expression a - b + c is

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translated as \((a - b) + c\). If two operators have the same precedence and are nonassociative, then they may not appear in the same expression. For example, the expression \(a = b = c\) gives a syntax error.

The type of the operator is expressed as a symbol consisting of the characters "x", "f" and "y". "f" represents the operator and "x" and "y" represent arguments. The choice of an "x" or "y" is used to convey information about the associativity. A "y" indicates that the argument can contain operators of the same or lower precedence than the operator, and an "x" indicates that any operators in the argument must have a strictly lower precedence than the operator. Table 2-3 lists the various types and describes their significance.

**Table 2-3. Type definitions for operators**

<table>
<thead>
<tr>
<th>Type</th>
<th>Position</th>
<th>Associativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>xfx</td>
<td>infix</td>
<td>nonassociative</td>
</tr>
<tr>
<td>xfy</td>
<td>infix</td>
<td>right to left</td>
</tr>
<tr>
<td>yfx</td>
<td>infix</td>
<td>left to right</td>
</tr>
<tr>
<td>fx</td>
<td>prefix</td>
<td>nonassociative</td>
</tr>
<tr>
<td>fy</td>
<td>prefix</td>
<td>left to right</td>
</tr>
<tr>
<td>xf</td>
<td>postfix</td>
<td>nonassociative</td>
</tr>
<tr>
<td>yf</td>
<td>postfix</td>
<td>right to left</td>
</tr>
</tbody>
</table>

Operators may be redefined, but
— their precedence cannot be changed
— an operator cannot be both prefix and postfix.

In expressions containing operators, the precedence rules may be overridden by using parentheses. In the expression,

\[
_V \text{ is } (_A + _B) \ast _C
\]

the addition is done first, followed by the multiplication and finally the evaluation.
The increased importance of arithmetic in BNR Prolog has resulted in a minor adjustment in operator definitions. The Edinburgh arithmetic equivalence operator, "==:==", has been changed to "==:==", as in the C programming language. This has a small ripple effect on some of the other operators, as summarized in Table 2-4.

Table 2-4. Differences in operators in BNR Prolog and Edinburgh

<table>
<thead>
<tr>
<th>Function</th>
<th>Edinburgh Prologs</th>
<th>BNR Prolog</th>
</tr>
</thead>
<tbody>
<tr>
<td>literal identity</td>
<td>==</td>
<td>@=</td>
</tr>
<tr>
<td>literal non-identity</td>
<td>=</td>
<td>@=</td>
</tr>
<tr>
<td>arithmetic equality</td>
<td>=&gt;</td>
<td>=</td>
</tr>
</tbody>
</table>

The operators "==:==", "==\=", and "\==" are defined to be equivalent to "==", "<>", and "@\=" respectively. Therefore only Edinburgh "==:==" must be changed to "@=".

Note: One of the consequences of using the list structure for clause bodies is that the comma (,) is not an operator. Therefore, all operators, regardless of their relative precedence, bind tighter (have higher precedence) than comma.

Table 2-5 lists the predefined operators, their precedence and their type.
### Table 2-5. Predefined operators

<table>
<thead>
<tr>
<th>Precedence</th>
<th>Type</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>xfx</td>
<td>:)</td>
<td>is true if</td>
</tr>
<tr>
<td>1100</td>
<td>xfy</td>
<td>;</td>
<td>disjunction, and else</td>
</tr>
<tr>
<td>1050</td>
<td>xfy</td>
<td>-&gt;</td>
<td>if-then</td>
</tr>
<tr>
<td>1000</td>
<td>xfy</td>
<td>&amp;</td>
<td>explicit and</td>
</tr>
<tr>
<td>950</td>
<td>xfx</td>
<td>where</td>
<td>constraints</td>
</tr>
<tr>
<td>950</td>
<td>xfx</td>
<td>do</td>
<td>foreach</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>=</td>
<td>unifiability</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>=</td>
<td>not unifiable</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>is</td>
<td>arithmetic evaluation</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>==</td>
<td>arithmetic equality</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>==&gt;=</td>
<td>synonym for ==</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>&lt;&gt;</td>
<td>arithmetic inequality</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>==</td>
<td>synonym for &lt;&gt;</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>&lt;</td>
<td>less than</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>&lt;=</td>
<td>less than or equal to</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>&gt;</td>
<td>greater than</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>&gt;=</td>
<td>greater than or equal to</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>@=</td>
<td>literal identity</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>@=</td>
<td>literal non-identity</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>@&lt;</td>
<td>literal less than</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>@=&lt;</td>
<td>literal less than or identical</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>@&gt;</td>
<td>literal greater than</td>
</tr>
<tr>
<td>700</td>
<td>xfx</td>
<td>@&gt;=</td>
<td>literal greater than or identical</td>
</tr>
<tr>
<td>700</td>
<td>xfy</td>
<td>:</td>
<td>external type specification</td>
</tr>
<tr>
<td>500</td>
<td>yfx</td>
<td>+</td>
<td>addition</td>
</tr>
<tr>
<td>500</td>
<td>yfx</td>
<td>-</td>
<td>subtraction</td>
</tr>
<tr>
<td>500</td>
<td>fx</td>
<td>-</td>
<td>unary minus</td>
</tr>
<tr>
<td>400</td>
<td>yfx</td>
<td>*</td>
<td>multiplication</td>
</tr>
<tr>
<td>400</td>
<td>yfx</td>
<td>/</td>
<td>division</td>
</tr>
<tr>
<td>400</td>
<td>yfx</td>
<td>//</td>
<td>integer division</td>
</tr>
<tr>
<td>300</td>
<td>yfx</td>
<td>**</td>
<td>exponentiation</td>
</tr>
<tr>
<td>300</td>
<td>xfx</td>
<td>mod</td>
<td>modulus</td>
</tr>
</tbody>
</table>
Clauses

Rules and facts have the syntactic form of a clause. Clauses have the following canonical form:

<structures> :- <list>.

The :-) operator, read as "is true if", separates the head of the clause (the left hand side of " :-") from its body (the right hand side of " :-"). The head of the clause is a structure. The body of the clause is a list. If a clause does not have a body, it will be coerced to a clause with a body consisting of an empty list. For example,

<structure> is coerced to <structure> : - [].

Similarly, if the body of a clause is not a list, it will be coerced to a list:

<structure> : - <non-list>
is coerced to <structure> : - [<non-list>].

Since the body of a clause is a list, it may contain elements which are also lists. Such lists are also called blocks, since they are analogous to code blocks in procedural languages. Many of the control predicates use blocks to define the limits of their effect.

If a symbol is supplied as the head of a clause, it is coerced to a structure which consists of a functor followed by a parenthesized empty list. For example,

true is coerced to true().

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Examples of clauses follow:

\[
\begin{align*}
\text{p}(1) & : - \ [\]. \\
\text{p}(2) & : - \ [\text{q}(1)]. \\
\text{p}(3) & : - \ [\text{q}(1), \text{r}(2)]. \\
\text{p}(4) & : \% \text{coerced to} \ p(4) : - \ [\]. \\
\text{p}(5, 6) & : - \ \text{q}(5, 6) \ % \text{coerced to} \ p(5, 6) : - \ [\text{q}(5, 6)]. \\
\text{false} & : - \ \text{fail}. \ % \text{coerced to} \ \text{false}() : - \ [\text{fail}].
\end{align*}
\]

A set of clauses with the same functor as the head of the clause defines a **predicate**. These clauses do not have to occur together.

If the head of a clause has a tail variable in its argument list, it is a **variadic predicate**. A variadic predicate can be written to accept any number of arguments. For example:

\[
\begin{align*}
\text{write}(\_A, \_B..) & : - \ [\text{write}(\_A), \text{write}(\_B)]. \\
\text{write}(\_B) & : - \ \text{nl}. \\
\text{/* nl is a predicate which writes a new line */}
\end{align*}
\]
The basic Prolog control sequence of goal satisfaction and failure driven backtracking is sufficient for writing any pure Prolog program. Such programs can be very inefficient or nonterminating, making it necessary to provide additional predicates which control program execution. The basic predicates, include fail which initiates backtracking, cut which limits backtracking by committing to a particular subset of possible solutions, and failexit which is a combination of cut and fail. The predicate block is used to control the scope of cut and is a useful concept for meta-programming applications. freeze and {} defer the execution of goals until variables are instantiated.

A second set of predicates is included to promote readability and standardize the use of certain control constructs. These include once, not, repeat, ";" (or), "->" (if-then), "->;" (if-then-else), and foreach. Finally, findall and findset are useful for generating lists of solutions; this is usually a problem when using Prolog mechanisms which do not have side-effects. count is used to enumerate solutions.
The following is a list of the control predicates.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>Edinburgh cut</td>
</tr>
<tr>
<td>;</td>
<td>or</td>
</tr>
<tr>
<td>-&gt;</td>
<td>if-then</td>
</tr>
<tr>
<td>-&gt;;</td>
<td>if-then-else</td>
</tr>
<tr>
<td>{}</td>
<td>constraints</td>
</tr>
<tr>
<td>block</td>
<td>creates a block of code that can be cut</td>
</tr>
<tr>
<td>count</td>
<td>enumerates solutions</td>
</tr>
<tr>
<td>cut</td>
<td>controls backtracking</td>
</tr>
<tr>
<td>fail</td>
<td>failure</td>
</tr>
<tr>
<td>failexit</td>
<td>failure exit</td>
</tr>
<tr>
<td>findall</td>
<td>constructs a list of all the solutions to a given goal</td>
</tr>
<tr>
<td>findset</td>
<td>constructs a sorted list of all the solutions to a given goal</td>
</tr>
<tr>
<td>foreach</td>
<td>generate each solution and test</td>
</tr>
<tr>
<td>freeze</td>
<td>deferral mechanism</td>
</tr>
<tr>
<td>not</td>
<td>negation by failure</td>
</tr>
<tr>
<td>once</td>
<td>finds first solution</td>
</tr>
<tr>
<td>repeat</td>
<td>generates infinite set of choicepoints</td>
</tr>
<tr>
<td>true</td>
<td>true</td>
</tr>
</tbody>
</table>

Descriptions of the predicates follow.
**Edinburgh cut**

**Arguments:** None.

**Succeeds:** The Edinburgh cut "!" removes all choicepoints back to and inclusive of the parent goal (with the exception of ";" and "->").

**Fails:** Never fails.

**Examples:**

```prolog
/* definition for cat */
cat(_X) :- !, _X = sylvester.
OK

cat(felix).
OK

?- cat(felix).
NO

/* deterministic member predicate only "finds" */
/* or "inserts" once */
member(_X, [_X, _ Rest..]) :- !.
member(_X, [_.. _Rest..]) :- member(_X, _Rest).
```

**See Also:** cut and fail in this chapter.
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_\text{P;}_\text{Q}

or

Arguments: +Goal ; +Goal

Succeeds: \_\text{P} ; \_\text{Q} (read as \_\text{P} "or" \_\text{Q}), specifies an alternation of goals. The alternation succeeds if \_\text{P} succeeds or \_\text{Q} succeeds on backtracking.

Fails: The alternation fails if both \_\text{P} and \_\text{Q} fail.

Note 1: The Prolog definition for ";" follows:

\begin{align*}
(\_\text{P} ; \_\text{Q}) & : = \_\text{P}. \\
(\_\text{P} ; \_\text{Q}) & : = \_\text{Q}.
\end{align*}

Note 2: The binding of ";" is tighter than that of the list separator ","; \[\_\text{P} , \_\text{Q} ; \_\text{R}\] is parsed as \[\_\text{P} , (\_\text{Q} ; \_\text{R})\]. (See the chapter titled "Basic language Elements" in this manual for details on the precedence of operators.)

Many Prologs parse this expression as \((\_\text{P} , \_\text{Q}) ; \_\text{R}\). To avoid confusion, it is generally a good idea to enforce precedence by using parentheses ().

Examples:

\begin{verbatim}
?- ((\_\text{X} = 2) ; (\_\text{X} = 3)).
?- ((2 = 2) ; (2 = 3)).
?- ((3 = 2) ; (3 = 3)).
\end{verbatim}

YES

\begin{verbatim}
/* Succeeds twice */
?- (true ; true).
?- (true ; true).
?- (true ; true).
\end{verbatim}

YES
_P -> _Q

if-then

Arguments: +Goal -> +Goal

Succeeds: If the goal _P succeeds then the goal _Q is executed and if _Q succeeds then the "->" goal succeeds. If _P fails, then _Q is not executed and the "->" goal succeeds.

Fails: The "->" goal fails if the goal _P succeeds and _Q then fails.

Note 1: The Prolog definition for "->" is as follows:
_ P -> _ Q :- _P, cut('->'), _Q.

Note 2: _P -> fail is the same as not(_P).

Note 3: _P -> true is the same as once(_P ; true).

Examples:

/* Assuming p(a) succeeds but p(b) fails */
/* p(a) succeeds, hello is output and goal succeeds */
?- p(a) -> [nl, write(hello)].
hello
    ?- (p(a) -> [nl, write(hello)]).
YES

/* p(b) fails, hello is not output, but goal succeeds */
?- p(b) -> [nl, write(hello)].
    ?- (p(b) -> [nl, write(hello)]).
YES

/* p(b) succeeds, but p(b) fails and goal fails */
?- p(a) -> p(b).
NO

See Also: "->;" (if-then-else) in this chapter.
if-then-else

Arguments: +Goal -> +Goal ; +Goal
Succeeds: The "->;" goal succeeds if _P and then _Q succeeds, or if _P fails and _R succeeds.
Fails: The "->;" goal fails if _P succeeds and then _Q fails, or if _P fails and _R fails.
Note 1: The "->;" predicate is defined as follows:
_P -> _Q ; _R :- _P, cut(';'), _Q.
_P -> _Q ; _R :- cut(';'), _R.
Note 2: The expression _P -> _Q1 , _Q2 ; _R is parsed as
(_P -> _Q1) , (_Q2 ; _R).
Examples:

/* Given the following facts: p(apple). p(ball). p(cat). */
:- p(apple) -> [nl, write(hello)] ; [nl, write(bye)].
hello
YES
:- p(orange) -> [nl, write(hello)] ; [nl, write(bye)].
bye
YES
/* define "translate" predicate */
translate :-
p(apple) -> write(pomme);
p(ball) -> write(balon);
p(cat) -> write(chat).

See Also: "->" in this chapter.
\{_Goal_1, \_Goal_2, \ldots \}\n
**constraints**

**Arguments:** \{+Goal_1, +Goal_2, \ldots \}

**Succeeds:** The constraint predicate succeeds if the constraints described by \_Goal_1, \_Goal_2, \ldots can be imposed on the subsequent computation. The constraints are removed on backtracking.

**Fails:** The constraint predicate fails if the constraints have already been violated.

**Note 1:** Some useful constraints follow:

1. /* write \_X whenever it is ground */
   \{write(\_X)\}.

2. /* prevent \_X from being instantiated */
   \{var(\_X)\}.

3. /* constrain \_X to be different from \_Y */
   \{_X /= \_Y\}.

4. /* do q if \_X becomes instantiated */
   \{nonvar(\_X) -> q(\_X)\}.

5. /* compute \_Y whenever \_X is instantiated */
   \{_Y is \_X * \_X\}.

6. /* constrain \_X to be an integer < \_Y */
   \{_X < \_Y, integer(\_X)\}.

**Note 2:** Refer to the *BNR Prolog User Guide* for a description of the use of passive constraints, active constraints and arithmetic data flow.
Examples:

/* constrains _X to be an integer */

?- [_X = 2, {integer(_X)}].
   YES

?- [(2 = 2), {integer(2)}].
   YES

?- [[integer(_X)], _X = 2].
   YES

?- [[integer(2)], (2 = 2)].
   YES

?- [_X = a, {integer(_X)}].
   NO

?- [{integer(_X)}, _X = a].
   NO
**block**(_Name, _Gl.._GN)

*creates a block of code that can be cut*

**Arguments:** block(+name, +term_sequence)

**Succeeds:** block associates a name _Name with a list of goals and then executes the list. The name can be used as the argument to cut and failexit within the list.

**Fails:** block fails if _Name is not a symbol.

**Note:** block is useful when it is desirable (particularly, in metalevel programs, such as Prolog emulators and debuggers) to create a named executable block of code that can be cut without requiring the creation of an extra predicate. For example

```prolog
block(fred,member(_X, _L),cut(fred), process(_X)).
```

**See Also:** cut and failexit in this chapter.
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\textbf{count}(_Goal, _N)
\textbf{count}(_Goal, _N, _Max)

\textit{enumerates solutions}

\textbf{Arguments:}
\begin{itemize}
  \item count(+Goal, ?integer)
  \item count(+Goal, ?integer, +integer)
\end{itemize}

\textbf{Succeeds:}
The predicate \textit{count} succeeds and unifies \_N with the number of solutions of \_Goal. The solutions are not necessarily distinct.

A variant of \textit{count}, \textit{count}(_Goal, _N, _Max) is provided to handle cases where the number of solutions is potentially very large. \_Max must be instantiated to an integer which represents an upper limit to the number of solutions. If the number of solutions reaches \_Max, the generation of solutions is stopped, and \_N is instantiated to the value of \_Max.

If \_Goal has no solutions, \_N is instantiated to 0.

\textbf{Fails:}
\begin{itemize}
  \item count(_Goal, _N) and count(_Goal, _N, _Max) fail if \_N is neither a variable nor an integer.
  \item count(_Goal, _N, _Max) fails if \_Max is an uninstantiated variable.
\end{itemize}

\textbf{Note:}
If \_N is initially instantiated then \textit{count} does not stop when \_N is exceeded.

\textbf{Examples:}

\begin{verbatim}
/* predicate to determine if a goal is deterministic */
deterministic(_Goal) :- count(_Goal, 1,2).
\end{verbatim}
**cut**

**cut (Name)**

*controls backtracking*

**Arguments:** None.

**cut (+symbol)**

**Succeeds:** cut always succeeds and removes all choicepoints (alternatives) back to and inclusive of the current block. The current block starts with the first preceding bracket "[#]."

**cut (Name)** always succeeds if Name is the name of an ancestor goal, and removes all choicepoints (alternatives) back to and inclusive of the most recent occurrence of the named goal or block.

**Fails:** cut (Name) fails if Name is not the name of an ancestor goal.

**Errors:** An error is generated if the argument Name is not a symbol.

**Note 1:** The Edinburgh cut "!" cuts all choicepoints back to, and including the parent goal, and is roughly equivalent to cut (P) where P is the parent goal.

**Note 2:** cut is sometimes called "snips".

**Examples:**

```prolog
/* cut removes the choicepoints of p1, but not p */
p(_X) :- [p1, cut, P2].

/* cut removes the choicepoints of p2, but not p1 or p */
P(_Y) :- [p1, [p2, cut], p3].
```

**See Also:** "!" and failexit in this chapter.
fail

default

Arguments: None.
Succeeds: Never succeeds.
Fails: Always fails.
Note: fail can be used to force backtracking.
Examples:

/* fail is used to force backtracking in the */
/* definition of foreach */
foreach(_P do _Q) :- _P, _Q, fail.
foreach(_P do _Q).

See Also: true and failexit in this chapter.
failexit
failexit(_Name)

failure exit

Arguments: None.
failexit(+symbol)

Succeeds: Never.

Fails: failexit is equivalent to the goal sequence cut,fail. This is a failure exit and all attempts to resatisfy the current block are abandoned.

failexit(_Name) is equivalent to the goal sequence cut(_Name),fail. This is a failure exit of the named predicate.

Errors: An error is generated if _Name is not a symbol.

Examples:

/* Both items are the same, so different must fail */
different(_X, _X) :- failexit(different).

/* Otherwise, different succeeds */
different(_X, _Y).

?- different(risky, risky).
NO

?- different(risque, risky)
  ?- different(risque, risky).
YES

/* forall solutions of the goal p do the goal q */
forall(_P, _Q) :-
  foreach(_P do (_Q->true;failexit(_P))).

See Also: cut and "!" in this chapter.
findall(_X, _Goal, _List)

construct a list of all the solutions to a given goal

Arguments: findall(?Term, +Goal, ?List)
Succeeds: findall constructs a list, _List, consisting of all the values of _X such that _Goal is satisfied. If the attempt to satisfy _Goal never succeeds, then _List will be instantiated to the empty list.
Fails: findall fails if _List does not unify with the list of solutions.
Examples:

/* Given the facts */
p(c).
OK
p(b).
OK
p(a).
OK
p(c).
OK

?- findall(_X, p(_X), _L).
?– findall(_X, p(_X), [c, b, a, c]).
YES

?- findall(q(_X), p(_X), _L).
?– findall(q(_X), p(_X), [q(c), q(b), q(a), q(c)]).
YES

See Also: findset in this chapter.
**findset(_X, _Goal, _List)**

**construct a sorted list of all the solutions to a given goal**

**Arguments:**

findset(?Term, +Goal, ?List)

**Succeeds:**

findset constructs a sorted list (duplicates are removed) _List, consisting of all the values of _X such that _Goal is satisfied. If the attempt to satisfy _Goal never succeeds, then _List will be instantiated to an empty list.

**Fails:**

findset fails if _List does not unify with the list of solutions.

**Examples:**

/* Given the facts */

```prolog
p(c).
OK
p(b).
OK
p(a).
OK
p(c).
OK

?- findset(_X, p(_X), _L).
   ?- findset(_X, p(_X), [a, b, c]).
   YES

?- findset(q(_X), p(_X), _L).
   ?- findset(q(_X), p(_X), [q(a), q(b), q(c)]).
   YES
```

**See Also:**

findall in this chapter.
foreach(_P do _Q)

*generate each solution and test*

**Arguments:**  
foreach(+Goal do +Goal)

**Succeeds:**  
For each solution of the generator _P do all solutions of the goal _Q. foreach always succeeds.

**Fails:**  
Never fails.

**Note:**  
The Prolog definition follows:

```prolog
foreach(_P do _Q) :- _P, _Q, fail.
foreach(_P do _Q).
```

**Examples:**  

```prolog
/* this predicate demonstrates the use of foreach */
/* to print the members of a list in a column */
printcolumn(_List) :-
    foreach(member(_X, _List) do [write(_X), nl]).
```
**freeze**(_Var, _Goal)

**deferral mechanism**

**Arguments:**

freeze(?term, ?goal)

**Succeeds:**

If the variable _Var is instantiated then execute the goal; otherwise, delay the execution of the goal until the variable is instantiated. If _Var is uninstantiated, freeze always succeeds, but any operation that subsequently binds _Var will fail if _Goal fails.

**Fails:**

freeze fails if the variable is instantiated but _Goal fails.

**Note 1:**

The constraint goals are executed immediately after the associated variables are instantiated, but the order is unspecified.

**Note 2:**

If the variable associated with a constraint is never instantiated, the constraint will disappear when the environment (that is, the scope) containing the variable is deallocated.

**Examples:**

/* given the following rule

/*
test_freeze :-
  nl, write('variable: ', _V), nl,
  freeze(_V, [write('bound variable: ', _V), nl]),
  write('constrained variable: ' _V), nl,
  _V = jack; _V = jill.

:- ([test_freeze, fail] ; true).

variable: _V
constrained variable: _1
bound variable: jack
bound variable: jill
YES

See Also:**

{} in this chapter and in the *BNR Prolog User Guide*. 

BNR Prolog Reference Manual
not (_P)

*negation by failure.*

**Arguments:** not(+Goal)

**Succeeds:** If the goal _P fails, then not(_P) succeeds.

**Fails:** If the goal _P succeeds, then not(_P) fails.

**Note 1:** The not predicate could be defined as follows:

\[
\text{not}(_P) :- \_P, \text{failexit(not)}. \\
\text{not}(_P).
\]

**Note 2:** not(not(_P)) is useful in cases where it is desirable to find out if _P is true for any possible assignment of its variables without actually binding those variables.

**Note 3:** If _P has side effects, not(not(_P)) has the same side effects.

**Note 4:** not(not(_P)) can be used to minimize storage.

**Note 5:** not(_P) is never a generator.

**Examples:**

/* Same as false. */
?- not(true).
NO

/* Same as true. */
?- not(fail).
?- not(fail).
YES

?- not(not(fail)).
NO

BNR Prolog Reference Manual
\texttt{once(\_P)}

\textit{finds first solution.}

**Arguments:** \texttt{once(+Goal)}

**Succeeds:** \texttt{once} finds the first solution to the goal \_P. If backtracking occurs, no further solutions are generated.

**Fails:** \texttt{once} fails if there are no solutions to \_P.

**Note 1:** The Prolog definition for \texttt{once} is as follows:
\begin{verbatim}
once(_P) :- _P, cut(once).
\end{verbatim}

**Note 2:** When appropriate the use of \texttt{once} instead of \texttt{cut} generally results in cleaner, more storage efficient and more understandable code. It is provided as part of the basic language to encourage its use.

**Examples:**

\begin{verbatim}
/* using the standard member predicate */
?- once(member(_X, [a, b, c])).
?- member(a, [a, b, c]).
\end{verbatim}

\texttt{YES}

**See Also:** \texttt{cut} and "!" in this chapter.
repeat

generates infinite set of choicepoints

Arguments: None.

Succeeds: repeat always succeeds, and when encountered during backtracking succeeds again.

Fails: repeat never fails.

Note: The prolog definition is as follows:
repeat.
repeat :- repeat.

Examples:

/* Here repeat is used to read a sequence of numbers and generate their squares. The sequence is terminated by the atom end. */
squares :- repeat,
  read(_X),
  _X = end -> failexit(squares),
  numeric(_X),
  _Y is _X * _X,
  write(_Y),
  fail.

See Also: cut and failexit in this chapter.
true

true

Arguments: None.
Succeeds: Always succeeds.
Fails: Never fails.
Examples:

/* Equivalent to same(_X, _X):- [] 
same(_X, _X) :- true. */

/* Equivalent to greek(socrates):- [] 
greek(socrates) :- true. */

See Also: cut, fail in this chapter.
Basic Filters

Prolog programs are constructed from terms whose types are discerned from their syntactic form. Basic filters are predicates which can be used to test the type of a term. The classification of terms according to their corresponding filter is shown in Figure 4-1.

```
Term
  └── var
    └── nonvar
        ├── atomic
        │   ├── symbol
        │   └── numeric
        │       └── number
        │           └── integer
        └── compound
            ├── bucket
            └── list
                └── structure
                    └── interval
                        └── float

Figure 4-1. Classification of Prolog terms
```
Basic filters are variadic, that is, they take one or more arguments. To succeed, all the arguments must be of the type required by the filters. Table 4-1 presents a list of the basic filters. An example of a query which succeeds is presented for each filter where appropriate.

**Table 4-1. Basic Filters**

<table>
<thead>
<tr>
<th>Name</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>atomic</td>
<td>?- atomic(fred, joe, susan).</td>
</tr>
<tr>
<td>bucket</td>
<td>See the chapter titled &quot;External Language Interface&quot;</td>
</tr>
<tr>
<td>compound</td>
<td>?- compound(fred(2,3), [2,3,4]).</td>
</tr>
<tr>
<td>float</td>
<td>?- float(4.4).</td>
</tr>
<tr>
<td>integer</td>
<td>?- integer(4, 5).</td>
</tr>
<tr>
<td>interval</td>
<td>?- [range(_X, [1, 10]), interval(_X)].</td>
</tr>
<tr>
<td>list</td>
<td>?- list([a, b, _X..]).</td>
</tr>
<tr>
<td>nonvar</td>
<td>?- [_X = fred, nonvar(_X)].</td>
</tr>
<tr>
<td>number</td>
<td>?- number(4.0, 4).</td>
</tr>
<tr>
<td>numeric</td>
<td>?- [range(_X, [1,10]), numeric(_X,4.0)].</td>
</tr>
<tr>
<td>structure</td>
<td>?- structure(fred(2, _X..)).</td>
</tr>
<tr>
<td>symbol</td>
<td>?- symbol(&quot;fred&quot;, 'fred', fred).</td>
</tr>
<tr>
<td>var</td>
<td>?- var(_).</td>
</tr>
</tbody>
</table>
Other Filters

Three other filters test some other properties of terms:

<table>
<thead>
<tr>
<th>Filter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>acyclic</td>
<td>tests for cyclic structures</td>
</tr>
<tr>
<td>ground</td>
<td>tests for variables in a term</td>
</tr>
<tr>
<td>tailvar</td>
<td>tests for tail variables</td>
</tr>
</tbody>
</table>

Descriptions of these filters follow.
acyclic(_Term)

tests for cyclic structures

Arguments: acyclic(?term)
Succeeds: acyclic succeeds if the term contains no cycles (that is, the term is a finite tree).
Fails: acyclic fails if the instantiated value of the argument is a term containing cycles.
Examples:

?- [_X = f(_Y) , acyclic(_X)].
    ?- [(f(_Y) = f(_Y)) , acyclic(f(_Y))].
    YES

?- [_X = f(2, _X) , acyclic(_X)].
    NO

?- [[_X..] = [2, 3, _X..] , acyclic(_X)].
    NO
ground(_Term)

_tests for variables in a term_

Arguments:  
ground(?term)

Succeeds:  
ground succeeds if _Term is ground (that is, contains no variables or tail variables).

Fails:  
ground fails if _Term contains one or more variables or tail variables.

Examples:

?- [_X = a , ground(_X)].
   YES

?- [(a = a) , ground(a)].
   YES

?- [_Z = f(_V) , ground(_Z)].
   NO

?- [_Z = f(_V..) , ground(_Z)].
   NO
tailvar(_Tailvariable..)

tests for tail variables

Arguments: tailvar(+tailvariable)

Succeeds: tailvar succeeds if the argument is a tail variable. The term _Tailvariable must syntactically appear as a tail variable. (Note that the format notation does not imply that tailvar is a variadic.)

Fails: tailvar fails if the argument is not a tail variable.

Note 1: Tail variables may only occur as the last component of a list or structure.

Note 2: tailvar is the lowest level test for detecting the presence of an open-ended list structure.

Examples:

?- [_L = [_H, _T..], tailvar(_T..)].
YES

?- [([_H, _T..] = [_H, _T..]), tailvar(_T..)].
YES

?- [2,3] = [_H, _T..], tailvar(_T..)].
NO
Comparing Terms

The term comparison operators compare two terms in a linear order. Since terms may be of different types (for example, integers, strings, structures) it is necessary to define the order of the types, as well as an order within each type. This type ordering, called the standard order, is described in the following section.

Term comparison should not be confused with arithmetic comparisons. Term comparison predicates perform literal comparisons of terms in expressions; they do not evaluate those expressions.

Standard Order

The standard order for BNR Prolog is defined as follows (lowest to highest):

Variables are compared by their age, oldest first. A variable's age is independent of its name.

Tail variables are compared by their age, oldest first. A tail variable's age is also independent of its name.

Floats and integers are put into numeric order. Integers are put before their floating point equivalent.

Intervals are compared by age, oldest first. An interval's age is independent of its name.

Symbols are arranged in alphabetical (ASCII) order.

Lists are ordered by a term comparison of their corresponding elements, in a left-to-right order.

Structures are ordered by the name of the principal functor, and then by their arguments in a left-to-right order.
Term Comparison Operators

The term comparison operators are listed in Table 4-2.

Table 4-2. Description of comparison operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>_X @= _Y</td>
<td>literal identity</td>
</tr>
<tr>
<td>_X @= _Y</td>
<td>literal non-identity</td>
</tr>
<tr>
<td>_X @&lt; _Y</td>
<td>literal less than or identical</td>
</tr>
<tr>
<td>_X @=&lt; _Y</td>
<td>literal less than or identical</td>
</tr>
<tr>
<td>_X @&gt; _Y</td>
<td>literal greater than or identical</td>
</tr>
<tr>
<td>_X @&gt;= _Y</td>
<td>literal greater than or identical</td>
</tr>
</tbody>
</table>
Chapter 4: Filters and Metapredicates

Note 1: If two terms are literally identical, they must have variables at equivalent positions. For example, the query

?- _X @= _Y.

fails, since _X and _Y are distinct variables.

However, the query

?- _X = _Y , _X @= Y.

succeeds, since the variables _X and _Y are unified first.

Note 2: "@=" is equivalent to "==" in most Edinburgh Prologs.

Term Compare Predicates

<table>
<thead>
<tr>
<th>sort</th>
<th>- sorts a list of terms and removes duplicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>term_compare</td>
<td>- compares terms</td>
</tr>
</tbody>
</table>

Descriptions of the predicates follow.
sort(_L1, _L2)

sorts a list of terms and removes duplicates

Arguments: sort(+list, ?list)
Succeeds: Sorts the elements in the list _L1 in standard order and unifies the result with _L2. Multiple occurrences of the same element (as defined by the "@=" relationship) are removed.
Fails: sort fails if
• _L1 is not a list
• _L2 is neither a variable nor a list
Note: Sorting of _L1 is done prior to unification with _L2. If _L1 contains variables which become instantiated when _L1 and _L2 are unified, the sort relationship may no longer hold. For example,

? - sort([_X, _Y], [2, 1]).
succeeds.

Examples:

/* sorts in standard order */
?- sort( [1, 2, 2.0, 3, 1.0, 3.0], _L2).
    sort([1, 2, 2.0, 3, 1.0, 3.0], [1, 1.0, 2, 2.0, 3, 3.0]).
YES

?- sort([[2,2], [1,2], [1,2,3]], _L2).
    sort([[2,2], [1,2], [1,2,3]], [[1,2], [1,2,3], [2,2]]).
YES
term_compare(_X, _Y, _Rel)

compares terms

Arguments:  

term_compare(+term, +term, ?symbol)

Succeeds:  
The comparison relation between _X and _Y is _Rel, where possible values for _Rel are
- '@=' if _X is identical to _Y,
- '@<' if _X is before _Y in the standard order,
- '@>' if _X is after _Y in the standard order.

Fails:  
term_compare fails if _Rel is neither a variable nor the comparison relation between the terms _X and _Y.

Examples:

?- term_compare(_X, 3, '@<').
  YES

?- term_compare(_X, 3, '@<').
  YES

?- term_compare('ab', 'B', _Rel).
  YES

?- term_compare(ab, B, '@>')
  YES
Metapredicates

Metapredicates are predicates supporting concepts which are outside the scope of first order logic. Primarily, they permit the treatment of variables as data. Further information on some uses of the metapredicates is available in the *BNR Prolog User Guide*.

The following is a list of the metapredicates.

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>arg</td>
<td>index into a compound term</td>
</tr>
<tr>
<td>bind_vars</td>
<td>binds variables to their names</td>
</tr>
<tr>
<td>decompose</td>
<td>decomposes a cyclic structure (minimal)</td>
</tr>
<tr>
<td>spanning_tree</td>
<td>decomposes a cyclic structure (maximal)</td>
</tr>
<tr>
<td>subsumes</td>
<td>generality relationship</td>
</tr>
<tr>
<td>termlength</td>
<td>relates a compound term and its length</td>
</tr>
<tr>
<td>variables</td>
<td>collects the variables and constraints in a term</td>
</tr>
</tbody>
</table>

BNR Prolog Reference Manual
arg(_N, _Term, _Arg)

index into a compound term

Arguments: arg(+integer, +term, ?term)

Succeeds: arg succeeds if the _Nth argument of _Term unifies with _Arg.
(The functor of a structure is element zero (0).)

Fails: arg fails if
• the _Nth argument of _Term is not unifiable with _Arg
• _N is not an integer
• _Term is not a compound term

Note: arg permits lists to be accessed as arrays. In some cases this may result in significant performance gains.

Examples:

?- arg(2, [canada, america, britain], america).
  arg(2, [canada, america, britain], america).
  YES

?- arg(2, country(canada, america, britain), _X).
  arg(2, country(canada, america, britain), america).
  YES

?- arg(0, country(canada, america, britain), _X).
  arg(0, country(canada, america, britain), country).
  YES

?- arg(3, country(canada, america, britain), _X), britain).
  arg(3, country(canada, america, britain), britain).
  YES

?- arg(2, country, _X).
  NO
bind_vars(_Term)

binds variables to their names

Arguments: bind_vars(+term)
Succeeds: Binds all variables in _Term to their canonical names. _Term is then ground.
Fails: Never fails.
Note: The canonical name of a variable is a symbol which starts with an underscore (for example, _Name). This name is usually given to the variable by the user. However, if distinct variables have the same name in any given expression, the system modifies the name by appending a suffix consisting of an underscore (_) followed by digits. Names of variables beginning with a capital letter will be prefixed with an underscore and disambiguated as necessary.

Examples:

/* print_column prints a list in a column */
/* The list many contain variables */
/* "bind_var" stabilizes the names in the context */
/* of _X while the not(not( undoes the binding */
/* made by "bind_var" */
prt_column(_X) :-
    [not(not([bind_var(_X), $print_col(_X)]))].

/* print subroutine */
$print_col([]) :- nl.
$print_col([_X, _Xs..]) :-
    [nl, write(_X), $print_col(Xs)].

See Also: ground in this chapter.
decompose(_Term, _Tree, _Fragments)

decomposes a cyclic structure (minimal)

Arguments: decompose(+compound_term, ?tree, ?list)

Succeeds: If _Term has no cycles or common subexpressions, then _Tree is a copy of _Term and _Fragments is the empty list. If _Term is cyclic then _Tree is a term which will become a copy of _Term when _Fragments is executed. _Fragments is a minimal list of unifications of the form: [V1 = tree1, V2 = tree2, ...], where the V's are variables and the tree's are minimal compound terms (lists or structures). _Tree and the tree's in the _Fragments list are acyclic.

Fails: decompose fails if _Term is not a compound term.

Examples:

/* given the following definition for "write_cyclic"

write_cyclic(_x) :-
    [decompose(_x, _a, _b), nl, write(_a), nl, write(_b)]
.

/* User imperative mode to suppress the echo */

/* simple cyclic structure */
:- [X = f(g(X)), write_cyclic(X)].

a
[(a = f(g(a)))]

YES
/* compound cyclic structure, decompose _x */
:- [_x = f(_y), _y = g(_x, _z), _z = h(_x, _y),
    write_cyclic(_x)].
_a
[ (_a = f(_l)), (_l = g(_a, h(a, _l)))]
YES

/* same compound cyclic structure, decompose _y */
:- [_x = f(_y), _y = g(_x, _z), _z = h(_x, _y),
    write_cyclic(_y)].
_a
[ (_a = g[_l, h(_l, _a))], (_l = f(_a))]
YES

/* same compound cyclic structure, decompose fred(_z) */
:- [_x = f(_y), _y = g(_x, _z), _z = h(_x, _y),
    write_cyclic(fred(_z))].
fred[_l]
[ (_l = g[_2, _3]), (_2 = f(_l), (_3 = h(_2, _l))]
YES
spanning_tree(_Term, _Tree, _Fragments)

decomposes a cyclic structure (maximal)

Arguments: spanning_tree(+compound_term, ?tree, ?list)
Succeeds: If _Term has no cycles or common subexpressions, then _Tree is a copy of _Term and _Fragments is the empty list. If _Term is cyclic then _Tree is a term which will become a copy of _Term when _Fragments is executed. _Fragments is a maximal list of unifications of the form: [_V1 = _tree1, _V2 = _tree2, ...], where the _V's are variables and the _tree's are maximal compound terms. _Tree and the _tree's in the _Fragments list are acyclic.
Fails: spanning_tree fails if _Term is not a compound term.
Examples:

/* given the following definition for "write_cyclic"
write_cyclic(_x) :-
spanning_tree(_x, _a, _b),
  nl, write(_a), nl,
  write(_b).

/* Use imperative mode to suppress the echo
/* simple cyclic structure
:- [_x = f(g(_x)), write_cyclic(_x)].
f(g(_1))
[(_1 = f(g(_1))))].
YES

/* compound cyclic structure, decompose _x
:- [_x = f(_y), _y = g(_x, _z), _z = h(_x, _y),
  write_cyclic(_x)].
f(g(_1, h(_2, _3)))
[(_1 = f(g(_1, h(_2, _3)))), (_2 = f(g(_1, h(_2, _3)))), (_3 =
g(_1, h(_2, _3)))]
YES

BNR Prolog Reference Manual
subsumes(_Term1, _Term2)

**generality relationship**

**Arguments:**

subsumes(+term1, +term2)

**Succeeds:**

subsumes succeeds if _Term1 is narrower than _Term2, that is, any term which unifies with _Term2 will unify with _Term1. (Note the reverse is not necessarily true.)

**Fails:**

subsumes fails if _Term1 is not as general as _Term2.

**Note:**

subsumes is a filter, that is, no variables are instantiated.

**Examples:**

?- subsumes(X, a).
    ?- subsumes(X, a).
    YES

?- subsumes(X, [Y..]).
    ?- subsumes(X, [Y..]).
    YES

?- subsumes([X, a, Y], [U, a, []]).
    ?- subsumes([X, a, Y], [U, a, []]).
    YES

?- subsumes([X, a, X], [b, a, b]).
    ?- subsumes([X, a, X], [b, a, b]).
    YES

?- subsumes([X, a, X], [b, a, c]).
    NO

?- subsumes([X, a, X], [Y, a, Y]).
    ?- subsumes([X, a, X], [Y, a, Y]).
    YES

BNR Prolog Reference Manual
term\text{length}(\_\text{Term}, \_\text{Size}, \_\text{Last})

relates a compound term and its length

Arguments: \text{term\text{length}(+\text{compound\_term}, ?\text{integer}, ?\text{list})}

Succeeds: \text{term\text{length succeeds if \_Term is a list or structure which contains \_Size top level elements. \_Last is unified with an empty list if \_Term is a definite compound term, or with the tail variable of \_Term if it is an indefinite compound term.}

Fails: \text{term\text{length fails if}

\begin{itemize}
\item \_Term is not a compound term
\item either of the unifications described above fail
\end{itemize}

Examples:

?- \text{term\text{length}(f(a,b,c), \_S, \_X).}
   \text{YES}

?- \text{term\text{length}(f(a,b,c), 3, \[\]).}
   \text{YES}

?- \text{term\text{length([a,b,\_C..], \_S, \_X).}
   \text{YES}

?- \text{term\text{length([a,b,\_C..], 2, \[_C..\]).}
   \text{YES}

?- \text{term\text{length(f(a,b,\_C..), \_S, \[\]).}
   \text{YES}

?- \text{term\text{length(f(a,b,\_C..), \_S, [e, f]).}
   \text{YES}

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variables(_Term, _Vl, _Tvl, _Con)

**collects the variables and constraints in a term**

**Arguments:**
variables(+term, ?list, ?list, ?list)

**Succeeds:**
Unifies _Vl with the list of occurrences of variables in _Term in breadth-first order. _Tvl is unified with the list of occurrences of tail variables in _Term. _Con is unified with the list of constraints, as a freeze expression, on variables in _Term.

**Fails:**
variables fails if any of the unifications described above fails.

**Examples:**

?- variables(f(_a, _b, _a, _Xs..), _Vl, _Tvl, _C).
   ?- variables(f(_a, _b, _a, _Xs..), [_a, _b, _a],
          [[_Xs..]],[]).
   YES

/* use imperative mode to suppress the echo */
:- [ _x = f(_b, _x), variables(_x, _vl, _tvl, _con),
    write(_vl), nl].
   [_b]
   YES

/* check that there are no outstanding constraints */
?- variables(_t, _, _, []).
   ?- variables(_t, [_t], [], [])
   YES

/* constrained variable example, note that variable */
/* name is modified when constraint is applied */
?- [ {integer(_X)}, variables(_X, _, _, _)].
   ?- [{integer(_l)}, variables(_l, [_l], [],
      [freeze(_l, {integer(_l)})])].
Arithmetic is performed by predicates (for example, `is` and `"=="`) that take arithmetic expressions as arguments. These expressions are built from numeric constants, infix arithmetic operators, and built-in arithmetic functions. The result of evaluating an arithmetic expression may be an integer, float, or an interval. For the evaluation to succeed, each variable must be instantiated to a number or another arithmetic expression. (The acceptable ranges for integers, floats and intervals are described in the chapter titled "Basic Language Elements" in this manual.) Functions that cannot be evaluated (for example, `0 ** 0`) also cause failures.

The arithmetic infix operators, comparison operators and built-in functions which operate on floats and integers are described in the first section of this chapter titled "Functional Arithmetic". Intervals are dealt with separately in the section titled "Relational Arithmetic". Additional information on relational arithmetic can be found in the chapter titled "Relational Arithmetic" in the BNR Prolog User Guide.
Functional Arithmetic

Arithmetic Operators

Table 5-1. Infix arithmetic operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Operation</th>
<th>Operand type</th>
<th>Result type</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>addition</td>
<td>integer, or float</td>
<td>integer if both operands are integers; else float</td>
</tr>
<tr>
<td>-</td>
<td>subtraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*</td>
<td>multiplication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/</td>
<td>division</td>
<td>integer or float</td>
<td>float</td>
</tr>
<tr>
<td>//</td>
<td>integer division</td>
<td>integer or float</td>
<td>integer (the result is truncated to the nearest integer)</td>
</tr>
<tr>
<td>mod</td>
<td>modulus</td>
<td>integer</td>
<td>integer</td>
</tr>
<tr>
<td>**</td>
<td>exponentiation</td>
<td>integer or float</td>
<td>integer if both operands are integers; else float</td>
</tr>
</tbody>
</table>

Note 1: The operations \_x / _Y, _x // _Y and _x mod _Y fail if the value of _Y is zero.

Note 2. The sign of the result of _x mod _Y is the same as the sign of _Y.

Note 3. The operation _x ** _Y fails if both _x and _Y are zero.

Note 4. The operation _x ** _Y may also fail if _x is negative and _Y is not an integer.
# Arithmetic Functions

**Table 5-2. Arithmetic functions**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>sin(_X)</code></td>
<td>Sine of _x. (_x is expressed in radians.)</td>
<td>float</td>
</tr>
<tr>
<td><code>cos(_X)</code></td>
<td>Cosine of _x. (_x is expressed in radians.)</td>
<td>float</td>
</tr>
<tr>
<td><code>tan(_X)</code></td>
<td>Tangent of _x. (_x is expressed in radians.)</td>
<td>float</td>
</tr>
<tr>
<td><code>asin(_X)</code></td>
<td>Returns the principal value of the arcsine of _x in radians. (-1 &gt;= _x &lt;= +1)</td>
<td>float</td>
</tr>
<tr>
<td><code>acos(_X)</code></td>
<td>Returns the principal value of the arccosine of _x in radians. (-1 &gt;= _x &lt;= +1)</td>
<td>float</td>
</tr>
<tr>
<td><code>atan(_X)</code></td>
<td>Returns the principal value of the arctangent of _x in radians.</td>
<td>float</td>
</tr>
<tr>
<td><code>abs(_X)</code></td>
<td>Absolute value of _x.</td>
<td>float</td>
</tr>
<tr>
<td><code>exp(_X)</code></td>
<td>e raised to the power of _x.</td>
<td>float</td>
</tr>
<tr>
<td><code>ln(_X)</code></td>
<td>Logarithm to the base e of _x. (_x must be a positive value.)</td>
<td>float</td>
</tr>
<tr>
<td><code>sqrt(_X)</code></td>
<td>Returns the floating point positive square root. (_x must be a non-negative value.)</td>
<td>float</td>
</tr>
<tr>
<td><code>integer(_X)</code></td>
<td>Returns the integer part of _x.</td>
<td>integer</td>
</tr>
<tr>
<td><code>float(_X)</code></td>
<td>Returns the floating point representation of _x.</td>
<td>float</td>
</tr>
<tr>
<td><code>floor(_X)</code></td>
<td>Returns the largest integer equal to or less than _x.</td>
<td>integer</td>
</tr>
<tr>
<td><code>ceiling(_X)</code></td>
<td>Returns the smallest integer greater than or equal to _x. (_x may be an integer, or float.)</td>
<td>integer</td>
</tr>
<tr>
<td><code>round(_X)</code></td>
<td>Returns the closest integer to _x.</td>
<td>integer</td>
</tr>
<tr>
<td><code>maxint</code></td>
<td>Returns the largest positive integer.</td>
<td>integer</td>
</tr>
<tr>
<td><code>maxreal</code></td>
<td>Returns the largest floating point value.</td>
<td>float</td>
</tr>
<tr>
<td><code>max(_X, _Y)</code></td>
<td>Returns the maximum of _x and _y.</td>
<td>integer if both _x and _y are integers; else float.</td>
</tr>
<tr>
<td><code>min(_X, _Y)</code></td>
<td>Returns the minimum of _x and _y.</td>
<td>integer</td>
</tr>
<tr>
<td><code>cputime</code></td>
<td>Returns the system elapsed time.</td>
<td>integer</td>
</tr>
<tr>
<td><code>pi/π</code></td>
<td>Returns the value of π.</td>
<td>float</td>
</tr>
</tbody>
</table>
Arithmetic Comparisons

Arithmetic comparisons are performed by the infix comparison operators. Both arguments are evaluated, using type coercions where necessary, and compared according to the operator semantics. If the relation is true, the goal succeeds. If one operand is an integer and the other a float, the integer is coerced to a float.

Table 5-3. Arithmetic comparison operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;</td>
<td>less than</td>
</tr>
<tr>
<td>&lt;=</td>
<td>equal to or less than</td>
</tr>
<tr>
<td>=</td>
<td>equal to</td>
</tr>
<tr>
<td>&gt;</td>
<td>greater than</td>
</tr>
<tr>
<td>&gt;=</td>
<td>greater than or equal to</td>
</tr>
<tr>
<td>&lt;&gt;</td>
<td>not equal</td>
</tr>
</tbody>
</table>

The "==" comparison operator performs a bit wise comparison on floats. Hence, the usual floating point anomalies are observed. For example, the following query fails

```prolog
?- 1.1 * 1.1 == 1.21.  
NO
```

due to rounding errors in inexact floating point values.
_X is _Expression

**arithmetic evaluation**

**Arguments:**

?X is +Expression

**Succeeds:**

If _X is a variable then the infix operator is evaluates the arithmetic expression _Expression and instantiates _X with the result. If _X is a numeric then the is operation succeeds if the value of the expression is equal to the value of _X.

**Fails:**

is fails if
- _Expression is not an evaluable arithmetic expression
- _X is neither an evaluated variable nor a numeric
- the value of _X is not equal to the value of _Expression

**Examples:**

/* leave a space before the final period when you have a query which ends with a numeric */

?- [_X is 3 * 4, 2 is _X // 5].
  =YES

/* right hand side contains a variable */

?- _X is _Y + 1 .
   =NO

/* fred is neither a variable nor a numeric */

?- fred is 77 .
   =NO
integer_range(_X, _Lb, _Ub)

integer range generator

Arguments: integer_range(?integer, +number, +number)

Succeeds: integer_range succeeds if _X is instantiated to an integer value between the lower bound _Lb and the upper bound _Ub inclusive. If, however, _X is a variable when the call is made then integer_range generates the set of integers in the range specified.

Fails: integer_range fails if
• _X is instantiated to a value which is not in the range specified
• either _Lb or _Ub is not an integer
• the value of the upper bound is less than the value of the lower bound

Examples:

/* Verify that an integer is in a given range */
?- integer_range(2, 1, 10).
?- integer_range(2, 1, 10).
YES

/* Generate integers between 1 and 3 */
?- integer_range(_X, 1, 3).
?- integer_range(1, 1, 3).
?- integer_range(2, 1, 3).
?- integer-range(3, 1, 3).
YES

/* Fails, bounds cannot be expressions */
?- integer_range(_X, [1, 2 + 2]).
NO
Relational Arithmetic

BNR Prolog introduces a new data type for numbers, distinct from floats or integers: the type interval. An interval defines a continuous range of real numbers lying between a lower and an upper bound. The bounds of an interval are floating point numbers that define its range. Any operations performed on intervals have the effect of attempting to narrow the range of the interval. An interval can only be unified with itself or an unbound variable. Intervals are created using the predicate `range` and printed using the predicate `print_interval` as described in the chapter titled "Text Input/Output". Refer to the chapter titled "Relational Arithmetic" in the *BNR Prolog User Guide* for further information on the use of intervals.
range(_I, [_Lb, _Ub])

creates or queries an interval

Arguments: range(?interval, [?number, ?number])

Succeeds: If _I is a variable, it is bound to an interval which lies between the upper and lower bounds specified. If the upper and lower bounds are not specified then range creates an interval which lies between the largest negative and the largest positive floating point values representable by the internal floating point format. If _I is instantiated when the call is made, range succeeds if _I lies between, or can be constrained to lie between, the bounds specified.

Fails: range fails if
- the interval specified does not lie between the bounds specified
- _Lb and _Ub are neither variables nor numbers
- _I is neither an interval nor a variable
- the value of upper bound is less than the value of the lower bound.
- _I is an interval with a range disjoint from [_Lb, _Ub]

Examples:

?- range(_I, [1.0, 10.0]).
   ?- range(_Interval_368264, [1.0, 10.0]).
   YES

/* Fails, _I cannot be >= 4.44 and =< 2.22 */
?- range(_I, [4.44, 2.22]).
   NO

?- range(_I, [_-, _-]). % Indefinite interval
   ?- range(_Interval_368376, [-3.4000e+38, 3.4000e+38]).
   YES
**Arithmetic Operations on Intervals**

With the exception of integer division (\(//\)) and modulus (mod), all the arithmetic operations work with intervals.

**Table 5-4. Arithmetic operations on intervals**

<table>
<thead>
<tr>
<th>Operator</th>
<th>Operation</th>
<th>Operand type</th>
<th>Result type</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>addition</td>
<td>interval and either interval, integer or float</td>
<td>interval</td>
</tr>
<tr>
<td>-</td>
<td>subtraction</td>
<td>interval and either interval, integer or float</td>
<td>interval</td>
</tr>
<tr>
<td>*</td>
<td>multiplication</td>
<td>interval and either interval, integer or float</td>
<td>interval</td>
</tr>
<tr>
<td>/</td>
<td>division</td>
<td>interval and either interval, integer or float</td>
<td>interval</td>
</tr>
<tr>
<td>**</td>
<td>exponentiation</td>
<td>interval and either integer or float</td>
<td>interval</td>
</tr>
</tbody>
</table>

The operation \(_x^{**}_y\) fails if both \(_x\) and \(_y\) are zero, or if \(_y\) is not an integer.
Arithmetic Functions using Intervals

Most of the arithmetic functions which operate on integers and floats also act as relations on intervals.

Table 5-5. Arithmetic relations on intervals

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>sin(_X)</td>
<td>Sine of _x. (_x is expressed in radians.)</td>
<td>interval</td>
</tr>
<tr>
<td>cos(_X)</td>
<td>Cosine of _x. (_x is expressed in radians.)</td>
<td>interval</td>
</tr>
<tr>
<td>tan(_X)</td>
<td>Tangent of _x. (_x is expressed in radians.)</td>
<td>interval</td>
</tr>
<tr>
<td>asin(_X)</td>
<td>Returns the principal value of the arcsine of _x in radians. (-1 &gt;= _x &lt;= +1)</td>
<td>interval</td>
</tr>
<tr>
<td>acos(_X)</td>
<td>Returns the principal value of the arccosine of _x in radians. (-1 &gt;= _x &lt;= +1)</td>
<td>interval</td>
</tr>
<tr>
<td>atan(_X)</td>
<td>Returns the principal value of the arctangent of _x in radians.</td>
<td>interval</td>
</tr>
<tr>
<td>abs(_X)</td>
<td>Absolute value of _x.</td>
<td>interval</td>
</tr>
<tr>
<td>sqrt(_X)</td>
<td>Non-negative square root of _x.</td>
<td>interval</td>
</tr>
<tr>
<td>exp(_X)</td>
<td>e raised to the power of _x.</td>
<td>interval</td>
</tr>
<tr>
<td>max(_X, _Y)</td>
<td>Maximum of _x and _Y.</td>
<td>interval</td>
</tr>
<tr>
<td>min(_X, _Y)</td>
<td>Minimum of _x and _Y.</td>
<td>interval</td>
</tr>
<tr>
<td>delta(_X)</td>
<td>Size of _x.</td>
<td>float</td>
</tr>
<tr>
<td>midpoint(_X)</td>
<td>Arithmetic mean of range of _x.</td>
<td>float</td>
</tr>
<tr>
<td>median(_X)</td>
<td>Zero (0) if _x contains 0; else a value which divides the interval into subintervals containing the same number of floats. Fails if the interval contains no numbers representable as floats.</td>
<td>float</td>
</tr>
</tbody>
</table>

The inverse functions asin, acos, atan and ln can be implemented by using the function "backwards". For example,

_Y == exp (_X) is equivalent to _X == ln (_Y).
Arithmetic Comparison of Intervals

Comparisons of expressions containing intervals are performed using the infix comparison operators listed in Table 5-3. If the comparison is successful, intervals involved in the evaluation may be narrowed. Type coercions are determined by the following rule:

If one operand is an interval and the other either an integer or a float, then the noninterval will be coerced to a "point" interval.

Interval Relational Expressions (is)

Evaluation of expressions of the form

\[ \text{\_V is expression} \]

where \_V is a variable and expression contains intervals, will instantiate \_V to an interval. Each subexpression using intervals is computed in the usual way (see the predicate description for "\_X is \_Expression" in this chapter). When a binary operation involves both an interval and either a float or an integer, the float or integer is converted to a point interval.

Miscellaneous Built-in Predicates

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>accumulate</td>
<td>accumulates values between interval computations</td>
</tr>
<tr>
<td>solve</td>
<td>forces solutions to sets of interval equations</td>
</tr>
</tbody>
</table>

Descriptions of the predicates follow.
accumulate(_X, _Expression)

transfers interval values between computations

Arguments:   accumulate(+interval, +expression)
Succeeds:   accumulate evaluates the expression (as an interval) and then adds the result to _X.
Fails:       accumulate fails if
• _X is not instantiated to an interval
• _Expression is not a valid and fully instantiated arithmetic expression

Note 1:   Unlike is, information from _X does not flow back in to the expression during this operation, and the original value of _X is not restored on backtracking. Therefore, this predicate should be used with care.

Note 2:   Since the value of _X is changed by the operation, not merely narrowed, it should not be constrained by any equations.

Examples:

/* computes the mean over the solutions given by a generator */
mean(_X where _P, _Mean) :-
    [range(_Acc, [0, 0]), % zero accumulator
count([_P, accumulate(_Acc, _X)], _N), % compute total
  _Mean is midpoint(_Acc)/_N % compute average
].

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solve(_X)

forces solution to sets of interval equations

Arguments: solve(+interval)
Succeeds: solve succeeds if _X is an interval and can be narrowed to a subinterval containing a possible solution to the current set of interval constraints on _X. On backtracking, successive disjoint subintervals will be generated. When solve succeeds, all intervals jointly constrained with _X will also be narrowed.
Fails: solve fails if
• _X is not an interval
• a subinterval containing a possible solution cannot be found
Note 1: The predicate solve can be used to artificially subdivide intervals in order to find solutions to sets of interval equations. See the chapter titled "Relational Arithmetic" in the BNR Prolog User Guide for more information on using solve.
Note 2: If _X is an interval and solve(_X) fails, then there are no solutions to the set of constraints on _X in the initial interval.
Examples:

:- range(X,_), 17 * X**256 + 35 * X**17 - 99 * X == 0, foreach(solve(X) do [nl, print_interval(X)]). [0.0, 0.0] [1.005, 1.0051] YES
Chapter 6
Symbol Manipulation

This chapter describes additional predicates used to process symbols. These predicates are analogous to the string procedures in C or Pascal.

Symbols are case exact, must not begin with an uppercase letter or underscore (unless they are enclosed in quotation marks) and may be any arbitrary sequence of up to 255 printable characters. Symbols may be enclosed in single or double quotation marks. The syntax of symbols is described in detail in the chapter titled "Basic Language Elements" in this manual. See the chapter titled "Filters and Metapredicates" for details of filters associated with symbols and Appendix A for a table of ASCII character codes. Conversion between symbols and other types of terms can also be performed by means of I/O operations as described in the chapter titled "Text Input and Output" in this manual.

Predicates for Manipulating Symbols

The following predicates are available for manipulating symbols.

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>concat</td>
<td>concatenates two symbols</td>
</tr>
<tr>
<td>lowercase</td>
<td>translates uppercase to lowercase</td>
</tr>
<tr>
<td>name</td>
<td>converts between a symbol and a list</td>
</tr>
<tr>
<td>namelength</td>
<td>returns the length of a symbol</td>
</tr>
<tr>
<td>substring</td>
<td>extracts a substring from a symbol</td>
</tr>
<tr>
<td>uppercase</td>
<td>replace lowercase with uppercase</td>
</tr>
</tbody>
</table>

Descriptions of each of the predicates follow.
concat(_Symbol1, _Symbol2, _Symbol3)

*concatenates two symbols*

Arguments: concat(?symbol, ?symbol, ?symbol)

Succeeds: concat succeeds if _Symbol2 is the concatenation of _Symbol1 and _Symbol2. If only _Symbol3 is instantiated, then successive values for _Symbol1 and _Symbol2 are produced on backtracking.

Fails: concat fails if
- _Symbol3, and either _Symbol1 or _Symbol2 are variable
- any of the instantiated arguments are not symbols

Examples:

```prolog
/* Concatenate two symbols */
?- concat(one, two, _X).
  ?- concat(one, two, onetwo).
  YES

/* determine the prefix */
?- concat(_X, 'Year', 'LeapYear')
  ?- concat('Leap', 'Year', 'LeapYear').
  YES

/* use as a generator */
?- concat(_First, _Last, abc).
  ?- concat('', abc, abc).
  ?- concat(a, bc, abc).
  ?- concat(ab, c, abc).
  ?- concat(abc, '', abc).
  YES
```

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lowercase(_Symbol1, _Symbol2)

_translates uppercase to lowercase_

**Arguments:**
lowercase(+symbol, ?symbol)

**Succeeds:**
lowercase succeeds if _Symbol2 is equivalent to _Symbol1 after all uppercase letters in _Symbol1 are replaced by their lowercase counterparts.

**Fails:**
lowercase fails if
- _Symbol1 is not a symbol
- _Symbol2 is neither a symbol nor a variable

```prolog
/* Convert uppercase character in the symbol to their lowercase counterparts. */
?- lowercase('HeLLo', _X).
    ?- lowercase('HeLLo', hello).
    YES
```

**See Also:**
uppercase in this chapter.
name(_Symbol, _List)

converts between a symbol and a list

Arguments: name(?symbol, ?list)

Succeeds: name succeeds if the elements of the list, _List, are the Apple Extended ASCII character codes (integers) composing the symbol, _Symbol.

Fails: name fails if
- _Symbol is neither a variable nor a symbol
- _List is neither a symbol of integers in the range of the Apple Extended ASCII character codes, nor a variable
- both are variables

Examples:

/* Convert a symbol to a list */
?- name(hello, _List).
   YES

/* Convert a list to a symbol */
?- name(_Symbol, [103, 111, 97, 116]).
   ?- name(goat, [103, 111, 97, 116]).
   YES

/* Check for equivalence */
?- name(got, [103, 111, 97, 116]).
   NO

/* Fails, some of the character codes are out */
/* of range */
?- name(_Symbol, [-23, 2000, 96, 97]).
   NO
name_length(_Symbol, _Integer)

returns the length of a symbol

Arguments:  name_length(+symbol, ?integer)
Succeeds:   name_length succeeds if _Integer can be unified with the number of characters in _Symbol.
Fails:      name_length fails if
            • _Symbol is not a symbol
            • _Integer is neither a variable nor an integer
Examples:

/* Find the length of the symbol */
?- name_length(dog, _X).
    ?- name_length(dog, 3).
    YES

/* Check the length of a symbol */
?- name_length(dog, 3).
    ?- name_length(dog, 3).
    YES
substring(Symbol₁, _N, _M, _Symbol₂)

extracts a substring from a symbol

Arguments: substring(+symbol, ?integer, ?integer, ?symbol)

Succeeds: substring succeeds if the substring of length _M > 0 starting at position _N of Symbol₁ is the symbol _Symbol₂. If only Symbol₁ is instantiated, successive values for _N, _M and _Symbol₂ are produced on backtracking.

Fails: substring fails if
• _Symbol₁ is not a symbol of length greater than zero
• _N and _M are neither variables nor integers
• _Symbol₂ is neither a variable nor a symbol of length greater than zero

Examples:

/* Extract the substring which starts at */
/* position 4 and is 3 characters in length */
?- substring(onetwothree, 4, 3, _X).
    ?- substring(onetwothree, 4, 3, two).
    YES

/* Backtracking example */
?- substring(abc, _N, _M, _X).
    ?- substring(abc, 1, 1, a).
    ?- substring(abc, 1, 2, ab).
    ?- substring(abc, 1, 3, abc).
    ?- substring(abc, 2, 1, b).
    ?- substring(abc, 2, 2, bc).
    ?- substring(abc, 3, 1, c).
    YES
uppercase(_Symbol₁, _Symbol₂)

replaces lowercase with uppercase

Arguments: uppercase(+symbol, ?symbol)

Succeeds: uppercase succeeds if _Symbol₂ is equivalent to _Symbol₁ after all lowercase letters in _Symbol₁ are replaced by their uppercase counterparts.

Fails: uppercase fails if
* _Symbol₁ is not a symbol
* _Symbol₂ is neither a symbol nor a variable

Examples:

/* Replace all lowercase character with their uppercase counterparts */
?- uppercase(hello, _X).
    yes
?- uppercase(hello, 'HELLO').
    yes

See Also: lowercase in this chapter.
The text input/output (I/O) predicates support the reading and writing of text, that is, sequences of characters. The target (source or destination) for these predicates may be streams associated with text files or pipes, or symbols, which are limited to sequences of less than 256 characters. The use of symbols with I/O predicates permits easy and efficient conversion between internal and external (that is, text) representations of Prolog objects.

Streams

Streams are sequences of characters associated with text files, text windows or pipes, and are identified by a unique integer while the association is valid. The open predicate returns the identifier, which is used in subsequent read and write operations until a close is performed. Multiple opens of the same file are not permitted and the limit on the number of simultaneously open streams is 10.

Associated with a stream is a stream pointer. This pointer indicates the next character position from where input is taken, or to where output is placed. The first character in a stream corresponds to stream pointer position 0, the second character is position 1, and so on. There are predicates to get (at) and set (seek) the stream pointer.

A text window provides the most recent version of a file, that is, the version that is not yet committed to disk. This mapping is maintained by the Prolog system, so the user need not be aware that reading or writing is occurring to or from a window or file. The contents of a window will not be saved in the file until the user explicitly does so. Note that interactively modifying a window while it is being read as a stream, may produce strange results. Note also that the cursor position in a text window is not the same as its stream pointer.
Pipes are buffers for supporting asynchronous read and writes, that is, two internal file pointers exist (as opposed to one for normal files). Pipes act as a queue; writing occurs at the tail of the queue while reading occurs at the head. Write operations add information to the pipe, while successful read operations consume information. Both readers and writers use the same stream identifier.

**Default Streams**

Many I/O predicates have a form which does not specify the stream as an explicit argument. These predicates use the default input and output streams. The default input stream is a pipe which has a stream identifier of 0. The default output stream is the console window which has a stream identifier of 1. The default input stream is used to acquire interactive input from the user and the default output stream to display system output. Standard input is always submitted from the currently active window, while standard output is always written to the console window.

**Macintosh Pathnames**

The filename passed as an argument to the open predicate must be a valid Macintosh pathname. See the chapter titled "Macintosh File System Access" in this manual for the rules on naming files.

**Input/Output Failure Conditions**

I/O predicates fail generally for one of two types of reasons: Macintosh file system errors or Prolog I/O errors.

**System Errors**

A complete list of the Macintosh file system error codes is presented in Appendix A of Volume III of *Inside Macintosh*. Examples of this type of error include: I/O error, too many files open, bad filename, file is locked, and disk is full. In addition to the Macintosh file system error codes, a number of additional codes have been defined by the Prolog system. These are listed below:
MaxDocErr = -200; (Maximum # of documents exceeded)
UserWindErr = -201; (Illegal operation on a user defined window)
UnkEvErr = -202; (Unknown or unexpected event type seen)
WinOflwErr = -203; (Implementation restriction, Windows <= 32k)
UnImplErr = -204; (Unimplemented or inaccessible routine)
IntMMIerr = -205; (Internal MMI error)
ConsOpErr = -206; (Illegal operation on the Console window)
ProBusyErr = -207; (Open prolog stream can't be closed)
UserCanErr = -208; (User 'Cancel'.)

Prolog Syntax Errors

On input (and occasionally on output) Prolog syntax errors can be generated. These are given error code values greater than zero. Some examples of Prolog syntax errors are:

2 Incomplete term.
16 Bad character in a symbol.
32 Token is too long (input or output).

A complete list of syntax errors is given in Appendix B of this manual. Normally the only one of special interest is "incomplete term". When used with pipes it can be used to synchronize readers and writers of pipes, since a read failure on a pipe with an incomplete term does not consume any characters in the pipe. This permits a subsequent read to be satisfied after additional text has been written to the pipe.

Failure conditions specific to a predicate are noted in the description for the predicate. The general response to error conditions is predicate failure. Some predicates support an error argument; these always succeed but the error code must be checked to determine whether the I/O operation succeeded.
Stream Control Predicates

- at - gets the stream pointer position
- close - closes a stream
- open - opens a stream
- seek - sets stream position
- set_end_of_file - sets end of file
- stream - gets stream information

Character I/O Predicates

These predicates read or write text entities other than Prolog terms, namely, single characters and lines of characters.

- get_char - gets character from input stream
- nl - writes a new line to an output stream
- put_char - writes a character to an output stream
- readln - reads a string of characters from an input stream

Term I/O Predicates

The read predicates (get_term, read, sread) all require period (.) punctuation to delimit the end of each term read. After reading a term, the stream pointer is positioned at the first character of the next term. Reading a term can fail for a number of reasons: if there are no complete Prolog terms from the current stream pointer position to the end of the stream (for example, there may be blank lines or lines of comments trailing the last Prolog term in the stream); attempting to read more than one term from a symbol; syntax errors in complete terms (that is, those with terminating punctuation) and in incomplete terms (that is, no terminating punctuation). Reading an incomplete term from a pipe will cause the read to fail, but nothing in the pipe will be consumed. (This permits subsequent writes to the pipe to satisfy the conditions necessary for a subsequent read to be successful.) All other failure conditions consumes the data, unless there is no data to consume.
(See the chapter titled "Basic Language Elements" in this manual for the syntax of Prolog terms.)

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at(_Stream, _Pointer)

*gets the stream pointer position*

**Arguments:**

at(+Stream, ?Pointer)

**Succeeds:**

Unifies _Pointer with the stream pointer position for the stream _Stream. The stream pointer position is the user's current position (in characters) from the start of the stream. If the stream pointer is at the end of the stream _Pointer is instantiated with the symbol end_of_file. The pointer position for pipes is always 0.

**Fails:**

The at predicate fails if

* _Stream is not a valid stream identifier

* _Pointer cannot be unified with the stream pointer position

**Note:**

When the stream pointer is at the first character of the stream, _Pointer is 0 (zero); at the second character, _Pointer is 1 and so on.

**Examples:**

```prolog
/* stream for benchmarks has just been opened */
?- [open(_X, benchmarks, read_only, 0), at(_X, _Pointer)].
   ?- [open(2, benchmarks, read_only), at(2, 0)].
   YES

/* at can only be used for valid streams */
?- at(42, _Pointer).
   NO
```

**See Also:**

open, seek and set_end_of_file in this chapter.
close(_Stream, _Error)

closes a stream

Arguments: close(+stream, ?integer)

Succeeds: Closes the stream _Stream. If the close operation succeeds, _Error is unified with 0; if the operation is unsuccessful _Error is unified with a non-zero error code as described at the beginning of the chapter.

Fails: The predicate close fails if
- _Stream is not an integer
- _Error cannot be unified with the generated error code
- _Stream is the default I/O stream

Note 1: If the stream is a window, the contents will not be written to a disk file. Use one of the save commands in the File menu to save the window contents on disk.

Note 2: When a pipe is closed any unused data in the pipe is discarded.

Examples:

?- open(_X, benchmarks, read_only, 0), close(_X, 0).
?- [open(2, benchmarks, read_only, 0), close(2, 0)].

YES

/* Mac file system error -38 is 'File not open.' */
?- close(4, _Err).
?- close(4, -38).

YES

/* invalid stream type */
?- close(a, _Err).

NO

See Also: open and stream in this chapter.
get_char(_Char)
get_char(_Stream, _Char)

gets a character from an input stream

Arguments:
get_char(?char)
get_char(+stream, ?char)

Succeeds:
get_char(_Char) takes the next character from the default input stream, converts it to a symbol and unifies it with _Char.
get_char(_Stream, _Char) performs the same operation but takes the next character from the stream specified.

In either case, the stream pointer is incremented by 1.

Fails:
get_char(_Char) and get_char(_Char, _Stream) fail if the converted symbol and _Char do not unify.

get_char(_Char, _Stream) fails if
• _Stream is not an open stream identifier
• the stream pointer position for _Stream is end_of_file.
• _Stream is an empty pipe and not the default input stream

Note:
The default input stream is a pipe which is normally filled by characters entered from the keyboard. If there are no characters in the pipe, get_char waits for a character to be typed and placed in the pipe. A message Type a Key is displayed in the activity box of the current window.

Examples:

/* if q typed after query entered */
?- get_char(C).
   ?- get_char(q).
   YES

?- get_char(0,C).
   ?- get_char(0,q).
   YES
get_term(_Source, _Term, _Error)

reads terms from a stream or symbol

Arguments:  
get_term(+source, ?term, ?integer)

Succeeds:  
get_term reads _Term from the source _Source (stream or symbol). _Error is unified with an integer error code (0 = no error) and can be used to detect syntax errors, including incomplete term (Error = 2), as well as system I/O errors. If an incomplete term is encountered in a pipe, the stream pointer is not advanced. Permitting subsequent data entered into the pipe to complete the term. In all other cases the stream pointer is advanced, independent of whether the error code is 0.

Fails:  
get_term fails if

• _Source is neither a valid stream identifier nor a symbol
• _Error is not unifiable with the error code

Examples:

/* get a term from symbol, fail on any error. */
?- get_term('f(x).',_Term,0).
   ?- get_term('f(x).',f(x),0).
YES

/* Demonstrate use of get_term */
/* with pipes */
?- open(X, pipe, read_write_pipe, _Err).
   ?- open(2, pipe, read_write_pipe, 0).
YES

?- get_term(2, _Term, _Err).
   ?- get_term(2, [], 2).
YES

?- put_term(2, f(x), _Err).
   ?- put_term(2, f(x), 0).
YES
?- get_term(2, _Term, _Err).
    ?- get_term(2, f(x), 0).
    YES

?- close(2, _Err).
    ?- close(2, 0).
    YES

See Also: read and sread in this chapter, and Appendix B.
\texttt{nl()} or \texttt{nl(\_Stream)}

writes a new-line character to an output stream

Arguments: None
\texttt{nl(+stream)}

Succeeds: \texttt{nl()} writes a new-line character to the default output stream, while \texttt{nl(\_Stream)} writes a new-line character to the stream specified.

Fails: \texttt{nl(\_Stream)} fails if
  * \texttt{\_Stream} is not a valid stream identifier
  * \texttt{\_Stream} is a read-only stream

Examples:

?- [\texttt{nl,write('hello')}].
hello
?- [\texttt{nl,write(hello)}].
YES
open(_Stream, _Filename, _Mode, _Error)

opens a stream

Arguments: open(-Stream, +filename, +mode, ?integer)

Succeeds: The predicate open instantiates _Stream with an identifier which is used for subsequent I/O operations on the specified stream. An integer error code is unified with _Error. (0 represents no error.) The mode defines the operations you can perform on the stream.

The following are valid modes:

read_only
The stream can only be used for input; you cannot write to the stream. If a related text window already exists, its contents will be used in preference to the underlying disk file.

read_write
The stream is open for both input and output. If a related text window already exists, its contents will be used in preference to the underlying disk file.

read_window
The text window is opened for the specified stream for input only; you cannot write, using Prolog, to the window. If a window does not exist, one is created.

read_write_window
The text window is opened for input and output. If a window does not exist, one is created.

read_write_pipe
The pipe is created and opened for input and output.

In all the above cases the stream pointer is positioned at the beginning of the stream if it is opened. (If a write operation is performed, any existing information will be overwritten by new information.)

If open is backtracked over, the stream remains open.
Fails: open fails if
• the _Filename specified is not a valid Macintosh pathname
• the file is currently open
• the file cannot be opened
• _Error is not unifiable with the error code

Examples:

/* open a file reading, fail if open fails */
?- open(_Stream, benchmarks, read_only, 0).
    ?- open(2, benchmarks, read_only, 0).
    yes

/* open a pipe */
?- open(_Pipe, anyname, read_write_pipe, _Err).
    ?- open(3, anyname, read_write_pipe, 0).

See Also: close and stream in this chapter.
print(_Term)
print(_Stream, _Term)

*outputs a term to an output stream*

**Arguments:**
- print(+term)
- print(+stream, +term)

**Succeeds:**
print(_Term) prints the _Term to the default output stream, while print(_Stream, _Term) prints the _Term to the stream specified by _Stream. This predicate provides a handle for user-defined pretty printing. If the user procedure portray is not defined then _Term is output, using writeq or swriteq as appropriate, and non-printable structures are converted to printable structures. If the user procedure portray is defined then it is used to specify the style output for _Term.

**Fails:**
print(Stream) and print(_Stream, _Term) fail if the user-defined portray exists and fails.

print(_Stream, _Term) fails if
- _Stream is not a valid stream identifier
- _Stream is an input-only stream
- any component of _Term is longer than 255 characters

**Examples:**

```
?- [nl, print('a\'b')].
'a\'b'
?- [nl, print('a\'b')].
YES

:- [nl, _X = f(_X), print(_X),].
[(_Tree where [(_Tree = f(_Tree))])].
YES
```

**See Also:**
swrite, swriteq, write and write in this chapter.
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print_interval(_Interval)
print_interval(_Stream, _Interval)

prints an interval

Arguments: print_interval(+interval)
            print_interval(+integer, +interval)

Succeeds: print_interval(_Interval) writes to the default stream,
          the 32 bit bounds, outward rounded interval _Interval in the
          form [lowerbound, upperbound], while
          print_interval(_Stream, _Interval) writes the interval
          to the stream _Stream.

Fails: print_interval fails if
       • _Stream is an invalid stream identifier
       • _Stream in an input-only stream
       • the stream pointer position is end_of_file
       • _Interval is not of type interval

Note: The bounds output by print_interval may be slightly wider than
      those input due to internal format conversions. The interval
      bounds are always conservative, that is, the interval always
      contains the input bounds.

Examples:

?- [range(_I, [3.9, 4.9]), nl, print_interval(_I)].
   [3.8999, 4.9001]

?- [range(_Interval_404612, [3.9, 4.9]), nl,
    print_interval(_Interval_404612)].
   YES

See Also: The chapter titled "Arithmetic" in this manual for further
          information on intervals.
**Chapter 7: Text Input and Output**

**put_char(_Char)**
**put_char(_Stream, _Char)**

*writes a character to an output stream*

**Arguments:**
- `put_char(+char)`
- `put_char(+integer, +char)`

**Succeeds:**
- `put_char(_Char)` writes the character in the single character symbol `_Char` into the default output stream.
- `put_char(_Stream, _Char)` puts the character into the output stream specified by `_Stream`.

**Fails:**
- `put_char(_Char)` and `putchar(_Stream, _Char)` fail if `_Char` is not a single character symbol.
- `put_char(_Stream, _Char)` fails if:
  - `_Stream` is not a valid stream identifier
  - `_Stream` is an input-only stream

**Examples:**

```prolog
?- [nl, put_char(a)].  
YES
a
?- [nl, put_char(a)].  
YES

?- [nl, put_char(ab)].
NO
```

**See Also:**
- `get_char` in this chapter.

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**put_term(_Target, _Term, _Error)**

*writes a term to a target*

**Arguments:**

put_term(?integer, +term, ?integer)

**Succeeds:**

Writes the term _Term followed by a term terminator (that is, a period (.) and a space) to a target, _Target. _Target is a stream or a variable which will be instantiated to a symbol containing the character sequence. The output is in a form which is immediately acceptable to get_term, read, and sread. _Error is unified with an integer error code. (0 represents no error.)

**Fails:**

put_term fails if

- _Target is neither a valid stream identifier nor a variable
- _Target is an input-only stream
- _Error is not unifiable with the error code
- the stream pointer position is at end_of_file
- any component of _Term is longer than 255 characters

**Examples:**

?- [nl, put_term(1, 2*3, _Err)].
(2 * 3).
?- [nl, put_term(1, (2 * 3), 0)].
YES
?- put_term(_S, f(a, [b, c]), _Err).
YES
?- put_term('f(a, [b, c]) .', f(a, [b, c]), 0).
YES

**See Also:**

get_term and various write predicates in this chapter.
**read(_Term₁, ..., _Termₙ)**

*inputs terms from the default input stream*

**Arguments:** read(-term₁, ..., -termₙ)

**Succeeds:** Reads a Prolog term or a sequence of Prolog terms from the default input stream (a pipe containing text "entered" from the keyboard). Each term must be terminated with a period (.) and a space or newline.

**Fails:** read fails if
- the term which was input has a syntax error
- the sequence of terms specified by the argument list does not unify with sequence of terms read

**Note:** A period (.) followed by a return character or space character triggers error recovery if the preceding expression cannot be parsed.

**Examples:**

```
?- read(X, Y).
a. b.
   ?- read(a, b).
   YES
```

**See Also:** `get_term` and `sread` in this chapter.
**readln(_Symbol)**
*readln(_Stream, _Symbol)*

reads the sequence of characters up to the next newline from an input stream

**Arguments:**
readln(?symbol)
readln(+stream, ?symbol)

**Succeeds:**
readln constructs a symbol composed of all the characters from the stream pointer position of the input stream to the next end of line character. readln(_Symbol) performs the read operation on the default input stream while readln(_Stream, _Symbol) performs the read operation on the stream specified by _Stream. _Symbol is unified with the constructed string and the pointer position is moved past the end of line character. End of file is treated as an end of line but is not consumed.

**Fails:**
readln(_Symbol) and readln(_Stream, _Symbol) fail if _Symbol is a sequence of more than 255 characters.

readln(_Stream, _Symbol) fails if
- _Stream is not a valid stream identifier
- the stream pointer for _Stream is end_of_file or the pipe is empty

**Examples:**

?- readln(Line).
a. b.
?- readln('a. b').
YES
Chapter 7: Text Input and Output

seek(_Stream, _Pointer)

sets pointer address

Arguments: seek(+stream, +pointer)

Succeeds: seek moves the pointer to an offset _Pointer from the beginning of the stream specified by _Stream. _Pointer is either an integer (which represents a number of characters) or the symbol end_of_file. Advancing the stream pointer in a pipe purges any data behind the new stream pointer.

Fails: seek fails if
• _Stream is not a valid stream identifier
• _Pointer is neither an integer nor the symbol end_of_file
• _Pointer is greater than the number of characters in the stream
• _Stream is a default I/O stream

Note: When the stream pointer is at the first character, _Pointer is 0 (zero), at the second character, _Pointer is 1 and so on.

Examples:

/* open the file benchmarks */
?- open(_X, benchmarks, read_only, 0).
   yes

/* Move the pointer 4 character from the start */
?- seek(2, 4), at(2, _Pointer).
   yes

/* Move pointer to the end of the file */
?- seek(2, end_of_file).
   yes

See Also: at and set_end_of_file in this chapter.

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set_end_of_file(_Stream)

sets end of file

Arguments: set_end_of_file(+stream)

Succeeds: Sets the end of stream marker at the current position in the stream _Stream. If the stream is a pipe, all data currently in the pipe will be discarded.

Fails: set_end_of_file fails if
• _Stream is not a valid stream identifier
• _Stream is the default I/O stream

See Also: at and seek in this chapter.
sread(_Source, _Term1, ..., _Termn)

*reads terms from a stream or symbol*

**Arguments:**

sread(+source, ?term1, ..., ?termn)

**Success:**

Reads a Prolog term or a sequence of terms from a stream or symbol. (Only a single term can be read from a symbol.) Each term must be terminated with a period (.) and a space or newline. Other occurrences of space or new lines are usually ignored, as are comments.

**Fails:**

sread fails if

- _Source is neither a valid stream identifier nor a symbol
- a term in the sequence is not parsed successfully
- _Source is a stream (pipe or file) and the stream pointer reaches the end_of_file before the read is satisfied
- an attempt is made to read more than one term from a symbol

**Examples:**

?- sread(O, X, Y).
a. b.
?- sread(O, a, b).
YES

?- sread('1.23.', X).
?- sread('1.23.', 1.23).
YES

?- sread('a. b.', X, Y).
NO

**See Also:** read and get_term in this chapter.
**Chapter 7: Text Input and Output**

**stream(_Stream, _Filename, _Mode)**

*accesses stream information*

**Arguments:**

```prolog
stream(?integer, ?filename, ?mode)
```

**Succeeds:**

stream unifies _Stream, _Filename and _Mode with the stream, name and mode of the first open stream. Upon backtracking, further solutions are generated if they exist. _Filename is the full pathname of the file or pipe.

**Fails:**

stream fails if _Stream, _Filename, and _Mode do not unify with the stream identifier, name, and mode of an open stream.

**Note:**

Valid modes are read_only, read_write, read_window, read_write_window and read_write_pipe.

**Examples:**

```prolog
?- stream(_Stream, _Filename, _Mode).
?- stream(0, default_in, read_write_pipe).
?- stream(1, 'HD:Prolog:console', read_write_window).
YES
```
swrite(_Stream, _Term₁, ..., _Termₙ)
swrite(_Symbol, _Term₁, ..., _Termₙ)

**writes terms to a stream or symbol**

**Arguments:**
- swrite(+stream, +term₁, ..., +termₙ)
- swrite(?symbol, +term₁, ..., +termₙ)

**Succeeds:**
swrite(_Stream, _Term₁, ..., _Termₙ) writes the specified sequence of Prolog terms to the stream _Stream. The terms are written according to current operator declarations, and spaces are inserted to separate operators from their arguments. Unbound variables and tail variables are written as their names and escape sequences inside symbols are expanded. Output does not include a period or a space after each term.

swrite(_Symbol, _Term₁, ..., _Termₙ) unifies _Symbol with the sequence of terms.

**Fails:**
- swrite(_Stream, _Term₁, ..., _Termₙ) fails if
  - _Stream is not a valid stream identifier
  - _Stream is an input-only stream

- swrite(_Symbol, _Term₁, ..., _Termₙ)
  - _Symbol is neither a symbol nor a variable
  - _Symbol is a symbol which does not unify with the list of characters that would be output from swrite
  - any component of any term is longer than 255 characters

**Errors:**
See section titled "I/O Failure Conditions" in this chapter.
Examples:

?- [nl, swrite(1, 'answer is', 16 mod 3)].
answer is(16 mod 3)
?- [nl, write(0, 'answer is', (16 mod 3))].
YES

/* no spaces between terms */
?- swrite(_S, 3, '+', 4, 6).
YES

?- swrite('3+46', 3, '+', 4, 6).
YES

?- [nl, swrite(1, 'X', X)].
X_X
?- [nl, swrite(1, 'X', _X)].
YES

See Also: write, writeq, swriteq, put_term and print in this chapter, and the section on operators in the chapter "Basic Language Elements".
**swriteq(_Stream, _Term1, ..., _Termn)**

**swriteq(_Symbol, _Term1, ..., _Termn)**

writes terms to a stream or symbol

**Arguments:**

- `swriteq(+target, +term1, ..., +termn)`
- `swriteq(?symbol, +term1, ..., +termn)`

**Succeeds:**

- `swriteq(_Stream, _Term1, ..., _Termn)` writes the specified sequence of Prolog terms to the stream `_Stream`.
- `swriteq(_Symbol, _Term1, ..., _Termn)` unifies symbol with the specified sequence of Prolog terms.

This predicate is the same as `swrite` except that it places single quotation marks around symbols when necessary. Symbols beginning with an underscore are never quoted. Escape sequences are not expanded and variables and tail variables are written as their names. This permits the written term sequence to be read with `sread`, `read`, or `get_term`, without ambiguity.

**Fails:**

- `swriteq(_Stream, _Term1, ..., _Termn)` fails if
  - `_Stream` is not a valid stream identifier
  - `_Stream` is an input-only stream

- `swriteq(_Symbol, _Term1, ..., _Termn)` fails if
  - `_Symbol` is neither a symbol nor a variable
  - `_Symbol` cannot be unified with the list of characters that would be output from `swriteq`

Both variants of the predicate fail if any component of any term is longer than 255 characters.

**Examples:**

```
?- [nl, swriteq(1, 'answer is', 16 mod 3)].
'answer is' (16 mod 3)
?- [nl, swriteq(1, 'answer is', (16 mod 3))].
YES
```
?- swriteq(_S,3,+,4,6).
  ?- swriteq('3 '+'4 6 ', 3, '+', 4, 6).
  YES

?- [nl,swriteq(1,'X',X)].
  'X' _X
  ?- [nl,swriteq(1, 'X', _X)].
  YES

See Also: swrite, write, writeq, put_term and print in this chapter, and bind_vars in the chapter titled "Filters and Metapredicates".
**write**(_Term₁, ..., _Termₙ)  

writes terms to the default output stream

**Arguments:** write(+Term₁, ..., +Termₙ)  

**Succeeds:** Writes the specified sequence of Prolog terms to the default output stream. The terms are written according to the current operator declaration and spaces are inserted to separate operators from their arguments. Unbound variables and tail variable are output as their canonical names. Parentheses may be output in expressions involving operators. Output does not include a period or space after each term.

**Fails:** write fails if any component of any term has more than 255 characters.

**Note:** Use writeq to put quotation marks around symbols.

**Examples:**

```prolog
?- [nl, write('answer is', 16 mod 3)].
anwer is(16 mod 3)
    ?- [nl, write('answer is', (16 mod 3))].
YES

/* no spaces between terms */
?- [nl, write(3, +, 4, 6)].
3+46
    ?- [nl, write(3, '+', 4, 6)].
YES

?- [nl, write('X', X)].
X_X
    ?- [nl, write('X', _X)].
YES
```

**See Also:** swrite, writeq, swriteq and print in this chapter, and the section on operators in the "Basic Language Elements" chapter.
writeq(_Term₁, ..., _Termₙ)

writes a term

Arguments: writeq(+term₁, ..., +termₙ)

Succeeds: writeq(_Term₁, ..., _Termₙ) writes the specified sequence of Prolog terms to the default output stream.

This predicate is the same as write except that it places single quotation marks around symbols when necessary. Escape sequences are not expanded and variables and tail variables are written as their names.

Fails: writeq fails if any component of any term is longer than 255 characters.

Note: Standard listener output uses writeq.

Examples:

?- [nl, writeq('answer is', 16 mod 3)].
'answer is' (16 mod 3)
    ?- [nl, writeq('answer is', (16 mod 3))].
YES

?- [nl, writeq(3, '+', 4, 6)].
3 ' + ' 4 6
    ?- [nl, writeq(3, '+', 4, 6)].
YES

?- [nl, writeq('X', X)].
'X' _X
    ?- [nl, writeq('X', _X)].
YES

See Also: swrite, write, swriteq, put_term and print in this chapter.
A Prolog knowledge base is a collection of clauses stored in an area of computer memory called the world stack which is structured as a stack of modules called contexts. These contexts exist in memory as a last-in-first-out (LIFO) stack where the top of the stack is the current context (See Figure 8-1). Each context contains a set of clauses that have either been entered interactively or loaded from a file and may vary in size. The knowledge base at any given time is the union of the contexts that exist at that time.

Figure 8-1. A representation of contexts
A number of predicates are provided to manage the knowledge base. Empty contexts can be created on top of the stack using enter_context. A set of clauses contained in a file can be loaded into a new context using load_context. reload_context is used to load a context which already exists. (If necessary, all contexts above the context being reloaded, are also reloaded. However, contexts which are not associated with files, or any dynamic assertions, are lost.)

Contexts can be removed using exit_context. This returns the knowledge base to the state it was in when the context was entered. The effect of any asserts, retracts or operator definitions that have taken place during the lifetime of the context are lost.

Clauses in Contexts

Names may be global, or local to a single context. Local names begin with a dollar sign ($). Predicates with global names may have their constituent clauses defined in different contexts. In this case, the clause order is "top to bottom" within each context, with the contexts ordered from most recent to least recent (B, A, userbase, base in Figure 8-1). This strategy permits controlled refinement and overloading of predicate definitions.

Predicates which have local names are not visible outside their context. (In modular programming terms, the global predicates form the "interface procedures" of the module, while the local predicates are the implementation.) Totally independent local predicates with the same name may exist in different contexts.

Clauses may only be added to or deleted from the current context. The predicates asserta and assertz add clauses to the top and the bottom of the current context respectively. retract and retractall delete clauses from the current context. Note that since clauses can only be asserted in the current context, assertz behaves somewhat differently when the clause definition is spread across several contexts. The clause is actually asserted at the end of the current context which may be in the middle of the full clause chain for that predicate. A number of predicates are also available for retrieving clause definitions, clause heads and the names of various predicates.
Clause definitions can be hidden by using the predicate hide. This can be used as a security mechanism. Clauses can also be closed, using close_definition. Clauses are not subject to assert and retract. This includes implicit assertions due to context loading.

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assert(_Clause)
asserta(_Clause)

adds a clause to the top of the current context

Arguments: assert(+clause)
              asserta(+clause)

Succeeds: asserta adds a new clause to the top of the list of clauses in the
current context. _Clause must be bound and unifiable with either
_Name(_Args..) :- [_Body..] where _Name is a symbol, or with
_Name(_Args..) where _Name is any symbol except ":-".

Fails: assert and asserta fail if
• _Clause is a variable
• _Clause is not unifiable with the form described above
• the functor of the clause head is the name of a closed predicate

Errors: An error is generated if the clause contains an interval, a bucket,
or a looped list.

Examples:

/* adds a fact to the top of the current context */
?- assert(father(tom, susan)).
     - assert(father(tom, susan)).
     YES

/* add a rule to the top of the current context */
?- assert(father(_X, _Y) :- [parent(_X, _Y), male(_X)]).
     - assert(father(_X, _Y) :- [parent(_X, _Y), male(_X)]).
     YES

/* fails, the argument is variable */
?- assert(_).
     NO

See Also: assertz in this chapter.
assertz(_Clause)

adds a clause to the bottom of the current context

Arguments:  assertz(+clause)

Succeeds:  assertz adds a clause to the bottom of the list of clauses in the current context. _Clause must be instantiated and unifiable either with _Name(_Args..) :- [_Body..] where _Name is a symbol, or with _Name(_Args..) where _Name is any symbol except ":-".

Fails:  assertz fails if
  • _Clause is a variable
  • _Clause is not unifiable with the form described above
  • the functor of the clause is the name of a closed predicate

Errors:  An error is generated if the clause contains an interval, bucket, or a looped list.

Note:  Since assertz applies to the current context, the clause is only placed at the end of the clause chain if the predicate definition is confined to that context.

Examples:

/* add a fact to the end of the current context */
?- assertz(father(tom, susan)).
   ?- assertz(father(tom, susan)).
   YES

/* add a fact to the top of the current context */
?- asserta(father(james, jenifer)).
   ?- asserta(father(james, jenifer)).
   YES

/* add another fact to the bottom */
?- assertz(father(adam, abel)).
   ?- assertz(father(adam, abel)).
   YES
/* Query the predicate */
?- father(_X, _Y).
    father(james, jenifer).
    father(tom, susan).
    father(adam, abel).
YES

/* fails, the argument is not instantiated */
?- assertz(_).
NO

See Also: assert and asserta in this Chapter.
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\[ \text{clause(}_{-}\text{Clause}) \]

\textit{generates clause definitions}

**Arguments:** \texttt{clause(\_Clause)}

**Succeeds:** The \texttt{clause} predicate searches the knowledge base and unifies \_Clause with a matching clause. Upon backtracking, further clause definitions are generated if they exist. If \_Clause is instantiated it must be unifiable with \_Name(\_Args..) :- [\_Body..] where \_Name is either a variable or a symbol.

**Fails:** \texttt{clause} fails if
- \_Clause is neither a variable nor a clause unifiable with the form described above
- there is no matching clause in the knowledge base
- the predicate specified by the clause is a hidden one

**Examples:**

\[
\begin{verbatim}
/* Assuming standard definition for member */
/* (not part of preloaded system) */

?- clause(member(\_Args..):-\_Body).
?-
clause((member(\_X, [\_X, \_..]) :- []).)
?-
clause((member(\_X, [\_, \_Xs..]) :- [member(\_X, \_[\_Xs..])])).

YES
\end{verbatim}
\]

**See Also:** \texttt{clause\_head} and definition in this chapter.
clause_head(_Head)

generates clause heads

Arguments: clause_head(?clause_head)

Succeeds: The clause_head predicate searches the knowledge base and unifies _Head with the head of a matching clause. Upon backtracking, further clause heads are generated if they exist. If _Head is instantiated it must be unifiable with _Name(_Args...) where _Name is either a variable or a symbol.

Fails: clause_head fails if

• _Head is neither a variable nor a clause unifiable with the form described above

• a matching clause head cannot be found

Note: clause_head works on hidden definitions.

Examples:

/* Assuming standard definition for member */
/* (not part of preloaded system) */
?- clause_head(member(_Args...)).
?- clause_head(member(_X, [_X, _..])).
?- clause_head(member(_X, [_X, _..])).

YES

See Also: clause in this chapter.
close_definition(_Name)

closes a predicate

Arguments: close_definition(+symbol)

Succeeds: close_definition closes the predicate _Name. A closed predicate is not subject to assert or retract. Clauses may not be added to, or deleted from closed predicates.

Fails: close_definition fails if
• _Name is not a symbol
• the predicate _Name is not defined in the clause space

Examples:
/* add some facts using listener assert syntax */
dog(poodle).
OK
dog(terrier).
OK

/* close the predicate dog */
?- close_definition(dog).
?- close_definition(dog).
YES

/* try to assert another clause */
?- assert(dog(spaniel)). Function closed, unable to add new clause
NO

See Also: closed_definition in this chapter.
closed_definition(_Name)

generates or verifies closed predicates

Arguments:  
closed_definition(?symbol)

Succeeds:  
If _Name is a variable, then closed_definition searches the knowledge base for the first closed predicate and generates the name of the predicate. Upon backtracking, further names will be generated if they exist. If _Name is a symbol, then closed_definition verifies the existence of the closed predicate _Name in the knowledge base.

Fails:  
closed_definition fails if
• _Name is neither a variable nor a symbol
• there are no closed predicates in the knowledge base
• _Name is not a closed predicate

Examples:

/* add some facts using listener assert syntax */
dog(poodle).
OK

dog(terrier).
OK

/* close the predicate dog */
?- closed_definition(dog).
YES

/* query for closed predicates */
?- closed_definition(_X).
    ?- closed_definition(dog).
YES

See Also:  
close_definition in this chapter.
**consult**(_Filename_)

loads a text file into the current context

**Arguments:**
consult(+filename)

**Succeeds:**
consult loads a text file into the current context. All clauses in the file are added to the current context. (This corresponds to Edinburgh consult in a single context world.)

**Fails:**
consult fails if _Filename_ is not an existing text file.

**Note:**
The preferred mechanism is load_context; consult is provided to support Edinburgh semantics.

**Examples:**

/* consult a file */
?- consult('MyFile').
    ?- consult('MyFile').
    YES

**See Also:**
load_context in this chapter.
context(_Name)

*generates or verifies contexts*

**Arguments**  
context(?symbol)

**Succeeds:**  
If _Name is a variable, it becomes instantiated to the name of the current context. Upon backtracking, further contexts are generated if they exist. If, _Name is a symbol, context verifies the existence of a context of the specified name.

**Fails:**  
context fails if
* _Name is neither a symbol nor a variable
* _Name is not an existing context

**Note:**  
An ordered list of the existing contexts is also displayed in the **Contexts** menus.

**Examples:**

```prolog
/* The context base is loaded by default when the Prolog application is opened. Userbase is the default context. */
?- context(_X).
?- context(userbase).
?- context(base).
YES

/* create a new context */
?- enter_context(temp).
?- enter_context(temp).
YES

/* the new context appears at the top of the list */
?- context(_X).
?- context(temp).
?- context(userbase).
?- context(base).
YES
```

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**definition**(_Clause, _Context)

*generates or verifies clause definitions*

**Arguments:** definition(?clause, ?symbol)

**Succeeds:** The definition predicate searches the knowledge base and unifies _Clause with a matching clause and _Context with the name of the context in which the clause was found. Upon backtracking, further clause definitions are generated if they exist. If _Clause is instantiated it must be unifiable with _Name(_Args..) :- [_Body..] where _Name is either an uninstantiated variable or a symbol.

**Fails:** definition fails if
- _Clause is neither a variable nor a clause unifiable with the form described above
- _Context is neither a symbol nor a variable
- there is no matching clause
- the predicate specified by the clause head is a hidden one

**Examples:**

```prolog
/* Assuming standard definition for member */
/* (not part of preloaded system) */

?- definition(member(_Arga ..) :- _Body, _Ctxt).
?- definition((member(_ X, [_ X, _..]) :- []). memctxt).
?- definition((member(_X, [__, _Xs ..]) :- [member(_X, [_Xs ..])]), memctxt).
```

**See Also:** clause and clause_head in this chapter.
enter_context(_Name)

*creates a new context*

**Arguments:**

enter_context(+symbol)

**Succeeds:**

Creates a new context _Name at the top of stack. This becomes the current context.

**Fails:**

enter_context fails if _Name is not a symbol.

**Examples:**

```prolog
/* The context base is loaded by default when the Prolog application is opened. Userbase is the default context created for users. */

?- context(_X).
   ?- context(userbase).
   ?- context(base).
   YES

/* create a new context */

?- enter_context(temp).
   ?- enter_context(temp).
   YES

/* the new context appears at the top of the list */

?- context(_X).
   ?- context(temp).
   ?- context(userbase).
   ?- context(base).
   YES
```

**See Also:**

exit_context and context in this chapter.
exit_context(_Name)

exits a context

Arguments: exit_context(+symbol)

Succeeds: Removes the context specified by _Name from the stack. The context stack is returned to the state it was in prior to the corresponding enter_context. All intervening asserts, retracts and operator definitions that took place during the life of that context are removed.

Exiting the predefined base context succeeds, but has no effect. Exiting userbase has the standard semantics but the system automatically creates a new (empty) userbase.

Fails: exit_context fails if _Name is not an existing context.

Note: exit_context must be used with care within programs as it can leave dangling references if any variables are instantiated to structures or names defined in the context(s) removed, or if execution of removed code is in progress.

See Also: context and enter_context in this chapter.
hide(_Name)


ty a predicate

Arguments: hide(+symbol)
Succeeds: Hides the specified predicate. Hidden predicates may be called, but their bodies cannot be seen.
Fails: Hide fails if
• _Name is not a symbol
• _Name is not a defined predicate
Note 1: Clause and definition predicates fail on a hidden predicates.
Note 2: Tracing, emulation and explanation facilities do not work on hidden predicates.
Note 3: The hide mechanism may be used as a security feature, since it cannot be broken using normal debugging facilities.
Examples:

/* Assert a clause */
animal(_X) :- dog(_X).
OK
?- hide(animal).
YES
?- hide(animal).
YES
?- clause(animal(_..):-_);
definition(animal(_..):-_,_).
NO
?- clause_head(animal(_..)).
YES
?- clause_head(animal(_X)).
YES
:- listing(animal).
animal(_X) :- [ ... ]. % Context: "userbase", Hidden Definition.
YES

See Also: clause_head in this chapter.
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listing()  
listing(_Name)  
listing(_Name, _Context)

displays predicate definitions

Arguments: None.

Succeeds:
listing() outputs all clause definitions in the current context to the console window.

listing(_Name) displays all clause definitions in the knowledge base for the predicate name _Name.

listing(_Name, _Context) displays all clause definitions in the knowledge base for the predicate name _Name in the context _Context.

In each case the source context for each clause is output as a comment.

Fails:
listing() never fails.

listing(_Name) fails if _Name is not a symbol.

listing(_Name, _Context) fails if _Name and _Context are not symbols.

Notes: The clauses are listed in execution search order. Individual predicates may also be listed using the Contexts menu.

Examples:

/* enter a new context and add some clauses */
?- enter_context(family).
  YES
mother(jessica, justine).
  OK

mother(geraldine, francis).
  OK

/* enter another context and add another clause */
?- enter_context(tree).
  ?- enter_context(tree).
  YES

mother(pat, francis).
  OK

/* list the clauses for the predicate */
?- listing(mother).
  mother(pat, francis) .  % Context: "tree"

  mother(jessica, justine) .  % Context: family

  mother(geraldine, francis) .  % Context: "family"

  ?- listing(mother).
  YES

?- listing.
  mother(pat, francis) .  % Context: "tree"

  ?- listing().
  YES

?- listing(mother, family).
  mother(jessica, justine) .  % Context: family

  mother(geraldine, francis) .  % Context: "family"

  ?- listing(mother, family).
  YES
load_context(_Filename)

loads a text file

Arguments: load_context(+filename)
Succeeds: load_context creates a new context with the same name as the specified text file, then enters the clauses from the text file into the newly created context. If the file has already been loaded then load_context succeeds, but has no other effect.
Fails: loadContext fails if _Filename is not an existing text file.
Note: A text file may also be loaded using the Load File.. command in the Contexts menu.
Examples:

?- load_context('MyFile').  
?- load_context('MyFile').
YES

See Also: reload_context in this chapter.
predicate(_Name)

*generates or verifies defined predicates*

**Arguments:**

`predicate(?symbol)`

**Succeeds:**

If `_Name` is a variable, `predicate` searches the knowledge base for the most recently defined predicate and returns its name. Upon backtracking, further names are returned if they exist. If `_Name` is a symbol, then `predicate` verifies the existence of a defined `predicate` with the name specified.

**Fails:**

`predicate` fails if

- `_Name` is not a symbol
- the predicate `_Name` is not defined in the knowledge base

**Examples:**

```prolog
?- predicate(predicate).
?- predicate(predicate).
YES

?- predicate(_P).
?- predicate(accumulate).
?- predicate(solve).
?- predicate(sub_solve).
.
.
.
YES
```

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reconsult(_Filename)

reloads a text file

Arguments: reconsult(+filename)
Succeeds: reconsult loads the text file _Filename into the current context. Any predicates defined in _Filename will have their clauses in the current context retracted before the file is loaded. (This corresponds to Edinburgh consult in a single context world.)
Fails: reconsult fails if _Filename is not an existing file.
Examples:

?- reconsult('Mydisk:MyFile').
   reconsult('Mydisk:MyFile').
YES

See Also: consult and reload_context in this chapter.
reload_context(_Filename)

reloads a context

**Arguments:**
reload_context(+filename)

**Succeeds:**
If the context is not already loaded, then reload_context creates a new context with the same name as the specified text file. It then enters the clauses from this file into the newly created context. If the file has already been loaded, then the contents of the context are completely replaced with the contents of _Filename. If necessary, all contexts which are higher on the stack (loaded after _Filename) will also be replaced, although any dynamic assertions in any of the contexts will be lost. Any contexts removed, but not corresponding to files, are lost.

**Fails:**
_FILENAME is not the name of an existing text file.

**Note:**
reload_context must be used with care within programs as it can leave dangling references if any variables are instantiated to structures or names defined in the context(s) removed.

**Examples:**

?- reload_context('MyFile').
   ?- reload_context('MyFile').
   YES

**See Also:**
reload_context in this chapter.
retract(_Clause)

removes clauses from the current context

**Arguments:**

`retract(+clause)`

**Succeeds:**

`retract` searches the current context for the first matching clause and removes it. Upon backtracking, all other matching clauses are successively removed. _Clause must be instantiated and unifiable with either _Name(_Args..) :- [_Body..] where _Name is a symbol, or with _Name(_Args..) where _Name is any symbol except ":-".

**Fails:**

`retract` fails if

* _Clause is a variable
* _Clause is not unifiable with the form described above
* there are no matching clauses

**Note 1:**

Execution in progress of the retracted clauses is not affected.

**Note 2:**

Space for the clauses is not recovered; removing the context will recover space for the entire context. (State space has dynamic space recovery.)

**Examples:**

```prolog
/* add some facts using listener assert syntax */
dog(poodle).
OK
dog(terrier).
OK
animal(_X) :- dog(_X).
OK
```
See Also:  

retractall in this chapter.
**retractall(_Head)**

*removes all clauses from the current context*

**Arguments:**
`retractall(+clause_head)`

**Succeeds:**
Removes all clauses with matching clause heads from the current context in one operation. `retractall` succeeds even if there are no matching clauses.

**Fails:**
`retractall` fails if
- `Head` is an uninstantiated variable
- the functor of the clause head is an uninstantiated variable

**Examples:**

```prolog
/* add some facts using listener assert syntax */
dog(poodle).
OK
dog(terrier).
OK

?- retractall(dog(_X)).
    YES
```

**See Also:**
`retract` in this chapter.
save_ws(_Filename)

*save* the clause knowledge base

**Arguments:**

save_ws(+filename)

**Succeeds:**

Saves the clause knowledge base, (that is, the stack of contexts) and configuration data (stack sizes and initial goal) as a binary image in the file specified.

**Fails:**

save_ws fails if _Filename is not a valid Macintosh file specification.

**Notes:**

The workspace file is loaded with the application when the file is "opened" from the desktop.

**Examples:**

?- save_ws(workspace).
?- save_ws(workspace).

YES
symbol_name(_Name)

generates or verifies the names of existing symbols

Arguments: symbol_name(?symbol)

Succeeds: If _Name is a variable, symbol_name searches the knowledge base for the most recent symbol and generates its name. Upon backtracking, further names are generated if they exist. If _Name is a symbol, then predicate verifies the existence of the specified symbol in the knowledge base.

Fails: symbol_name fails if _Name is neither a symbol nor a variable.

Examples:

?- symbol_name(userbase).
  ?- predicate(userbase).
  YES

?- symbol_name(_Sn).
  ?- symbol_name($local).
  ?- symbol_name(base_ws).
  ?- symbol_name(accumulate).

  YES
visible(_Name)

generates or verifies visible names

Arguments: visible(?symbol)

Succeeds: If _Name is a variable, then visible searches the knowledge base for the first visible predicate (that is, one which has not been hidden using the predicate hide) and generates its name. Upon backtracking, further names are generated if they exist. If _Name is a symbol then visible verifies the existence of a visible predicate with the name specified.

Fails: visible fails if
• _Name is neither a symbol nor a variable
• there is no visible predicate _Name

Examples:

/* add a predicate using listener assert syntax */
dog(poodle).
OK

?- visible(_P).
   ?- visible(dog).
   ?- visible(accumulate).
   ?- visible(solve).
   YES

?- hide(dog).
   ?- hide(dog).

?- visible(_P).
   ?- visible(accumulate).
   ?- visible(solve).
   ?- visible(sub_solve).
   YES
with_context(_Name, _Goal)

executes predicate in context

Arguments:  with_context(+symbol, +goal)
Succeeds:  Executes the goal _Goal in a new temporary context _Name (isolate from clause space side effects). The temporary context is removed whether _Goal succeeds or fails unless with_context is cut within _Goal.
Fails:  with_context fails if
• _Name is not a symbol
• _Goal fails
Note:  with_context must be used with care within programs as it can leave dangling references if any variables are instantiated to structures or names defined in the temporary context.
Examples:

/* Use with_context to discard side effects of op */
?- with_context(temp [nl, write('Hello')]).
Hello
    ?- with_context(temp, [nl, write('Hello')]).
YES
State spaces are internal data bases for storing Prolog structures which are independent of the clause space. They provide user controlled storage on either a global or local basis. The important properties of state spaces include:

- Separation of data (state) from programs (clauses). This permits storing data without asserting its truth.
- Independence from the context stack.
- Automatic incremental garbage collection.
- Flexible data access.
- Support for atomic transactions including order preserving replacement.

The global state space is decoupled from contexts, which permits moving structures between contexts. Only one global state space exists in memory at any given time, but a global state space can be saved and restored from a binary file using the load_state and save_state predicates.

The local state space is associated with a context and exists for the life of that context. The local state space is normally only accessible to clauses inside the context, thus permitting state information to be stored private to that context.

The unit of storage in state spaces is the Prolog structure with the functor acting as a principal key. (The syntax of structures is described in the chapter titled "Basic Language Elements" in this manual.) For each functor there is an ordered list of structures defining the recall order associated with that functor. The predicates remember, remembera, rememberz, recall, recallz, forget and forget_all are used to store structures in a state space, retrieve them, or remove them. These predicates are analogous to the clause space predicates assert, asserta, assertz, clause, retract and retractall.
State spaces are automatically extended when required, memory permitting. Removing items from a state space automatically results in storage being reclaimed. The predicate `new_state` may be used to create and destroy state spaces.

Looped lists (for example, `_X = [a, _X..]`) cannot be stored in state spaces. Also, structures containing intervals or buckets cannot be stored in a state space since they are meaningless when disconnected from their contexts. For similar reasons, constrained variables lose their constraints when stored in state spaces. (These restrictions also apply to storing structures in the clause space.)

**State Space Predicates**

- `forget` - removes structures from a state space
- `forget_all` - removes all structures from a state space
- `inventory` - generates the principal functors of all structures in a state space
- `load_state` - loads the global state space
- `new_state` - creates a new state space
- `recall` - retrieves structures in recall order
- `recallz` - retrieves structures in reverse order
- `remember` - store a structure in a state space at the beginning of the recall order
- `remembera` - same as `remember`
- `rememberz` - store a structure in a state space at the end of the recall order
- `save_state` - saves the global state space
- `update` - replaces a structure while maintaining the recall order
forget(_Structure)
forget(_Structure, $local)

removes structures from a state space

Arguments:  
forget(+structure)
forget(+structure, +$local)

Succeeds:  
forget(_Structure) removes the first structure in the recall order which unifies with _Structure from the global state space. Upon backtracking, any other matching structures are removed. forget(_Structure, $local) removes the matching structures from the local state space.

If forget succeeds, _Structure will be bound to the structure that was actually removed from the state space.

Fails:  
forget fails if
   • the functor of the structure is a variable
   • there are no matching structures, or no state space allocated
   • the second argument is not $local

Note:  
If forget is placed in the scope of a state space structure generator (for example, [recall(fred(_X)), forget(fred(_X)), fail] it may cause an unexpected termination of the generator.

Examples:

/* Store two structures in the state space */
?- remember(fred(_X, 3, [_, apple, _Y, _X])).
  ?- remember(fred(_X, 3, [_ , apple, _Y, _X])).
  YES
?- remember(fred(4, 2, [])).
  ?- remember(fred(4, 2, [])).
  YES
/* Now remove a structure by pattern matching */
?- forget(fred(_X, 3, _U)).
    ?- forget(fred(_X, 3, [_1, apple, _2, _X])).
    YES

/* the first matching item has been removed. */
?- recall(fred(_X, _Y, _Z)).
    ?- recall(fred(4, 2, [])).
    YES

See Also: forget_all in this chapter.
**forget_all(Structure)**

**removes all structures from a state space**

**Arguments:**
- `forget_all(+structure)`
- `forget_all(+structure, +$local)`

**Succeeds:**
- `forget_all(+structure)` removes all structures with instantiated functors which unify with `Structure` from the global state space. If there are no matching structures `forget_all` succeeds anyway. `forget_all` is a filter; `Structure` is unchanged.
- `forget_all(+structure, +$local)` removes the matching structures from the local state space.

**Fails:**
- `forget_all` fails if
  - the functor of `Structure` is a variable
  - there are no matching structures, or no state space allocated
  - the second argument is not `$local`

**Examples:**

```prolog
/* Store two structures in the state space */
:- remember(fred(_X, 3, [__ apple, _Y, _X])).
YES
:- remember(fred(4, 2, [])).
YES

/* Now remove the structures by pattern matching */
?- forget_all(fred(_X, _Y, _Z)).
    ?- forget_all(fred(_X, _Y, _Z)).
YES

/* Use recall to verify both structures have been removed */
?- recall(fred(_X, _Y, _Z)).
NO
```

**See Also:**
- `forget` in this chapter.

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inventory(_Pfunctor)
inventory(_Pfunctor, $local)

generates the functors of all structures in a state space

Argument: inventory(+symbol)
inventory(+symbol, +$local)

Succeeds: If _Pfunctor is a variable, inventory(_Pfunctor) generates on backtracking, the principal functors of all structures in the global state space. If _Pfunctor is a symbol, then inventory verifies the existence of a structure whose principal functor is _Pfunctor. inventory(_Pfunctor, $local) generates the principal functors of structures in the local state space.

Fails: inventory fails if
• _Pfunctor is neither a variable, nor a symbol; which is the principal functor of a structure in the state space
• the state space does not exist
• the structure whose principal functor is the symbol _Pfunctor does not exist in the state space.
• the second argument is not $local

Examples:

/* Place some structures in the state space */
:- remember(dog(terrier)), remember(cat(siamese)).
YES
:- remember(animal(_X) :- furry(_X)).
YES
?- inventory(_Pfunctor). % now taking inventory...
?- inventory(':-').
?- inventory(cat).
?- inventory(dog).
YES
load_state(_Filename)

loads the global state space

Arguments: load_state(+filename)
Succeeds: Loads the saved global state space from the specified file. load_state will delete any previously existing global state space.
Fails: load_state fails if _Filename is not the name of a saved state space document (file type APSS), or if there is insufficient memory to load the state space.
Examples:

?- load_state('plg:common:example').
?- load_state('plg:common:example').
YES

See Also: save_state in this chapter.
new_state(_Size)
new_state(_Size, $local)

creates a new state space

Arguments:
new_state(?size)
new_state(?size, +$local)

Succeeds:
If the argument _Size is an integer, a new global state space of _Size K bytes is created. If no state space currently exists.
new_state(0) discards the current global state space. If _Size is a variable, new_state instantiates _Size to the current size of the global state space. new_state(_Size, $local) provides equivalent functionality for local state spaces.

Fails:
new_state fails if
• _Size is less than zero
• _Size is greater than zero and a state space already exists
• there is insufficient free memory to create the desired state space
• the second argument is not $local

Note:
"Remembering" will create a state space with a default size, if no state space exists.

Examples:

/* Create a new state space of size 30 Kbytes */
?- new_state(30).
?- new_state(30).
YES
?- new_state(_X).
?- new_state(30).
YES

/* Discard the current local state space */
?- new_state(0, $local).
?- new_state(0, $local).
YES
recall(_Structure)
recall(_Structure, $local)

retrieves structures from a state space in recall order

Arguments:
recall(+structure)
recall(+structure, +$local)

Succeeds:
recall(_Structure) retrieves from the global state space, the first structure in the recall order, which unifies with _Structure. Upon backtracking, any other matching structures are retrieved if they exist. recall(_Structure, $local) retrieves structures from the local state space.

Fails:
recall fails if
• the principal functor of _Structure is a variable
• there are no matching structures or no state space allocated
• the second argument is not $local

Examples:

/* Store some structures in state space. */
:- remember($fred(_X, 3, [_ , apple, _Y, _X]), $local).
YES
:- remember($fred(4, 2, []), $local).
YES

/* Recall the structures */
?- recall($fred(_X, _Y, _Z), $local).
?- recall($fred(4, 2, []), $local).
?- recall($fred(_X, 3 [,_1, apple, _2, _X]), $local).
YES

/* Or you can be more specific with the pattern */
?- recall($fred(_X, 2, _Y), $local).
?- recall($fred(4, 2, []), $local).
YES

See Also: recall in this chapter.

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recallz(_Structure)
recallz(_Structure, $local)

retrieves structures from a state space in reverse recall order

Arguments:
recallz(+structure)
recallz(+structure, +$local)

Succeeds:
recallz(_Structure) retrieves from the global state space, the first structure in reverse recall order, which unifies with _Structure. Upon backtracking, any other matching structures are retrieved if they exist. recallz(_Structure, $local) retrieves structures from the local state space.

Fails:
recallz fails if
• the principal functor of structure is a variable
• there are no matching structures, or no state space allocated
• the second argument is not $local

Examples:

/* Store some structures in the global state space */
:- remember(fred(_X, 3, [_, apple, _Y, _X])).
YES
:- remember(fred(4, 2, [])).
YES

/* Recall the structures */
?- recallz(fred(_X, _Y, _Z)).
?- recallz(fred(_X, 3, [_, apple, _2, _X])).
?- recallz(fred(4, 2, [])).
YES

See Also:
recall in this chapter.
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**remember(_Structure)**

**remembera(_Structure)**

**remember(_Structure, $local)**

**remembera(_Structure, $local)**

*stores structure in the global state space at the beginning of the recall order*

**Arguments:**

- `remember(+structure)`
- `remembera(+structure)`
- `remember(+structure, +$local)`
- `remembera(+structure, +$local)`

**Succeeds:**

- `remember(_Structure)` stores the structure, _Structure, in the global state space, at the beginning of the recall order for the principal functor of _Structure. `remember(_Structure, $local)` stores the structure in the local state space.

- remembera is the same as remember.

**Fails:**

- `remember` fails if
  - the principal functor of _Structure is a variable
  - the structure contains intervals, buckets or looped lists
  - the second argument is not $local

**Note:**

Local names are saved as a reference if they are stored in local state spaces at an equivalent or higher context level (that is, the named objects cannot disappear before the local state space is removed). Global names and local names from higher contexts than the state space level are stored as names, and are re-entered into the symbol table (as necessary) when the terms are recalled from the state space.
Examples:

/* Use remember to store structures */
?- remember(sport(swimming, tennis, _Y)).
   ?- remember(sport(swimming, tennis, _Y)).
   YES

?- remember(sport(_X, baseball, _Y)).
   ?- remember(sport(_X, baseball, _Y)).
   YES

?- remember(sport(football, baseball, soccer)).
   ?- remember(sport(football, baseball, soccer)).
   YES

/* Use recall to retrieve the structures */
/* Observe the order */
?- recall(sport(_X, _Y, _Z)).
   ?- recall(sport(football, baseball, soccer)).
   ?- recall(sport(_X, baseball, _Z)).
   ?- recall(sport(swimming, tennis, _Z)).
   YES

See Also: rememberz in this chapter.
rememberz(_Structure)
rememberz(_Structure, $local)

stores a structure in a state space at the end of the recall order

Arguments:

rememberz(+structure)
rememberz(+structure, +$local)

Succeeds:

rememberz(_Structure) stores the structure _Structure in a state space at the end of the recall order for the principal functor of _Structure.

rememberz(_Structure, $local ) stores the structure _Structure in the local state space.

Fails:

rememberz fails if
• the principal functor of _Structure is a variable
• the structure contains intervals, buckets or looped lists
• the second argument is not $local

Note:

Local names are saved as a reference if they are stored in local state spaces at an equivalent or higher context level (that is, the named objects cannot disappear before the local state space is removed). Global names and local names from higher contexts than the state space level are stored as names, and are reentered into the symbol table (as necessary) when the terms are recalled from the state space.
Examples:

/* Use rememberz to store structures at the bottom of the recall order */
?- rememberz(sport(_X, baseball, _Y)).
   ?- rememberz(sport(_X, baseball, _Y)).
   YES

?- rememberz(sport(football, baseball, soccer)).
   ?- rememberz(sport(football, baseball, soccer)).
   YES

/* Use recall to retrieve the structures */
/* Observe the order */
?- recall(sport(_X, _Y, _Z)).
   ?- recall(sport(_X, baseball, _Y)).
   ?- recall(sport(football, baseball, soccer)).
   YES

See Also: remember and remembera in this chapter.
\textbf{save\_state}(_Filename)

\textit{saves the global state space}

\begin{itemize}
  \item \textbf{Arguments:} \texttt{save\_state(+filename)}
  \item \textbf{Succeeds:} Saves the global state space in the file _Filename.
  \item \textbf{Fails:} \texttt{save\_state} fails if the file system is unable to write the file.
  \item \textbf{Examples:}
    \begin{verbatim}
    /* saves the state in the file "example" of type APSS */
    ?- save\_state('plg:common:example').
    ?- save\_state('plg:common:example').
    YES
    
    \end{verbatim}
  \item \textbf{See Also:} \texttt{load\_state} in this chapter.
\end{itemize}
update(_Structure, _New_structure)
update(_Structure, _New_structure, $local)

replaces a structure with a new one while maintaining the recall order

Arguments:
update(+structure, +structure)
update(+structure, +structure, $local)

Succeeds:
update(_Structure, _New_structure) replaces the first occurrence of _Structure in the global state space with _New_structure without changing the order. Upon backtracking, the update will be undone.

update(_Structure, _New_structure, $local) replaces the structure in the local state space.

Fails:
update fails if
• either _Structure or _New_structure are variables
• the principal functors of _Structure and _New_structure are not instantiated to the same symbol
• there is no matching structure, or the state space does not exist
• the third argument is not $local

Note 1: Subsequent binding of variables in either structure does not affect the contents of the state space.

Note 2: An atomic transaction composed of multiple updates can be made by
[update(s1(old1), s1(new1)),
update(s2(old2), s2(new2)),
cut].

Note 3: If update is placed in the scope of a generator for the same principal functor, the update structure may be visible to the generator. Unlike forget, it does not unexpectedly terminate the generator.
Examples:

/* Use remember to store a structure at the top */
/* of the state space. */
?- remember(sport(swimming, tennis, _Y)).
   yes
?

/* Use rememberz to store a structure at the */
/* bottom of the state space */
?- rememberz(sport(_X, baseball, _Y)).
   yes
?

/* Use update to replace the first occurrence of */
/* the structure */
?- once(update(sport(_A, _B, _C), sport(field, track, aerobics))).
   yes
?

/* Use recall to retrieve the structures */
?- recall(sport(_X, _Y, _Z)).
   yes
?
This chapter describes the facilities provided for debugging BNR Prolog programs.

The Box Model

The debugger is based on the traditional box model of Prolog predicates. The collection of all clauses which define a given predicate is called a predicate definition. In this model, a Prolog predicate is treated as a black box having four ports: call, exit, redo and fail. The ports represent the states in which a call may be found during its execution.

![Diagram of the Box Model]

- **call** represents the initial invocation of a predicate. The variable instantiations of the goal displayed in the port message are that of the initial call.
- **exit** represents the successful completion of a call. That is, the initial goal has successfully unified with the head of some clause and the body of this clause has been satisfied. The variable instantiations of the goal displayed in the port message are that of the return from the call.

Figure 10-1. The Box Model
The redo port represents the situation in which a subsequent goal has failed and the interpreter is backtracking in an attempt to find an alternative solution to a previously satisfied goal. The redo indicates that the interpreter is either attempting to resatisfy subgoals in the body of the clause that last succeeded; or, if that fails, is attempting to select a new clause whose head is unifiable with the initial goal and whose subgoals are satisfiable. The variable instantiations of the goal displayed in the port message are that of the previous successful completion of the goal.

The fail port represents the failure of the initial goal. The fail port may be reached for a variety of reasons including the following: the predicate being called is undefined; the heads of the clauses defining the predicate is not unifiable with the given goal; the subgoals in the bodies of clauses selected cannot be satisfied; the failure of subsequent goals exhaust all solutions to the given goal. The variable instantiations of the goal displayed in the port message are that of the initial call.

The Format of Port Messages

When the debugger displays a port message for a given goal, the message provides information in addition to just displaying the given goal.

The port message is formatted as follows:

```
Status Callid  Depth  Port:  Goal
```

where:

- **Status**: The status of the given goal's principal functor with respect to its being defined, and the predicate defining it being spied. This component of the message occupies the two leftmost character positions.

- **Callid**: The unique invocation number for the goal. This component of the message has the form of an integer within parentheses.

- **Depth**: The number of direct ancestors of the given goal. This component of the message is an integer.
<table>
<thead>
<tr>
<th>Port</th>
<th>The name of the port reached. This component of the message is one of, call, exit, fail, or redo.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>The given goal with its variable bindings reflecting their current instantiation.</td>
</tr>
</tbody>
</table>

A sample port message together with an explanation of the component values follow:

```
** (321) 18 redo: p(s(0)) ?
**
The status of the principal functor of the given goal. The ** indicates that the principal functor of the given goal is defined, and the predicate defining it is spied. If the status was white space (that is, two blanks) then this indicates that the principal functor of the given goal is defined, but that the predicate defining it is not spied. If the status was ?? then this indicates that the principal functor of the given goal is not defined.

(321) The invocation number for the given goal. The call, fail, and exit port messages for this goal have the same number.

18 The number of direct ancestor goals of the given goal. The call, fail, and exit ports messages for this goal have the same number.

redo The name of the port reached.

p(s(0)) The current instantiation of the given goal.

? Not part of the message, but rather, it is the prompt indicating that the debugger is waiting for the user to enter a port command.
Interactive Port Commands

When the debugger reaches a leashed port, it outputs the appropriate port message, prompts with a "?", and waits for the user to interactively enter a port command.

Port commands are entered as single keystrokes. An alphabetical list of the available port commands follow:

```
abort
Aborts the execution of the top level goal, turns off the debugger, and passes control to the top level of the current invocation of the listener.

break
Suspends execution and invokes the listener. Essentially, the debugger calls the break primitive. When the "break" session is terminated (by typing the continue primitive) the debugging session prior to the break is resumed and the last port message of the session is displayed again. Any changes to leashing or spying made during the "break" session remain in effect when the debugging session is resumed.

creep
Causes the debugger to single step to the next port and output the corresponding port message. If this port is leashed, the user is prompted for another port command. Otherwise, execution of the program continues, possibly outputting other port messages, until either a leashed port is encountered, or the program terminates.

fail
Fails the current goal and positions control at the point where it is about to backtrack to the next appropriate goal. Issuing the fail command at the fail port is redundant and has no effect.
```
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ancestor goals
Outputs the direct ancestors of the current goal starting with the root goal and ending with the current goal. The goals output have the following form:

Status (N) Depth Goal

where:

Status is "**" if the predicate defining the principle functor of Goal is spied, and otherwise is blank.

N is the invocation number of Goal if the execution of Goal was previously reported by the debugger. Otherwise it is ".-".

Depth is the number of direct ancestors of Goal.

Goal is a goal.

help
Displays a reminder of the available port commands.

leap
Resume execution of the program. The debugger will only output another port message if it encounters a call to a spied or undefined predicate. Otherwise, the execution continues until program termination.

nodebug
 Turns off the debugger and resumes execution of the program.

print
Outputs the current goal using print.
r
retry
Transfers control back to the point where the current goal was initially called (that is, the call port). Issuing the retry command at the call port is redundant, and has no effect. After issuing a retry, the state of execution is exactly the same as when the call was initially made except for any changes to the state space or clause space caused by remember, forget, retract or assert.

s
skip
Skips from the call or redo port of the current goal to its exit or fail port. Any intervening spy points or calls to undefined predicates are ignored. At the fail and exit ports, the skip port command is equivalent to the creep port command.

? help
Equivalent to the help port command.

+ spy
If the principal functor of the current goal is defined, a spy point is placed on the predicate defining it.

- nospy
If a spy point exists on the predicate defining the principal functor of the current goal, it is removed.

<return> creep
Equivalent to the creep port command.

The Debugger

In keeping with the traditional box model style of the debugger, the BNR Prolog debugger has two start-up modes of operation: "trace" and "debug". The only difference between these two modes concerns the initial predicates for which port messages are output. Once a leashed port is arrived at, the port commands entered determine subsequent debugger modes.

The debugger is turned on in trace mode by means of the trace predicate. In this mode the debugger interrupts a program's execution and outputs a port message, immediately upon encountering a goal having a principal functor which is spyable. In
contrast, when the debugger is turned on in debug mode by means of the `debug` predicate, the debugger interrupts a program's execution and outputs a port message, only upon encountering a goal whose principal functor is actually spied. Intuitively, debug mode is like leaping to the first spied predicate, whereas, trace mode is like single-stepping (creeping) a program's execution.

When debugging, certain predicates are of greater interest than others. Such predicates are good candidates for spying. Spy points may be set and removed using the `spy` and `nospy` predicates, respectively. When control arrives at a spied predicate, the debugger stops, outputs information, and waits for the user to enter a port command. The use of spy points makes it possible to quickly move through a program, stopping only at the points of interest.

For a more detailed look at a program, creeping (single-stepping) takes the user from the current port to the next port, independent of spy points.

Skipping essentially provides a temporary spy point, disabling preset spy points and creeping.

Leashing specifies the type of ports at which the debugger stops and waits for the user to enter a port command. As well as leashing all predicates, it is possible to leash predicates individually by including a leash list in a spy command.

Some predicates are not traceable, and consequently, port messages are not output for these predicates. These predicates are as follows: `attention_handler`, `break`, `capsule`, `continue`, `cut`, `debug`, `fail`, `failexit`, `goal`, `grand_caller`, `is`, `leash`, `listener`, `nodebug`, `nospy`, `nospyall`, `notrace`, `recovery_unit`, `repeat`, `set_trace`, `spied`, `spy`, `spyall`, `trace`, `tracer`.

The debugger does not make a distinction with respect to a predicate's status of being hidden, nonhidden, closed or open; they are all treated equivalently. Also, for convenience (since local predicates in lower contexts are not normally intended to be seen) they are treated in the following manner: Only those predicates that can be called from the top level of the listener may be spied or creeped.
Debugging information concerning the mode in which the debugger was initialized, and the leashing of nonspied predicates, is retained over context reloads. Spy point information is retained only if the predicates are defined in contexts lower than those being reloaded, otherwise, it must be respecified.

Should control of a program's execution be lost during debugging, then a Command-. causes the debugger to immediately enter trace mode with leashing restored to full.

Debugger Predicates

In this section the predicates for turning on and off the debugger, setting and resetting spy points, and leashing ports are discussed. Specifically, the following predicates are discussed:

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>debug</td>
<td>turns the debugger on</td>
</tr>
<tr>
<td>leash</td>
<td>sets or queries leashing</td>
</tr>
<tr>
<td>nodebug</td>
<td>turns the debugger off</td>
</tr>
<tr>
<td>nospy</td>
<td>disables spying on specific predicates</td>
</tr>
<tr>
<td>nospyall</td>
<td>disables spying on all spied predicates</td>
</tr>
<tr>
<td>notrace</td>
<td>turns the debugger off</td>
</tr>
<tr>
<td>spied</td>
<td>generates currently spied predicates</td>
</tr>
<tr>
<td>spy</td>
<td>enables spying on specific predicates</td>
</tr>
<tr>
<td>spyall</td>
<td>enables spying on all spyable predicates</td>
</tr>
<tr>
<td>trace</td>
<td>turns the debugger on in trace mode</td>
</tr>
</tbody>
</table>

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debug ()

turns the debugger on

Arguments: None.
Succeeds: Turns the debugger on and places the debugger in "debug" mode.
Fails: Never fails.
Note 1: Turning the debugger on in debug mode means that the debugger will not interrupt execution until a spied predicate is encountered.
Note 2: Turning the debugger on is independent of the predicates being spied and the ports being leashed.
See Also: nodebug, trace and notrace in this chapter.
leash(_Ports)

sets or queries leashing

Arguments: leash(?list)

Succeeds: If _Ports is a list consisting of zero or more of the following symbols: call, exit, redo, and fail, then leash sets the leash list for those predicates not specifically spied. If _Ports is a variable then leash returns a list of the currently leashed ports.

Fail: leash fails if _Ports is neither a variable nor a list containing zero or more of the following symbols: call, exit, redo, and fail.

Note 1: By default, all four ports are leashed.

Note 2: leash([]) removes all leashing. Consequently, the only interaction with the debugger occurs at the leashed ports of the spied predicates.

Note 3: On arrival at a "leashed" port, the debugger outputs the appropriate port message and waits for the user to interactively enter a port command. On arrival at an unleashed" port, the debugger outputs the appropriate port message, and continues program execution.

Examples:

/* leash just the call and exit ports */
?-leash([exit, call]).
    YES
?-leash([exit, call]).
    YES

/* restore leashing to all ports */
:- leash([redo, fail, exit, call]).
    YES

See Also: spy in this chapter.
nodebug()

turns the debugger off

Arguments: None.
Succeeds: Turns the debugger off.
Fails: Never fails.
Note 1: Turning off the debugger does not remove spy points or alter leashing.
Note 2: nodebug and notrace are equivalent.
See Also: debug, trace and notrace in this chapter.
nospy(_P₁, _P₂, ..., _Pₙ)

disables spying on specific predicates

Arguments:  nospy(+symbol, +symbol, ..., +symbol)
Succeeds:   Removes the spy points, if they exist, on the predicates, _P₁, _P₂, 
            ..., _Pₙ.
Fails:      nospy fails if 
            • any of the predicates are not defined 
            • no predicates are specified (n=0)
See Also:   spied in this chapter.
nospyall()

disables spying on all predicates

Arguments: None
Succeeds: Disables spying on all spied predicates.
Fails: Never fails.
See Also: nospy in this chapter.
`notrace()`

*turns the debugger off*

**Arguments:** None

**Succeeds:** Turns the debugger off.

**Fails:** Never fails.

**Note 1:** Turning off the debugger does not remove spy points or alter leashing.

**Note 2:** `nodebug` and `notrace` are equivalent.

**See Also:** `nodebug` in this chapter.
\texttt{spied(_Predicate)}

\texttt{spied(_Ports, _Predicate)}

\textit{generates currently spied predicates}

**Arguments:**

- \texttt{spied(?symbol)}
- \texttt{spied(?list, ?symbol)}

**Succeeds:**

If \_Predicate is a variable then \texttt{spied} successively unifies it on backtracking with the predicate names that are currently spied. If \_Predicate is a symbol then \texttt{spied} verifies that \_Predicate is spied.

In the extended form of \texttt{spied}, if \_Ports is a variable it is unified with the ports of the spied predicate that are leashed. If \_Ports is a list, it is unified with the list of currently spied ports.

**Fails:**

\texttt{spied} fails if

- there are currently no spied predicates
- \_Predicate is neither a symbol nor a variable
- \_Predicate is not defined
- \_Predicate is not defined by a spied predicates
- \_Ports is not a variable or a list containing zero or more of the following symbols: \texttt{call}, \texttt{fail}, \texttt{exit}, \texttt{redo}.

**See Also:**

\texttt{spy} in this chapter.
\textbf{spy}(_P1, _P2, \ldots, _Pn) \\
\textbf{spy}(_Ports, _P1, _P2, \ldots, _Pn)

\textit{enables spying on specified predicates}

\begin{itemize}
  \item \textbf{Arguments:} \textbf{spy}(+symbol, +symbol, \ldots, +symbol) \\
  \textbf{spy}(+list, +symbol, +symbol, \ldots, +symbol) \\
  \item \textbf{Succeeds:} \textbf{spy} places spy points on the predicates _P1, _P2, \ldots, _Pn. If the extended form of \textbf{spy} is used then only the ports specified by the leash list, _Ports, are leashed. \\
  \item \textbf{Fails:} \textbf{spy} fails if \\
    \begin{itemize}
      \item any of the _Pi's are not defined, in which case, none of the predicates are spied. \\
      \item _Ports is not a list containing zero or more of the following symbols: \texttt{call}, \texttt{exit}, \texttt{redo} and \texttt{fail}. \\
      \item no predicates are specified (n=0). 
    \end{itemize}
  \item \textbf{Note 1:} By default, all four ports are leashed. \\
  \item \textbf{Note 2:} On arrival at a "leashed" port, the debugger outputs the appropriate port message and waits for the user to interactively enter a port command. On arrival at an "unleashed" port, the debugger outputs the appropriate port message, and continues program execution. \\
  \item \textbf{See Also:} spied and leash in this chapter.
\end{itemize}
spyall()

enables spying on spyable predicates.

Arguments: None.
Succeeds: Places spy points on all spyable predicates.
Fails: Never fails
See Also: spy in this chapter.
**trace**

*turns debugger on in trace mode*

**Arguments:** None.

**Succeeds:** Turns the debugger on and places the debugger in "trace" mode.

**Fails:** Never fails.

**Note 1:** Turning the debugger on is independent of the predicates being spied and the ports being leashed.

**Note 2:** Turning the debugger on in trace mode means that the debugger will interrupt the program's execution immediately upon encountering a goal.

**See Also:** `nodebug`, `debug` and `notrace` in this chapter.
Writing a Debugger

There are three predicates which are fundamental to the BNR Prolog debugging facility, and are available for use when designing and implementing a debugger. They are: enable_trace, set_trace, and tracer.

The predicate enable_trace sets, resets, and queries a global trace flag. The format of enable_trace is as follows:

```
enable_trace(_FlagSetting)
```

To set the global trace flag, bind _FlagSetting to the integer 1. To reset the global trace flag, bind _FlagSetting to the integer 0. The current setting of the flag may be queried by leaving _FlagSetting as an unbound variable; the variable becomes bound to the setting.

The predicate set_trace, sets, resets, and queries a symbol's trace flag. The format of set_trace is as follows:

```
set_trace(_Symbol, _FlagSetting)
```

Each symbol known to the system has its own trace flag, and, depending on the status of _Symbol, the characteristics of the trace flag are different:

_Symbol is a predicate symbol. To set the trace flag, bind _FlagSetting to any integer in the range 1 to 255 inclusive. To reset the trace flag, bind _FlagSetting to the integer 0, and to query its current value, leave _FlagSetting as an unbound variable. The ability to set the trace flag with any number in the range of 1 to 255 presents some interesting possibilities. For example, the BNR Prolog debugging facility uses the value stored in a predicate symbol's trace flag to determine if the predicate is spied, and which of its ports are leashed.

_Symbol is a nonpredicate symbol. To set the trace flag, bind _FlagSetting to any nonzero integer. To reset the trace flag, bind _FlagSetting to the integer 0, and to query its current value, leave _FlagSetting as an unbound variable. For such symbols, irrespective of the value used to set the trace flag, querying its trace flag always returns the value -1. Also note that the trace flag for all nonpredicates is initially set.
An exception to the above characteristics of a symbol's trace flag applies: If the symbol in question is currently not a predicate symbol because the clauses defining it have been retracted, and the context from which these clauses have been retracted has not been exited, then, in the transition from a predicate symbol to a nonpredicate symbol, the symbol's trace flag is initialized to have the value 255. Furthermore, the trace flag for such symbols may be reset to have any value in the range 1 to 255 inclusive. However, upon exiting the context, the trace flag for such symbols resorts to those of nonpredicate symbols described above.

The predicate tracer is the predefined "catchall" clause. The interpreter, before evaluating any goal having a principle functor, first checks two flags: the global trace flag and the trace flag of the principle functor of the current goal. If both flags are set then the given goal is evaluated (reduced) to the goal tracer(). Intuitively, the situation is analogous to having the following clause as the very first clause in the clause space:

```
_P(_Args..) :- [ 
    enable_trace(_El),
    (_El > 0),
    set_trace(_P, _E2),
    (_E2 > 0),
    cut(_P),
    tracer() ].
```

The immediate ancestor of tracer is the goal responsible for the call to tracer. The kernel of a debugging facility utilizing the trace flags amounts to an appropriate implementation for the predicate tracer.
Predicates for Implementing Debuggers

This section describes a few basic predicates which may be used when designing and implementing a debugger. The predicates, break, continue, listener, tracer may be overloaded or replaced entirely by user written Prolog code.

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</table>
break

suspends execution

Arguments: None.

Succeeds: break suspends execution and returns the user to interactive mode. The listener prompt is displayed. Execution is resumed by calling the continue predicate. When execution is resumed the call to break succeeds.

Fails: Never fails.

Notes: A break may be executed from within a break. The break nesting level is output.
caller(_Goal)

returns or verifies the caller's immediate goal

Arguments: caller(?goal)
Succeeds: caller succeeds if _Goal is unifiable with the immediate ancestor of the goal caller(_Goal).
Fails: caller fails if _Goal is not unifiable with the immediate ancestor.
Examples:

```prolog
/* assert a clause */
foo(fred) :- [ caller(_Goal),
               write('\\n**** -> ', _Goal, '\\n') ].
OK

?- foo(_X).
**** -> foo(fred).
    ?- foo(fred).
YES
```

See Also: grand_caller in this chapter.
continue

resumes execution

Arguments: None.
Succeeds: If it exists, the current break session is terminated and the previous session resumed. Otherwise continue simply succeeds.
Fails: Never fails.
See Also: break in this chapter.
enable_trace(_Setting)

enables and disables tracing

Arguments: enable_trace(?integer)

Succeeds: If _Setting is bound to 0 or 1, or is an unbound variable, enable_trace is used to set, reset and query the global trace flag setting, respectively.

Fails: enable_trace fails if _Setting is not a variable or the integer 0 or 1.

See Also: set_trace in this chapter.
goal(_Goal)

generates ancestor goals

Arguments: goal(?goal)

Succeeds: On backtracking, successively unifies _Goal with those ancestor goals that are unifiable with it.

Fails: goal fails if _Goal is not unifiable with some ancestor goal.

Examples:

/* Assert some clauses */
p(1) :- q(2).
OK

q(2) :- p(3).
OK

p(3) :- q(4).
OK

q(4) :- [nl, goal(_G), write(_G), nl, _G = p(1)].
OK

?- p(X).
q(4)
p(3)
q(2)
p(1)
    ?- p(1).
YES

See Also: grand_caller in this chapter.
grand_caller(_Goal)

returns grand_caller's ancestor goal

Arguments: grand_caller(?goal)

Succeeds: grand_caller succeeds if the immediate ancestor of 
grand_caller's immediate ancestor is unifiable with _Goal.

Fails: grand_caller fails if the immediate ancestor of grand_caller's 
immediate ancestor is not unifiable with _Goal.

Examples:

/* assert a clause defining tracer */
tracer() :- [
  grand_caller(_G),
  write('\n***** -> ', _G),
  nl].
OK

/* assert an arbitrary clause */
foo(_X).
OK

/* set trace flags */
?- [set_trace(foo, 1), enable_trace(1)].
  ?- [set_trace(foo, 1), enable_trace(1)].
YES

/* call foo */
?- foo(fred).
  ***** -> foo(fred).
  ?- foo(fred).
YES

See Also: caller in this chapter.
listener()  

*the default Prolog system listener*

**Arguments:** None.

**Succeeds:** Invokes the system listener.

**Fails:** `listener` fails if the command read by the invoked listener causes a system error.
**retry**(_Goal)  

*re-executes a goal*

**Arguments:**  
retry(+goal)

**Succeeds:**  
Re-executes a goal which has an ancestor **try**(_Goal).

**Fails:**  
retry fails if **try**(_Goal) is not an ancestor on the goal stack.

**See Also:**  
**try** in this chapter.
Chapter 10: Debugger

**set_trace(_Predicate, _Setting)**

*sets the trace flag of symbols*

**Arguments:**

set_trace(+symbol, ?integer)

**Succeeds:**
Sets, resets and queries the trace flag of symbols.

**Fails:**
set_trace fails if _Setting is not a variable or an integer.

**Examples:**

```prolog
/* disable the trace flag of foo */
?- set_trace(foo, 0).
     ?- set_trace(foo, 0).
     YES

/* enable the trace flag of foo */
?- set_trace(foo, 1).
     ?- set_trace(foo, 1).
     YES
```

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traceback()

outputs the goal stack

Arguments: None.
Succeeds: Outputs the top 16 items of the ancestor goal stack to the console.
Fails: Never fails.
**try**

*executes a goal*

**Arguments:** `try(+goal)`

**Succeeds:** Executes a goal in a manner permitting a subsequent `retry`.

**Fails:** `try` fails if `_Goal` fails

**See Also:** `retry` in this chapter.
tracer()

**invokes the tracer**

**Arguments:** None.

**Succeeds:** This predicate is called whenever the global trace flag and the trace flag on the principal functor of the current goal are both set.

**Fails:** Never fails.
System predicates support monitoring and configuration of Prolog memory resources, measuring performance, and accessing date and version information. These predicates are generally operating-system and machine-independent.

Prolog System Predicates

- configuration - configures the Prolog stack sizes and initial predicate
- delay - delays program execution
- halt - exits the Prolog system
- memory_status - queries the stack utilization
- quit - same as halt
- restart - restarts Prolog execution
- stats - initializes performance counters or queries performance measures
- timedate - queries the system time and date
- version - queries the system version number
configuration(_WS, _GS, _LS, _Initial_goal)

configures the Prolog stack sizes and initial predicate


Succeeds: configuration sets or queries the Prolog initial configuration environment using the values specified by the following arguments:

• _WS specifies the size of the world stack in Kilobytes.
• _GS specifies the size of the global stack in Kilobytes.
• _LS specifies the size of the local stack in Kilobytes.
• _Initial_goal is a symbol specifying a single executable term to be executed prior to entering normal interactive mode. (Multiple goals can be combined in a list.) Execution is defined by once(_Initial_goal).

These changes come into effect the next time Prolog is launched or restarted (using the restart predicate).

If an argument is not instantiated, it is unified with the current setting.

Fails: configure fails if

• _WS, _GS and _LS are neither integers nor variables
• _Initial_goal is neither a symbol nor a variable

Note 1: A special case exists when the value specified for any of the stack sizes is zero bytes. In this case, when Prolog is either started or restarted, the system chooses values determined by the available free memory for each stack whose value is zero. The system will not initialize unless the available memory is large enough to satisfy certain minimum size criteria.
Note 2: The Prolog development environment has an initial predicate `pde_init`. This predicate is responsible for opening the initial text files (Console and selected files at application launch) and installing the menus.

Examples:

```prolog
/* Query current configuration */
?- configuration(_,_,_,_).
    configuration(0, 0, 0, 'pde_init').
YES

/* Set world and global stack sizes to 200 K each, local */
/* stack to system calculated default, and initial */
/* predicate to also load context utils */
?- configuration(200, 200, 0, [pde_init, load_context(utils)]).
    configuration(200, 200, 0, [pde_init, load_context(utils)]).
YES

/* '?-restart.' or application launch required before */
/* configuration changes effective */
```

See Also: `memory_status` and `build_application` in this chapter.
delay(_Seconds)

delays program execution

Arguments: delay(?number)

Succeeds: Suspends program execution for the specified number of seconds rounded to the nearest tick. (A tick is 1/60 of a second on the Macintosh). If _Seconds is not a number (integer or float) then delay succeeds with a delay of zero.

Fails: delay never fails.

See Also: cputime in the chapter titled "Arithmetic" in this manual.
halt ()

*exits the Prolog system*

**Arguments:** None.

**Succeeds:** 

halt exits the Prolog system. Graph and text windows are closed. The user is prompted to save any active windows whose contents are different from the underlying disk files.

**Fails:** 

halt never fails. However, it can be aborted and the system restarted, by selecting cancel when prompted to save a text window.

**Note:** 

halt is the same as quit. Both are included to provide compatibility with other Prologs

**See Also:** 
quit and restart in this chapter.
memory_status([_WS_List], [_GS_List], [_LS_List],
[_SS_List])

queries the stack utilization

Arguments: memory_status(?list, ?list, ?list, ?list)

Succeeds: memory_status unifies its arguments with the current status of the
world stack, global stack, local stack and the global state space.
Each argument, for example, [_WS_List] is returned in the form
of a list of three numbers [_T, _U, _H] which gives the total size, the
amount currently in use and the maximum used (the high water
mark) since stats() was called. All sizes are expressed in bytes.

Fails: memory_status fails if any of the argument unifications fail.

Note: configuration, described in this chapter, is used to control the
sizes of the stacks. new_state described in the chapter titled "State
Space Management" is used to set the size of the global state space.
The maximum amount of memory used by the state space (that is,
the high water mark) will always be zero bytes since the state space
is not organized as a stack.

Examples:

?- memory_status(_, _, _, _).
?- memory_status([261120, 150112, 159436], [98304,1948,
16196], [52224, 16, 220], [4096,2196,0]).
   YES

?- memory_status([261120, _, _], [98304, _, _], [52224, _, _],
[4096,2196,0]).
?- memory_status([261120, 150112, 159436], [98304,1948,
16196], [52224, 16, 220], [4096,2196,0]).
   YES

See Also: configuration and stats in this chapter.
quit()

exits the Prolog system

Arguments: None.

Succeeds: quit exits the Prolog system. Graph and text windows are closed. The user is prompted to save any text windows whose contents are different from the underlying text files.

Fails: quit never fails. However, it can be aborted, and the system restarted, by selecting cancel when prompted to save a text window.

Note: quit is the same as halt. Both are included to provide compatibility with other Prologs.

See Also: halt in this chapter.
restart()  

*restarts Prolog execution*

Arguments: None.

Succeeds: This predicate restarts execution of the Prolog application according to the current configuration information. All graphics windows are closed; text windows remain open. All user contexts are lost.

Fails: restart never fails.

See Also: configuration in this chapter.
stats()  
stats(_Lis, _Prims, _Intops, _Iterations, _DeltaT)

initializes performance counters or queries performance measures

Arguments: None.

stats(?number, ?number, ?number, ?number, ?number)

Succeeds: stats initializes the following performance counters:

• number of logical inferences
• number of primitive calls
• number of interval operations
• number of narrowing iterations
• time, in ticks (1/60 sec.) since the counters were zeroed

stats also initializes the stack and the state space high water marks.

stats(_Lis, _Prims, _Intops, _Iterations, _DeltaT) generates the performance measures listed above.

Fails: stats never fails.

stats(_Lis, _Prims, _Intops, _Iterations, _DeltaT) fails if any of the arguments do not unify with the returned values.

Note: Logical Inferences Per Second (LIPS) are usually calculated as \((\_Lis + _Prims)/(\_DeltaT/60)\).

Examples:

?- [stats, [integer_range(_,1,10),fail];stats(_,_,_,_,_)].
stats(_,_,_,_,_).

?- [stats,[integer_range(_,1,10),fail];stats(81,84,0,0,5)]

YES
\texttt{timedate(_Time, _Date)}

\textit{queries the system time and date}

\textbf{Arguments:} \texttt{timedate(?symbol, ?symbol)}

\textbf{Succeeds:} timedate unifies \texttt{_Time} with a symbol containing the system time (in the form 'hh:mm'), and \texttt{_Date} to a symbol containing the system date (in the form 'yy mm dd').

\textbf{Fails:} timedate fails if \texttt{_Time} and \texttt{_Date} do not unify with symbols representing the current time and date.

\textbf{Examples}

\begin{verbatim}
/* queries the system date and time */
?- timedate(_Time, _Date).
    ?- timedate('20:12', '88 02 01').
    YES

/* Verifies the system date and time */
?- timedate('20:12', '88 02 01').
    ?- timedate('20:12', '88 02 01').
    YES
\end{verbatim}
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version([_Vints])
quaries the system version number

Arguments: version(?list)
Succeeds: version succeeds if _Vints unifies with a list of integers specifying the Prolog system version number.
Fails: version fails if _Vints does not unify with a list of integers specifying the Prolog system version number.
Examples:

/* version used to query the version number */
?- version(_Vints).
   ?- version([1,0,0]).
   YES
Building an Application

An application is a single disk file containing the Prolog run-time system, contexts (including base definitions) and other code required by the application, initial system configuration options, and Macintosh resources. It is intended that the creators of BNR Prolog applications will be able to distribute their applications without restrictions.

BNR Prolog is a special application which supports the program development environment (PDE). Any BNR Prolog application created will not support the full PDE. In particular, the primitives build_application, save_ws, and set_trace will not be available. The actual building of an application is done by using the build_application predicate.

Refer to the chapter titled "System Information" in the BNR Prolog User Guide for further information on Building Applications.
Chapter 11: System Predicates

**build_application**(_Filename, _Signature, _Stack_sizes, _Initial_predicate, [_Contexts])

**builds an application**

**Arguments:**

build_application(+filename, +filecreator, ?list, +goal_list, ?list)

**Succeeds:**

Builds a BNR Prolog application where

_filename is the pathname of a file to be created

_signature is a symbol representing the "creator" of the application. The type of the file will be 'APPL'. Signature should be a unique identifier as described in Volume III of *Inside Macintosh*. Signature must be exactly 4 characters in length, padded with blanks if necessary.

_stack_sizes is a list of three numbers specifying the size of the world stack, global stack, and local stack respectively in Kilobytes. If this argument is unbound, then the current PDE configuration sizes will be used. A stack size of zero causes BNR Prolog to allocate the stack based on the amount of free memory available to the application.

_initial_predicate is a term specifying the initial goal list. Upon completion of this term, the application exits.

_contexts is a list of context filenames to be included in the application file. "Current" binary forms will be created if necessary. If uninstantiated or an empty list, no contexts will be added.
Fails: build_application fails if
• _Filename is an invalid Macintosh file specification, or the file
  _Filename already exists
• _Signature is not a valid symbol for the creator of the
  application
• _Stack_sizes is neither a variable nor a list of numbers
• _Initial_predicate is not a term specifying a valid goal list
• _Contexts is neither an variable nor a list of zero or more
  context filenames

Example:

/*To create a simple application that simply brings up a */
/* dialog with a message and then quits. Try: */
?- build_application(silly,'SAMP',_X, 'message(\'Hi there\'),[]).

/* If you exit BNR Prolog and launch the program silly, */
/* you should get a dialog with the words 'Hi there' */
/* Clicking on OK causes the program to terminate. */
A number of predicates are provided for interfacing with the Macintosh hierarchical file system. These predicates are used to copy, delete, and rename files, as well as for generating or testing names of entities in the file system.

### Macintosh Filenames, File Types and File Creators

Associated with a file is a filename, a file type and a file creator.

The syntax of valid Macintosh file names is defined in Volume IV of *Inside Macintosh*. In summary, a full filename consists of a volume name, followed by a colon (:), followed by zero or more directory (folder) names, each terminated by a colon, and a filename. Each component can be up to 31 characters long, except for volume names which are constrained to 27 characters. Partial filenames (also called partial pathnames) omit one or more of the leading components of the full filename and are interpreted relative to the current default directory. Examples of valid filenames are:

```plaintext
MyDisk: % Volume name
MyDisk:MyFolder:MyFile % Full Filename
:MyFolder:MyFile % Three Partial Pathnames
:MyFile
MyFile
```

A file type is a four-character sequence, identifying the type of the file created by the application. The file types used by BNR Prolog are 'TEXT' for a standard text document, 'APWS' for a saved workspace, and 'APSS' for a saved state space. 'APPL', which is the standard application file type, is the file type for the BNR Prolog application.
A file creator is a unique four-character sequence which identifies the application which created the file. The file creator for BNR Prolog text documents and work spaces is 'APRO'.

File Predicates

The following is a list of the file predicates:

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<td>renames a file</td>
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</table>
copyfile(_Filename, _Copyname)

copies a file

Arguments:  

`copyfile(+filename, +filename)`

Succeeds:  

Copies the contents of the file _Filename to the file _Copyname. The previous contents of _Copyname are overwritten.

Fails:  

`copyfile` fails if

• _Filename is not the name of an existing file
• _Copyname is not a valid Macintosh file specification
• a file system or memory error occurs

Examples:

  YES

/* Invalid parameter */  
?- `copyfile('MyFile', _Newfile)`.  
  NO
defaultdir(_Directoryname)

queries or sets the name of the default directory

Arguments: defaultdir(?directory_name)

Succeeds: If _Directoryname is a variable then defaultdir returns the name of the current default directory. If _Directoryname is a valid Macintosh directory name then this becomes the default directory.

Fails: defaultdir fails if _Directoryname is neither a variable nor the name of a valid Macintosh directory.

Note: The initial default directory is one from which BNR Prolog was invoked by clicking on a desktop document or application. The default directory name will be affixed to any filename which is not a full filename. This applies to any or all file operations which take a filename.

Examples:

/* Querying the default directory */
?- defaultdir(_DD).
    ?- defaultdir(':MyDisk:MyFolder:').
    YES

/* Setting the default directory */
?- defaultdir('':NextFolder:'').
    ?- defaultdir('':NextFolder:'').
    YES

See Also: homedir in this chapter.
deletefile(_Filename)

*deletes a file*

**Arguments:** delete(+filename)

**Succeeds:** Deletes the file _Filename. _Filename can be either a full or partial filename.

**Fails:** deletefile fails if
- _Filename is not the name of an existing file
- the file _Filename is open
- the file _Filename is locked

**Examples:**

```prolog
?- deletefile('MyDisk:MyFolder:MyFile').
?- deletefile('MyDisk:MyFolder:MyFile').
YES
```
fullfilename(_Partialfilename, _Fullfilename)

queries or verifies full and partial filenames

Arguments: fullfilename(?Partialfilename, ?Fullfilename)

Succeeds: If the partial pathname is specified, fullfilename returns the corresponding full filename. If the full filename is specified, fullfilename generates the last component of the pathname, which is the actual file name. If both arguments are given, fullfilename succeeds if the partial filename corresponds to the same file as the full filename.

Fails: fullfilename fails if
  • either _Fullfilename or _Partialfilename is not the name of an existing file, or a variable
  • both arguments are variables

Examples:

?- fullfilename('MyFile', _FF).
   ?- fullfilename('MyFile', 'MyDisk:MyFolder:MyFile').
      YES

?- fullfilename(_PF, 'MyDisk:OtherFile').
   ?- fullfilename('OtherFile', 'MyDisk:OtherFile').
      YES

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**homedir(_Directoryname)**

*queries or verifies the name of the home directory*

**Arguments:**

`homedir(?directory_name)`

**Succeeds:**

If _Directoryname is a variable, then homedir returns the name of the home (or application) directory. This is the directory which contained the Prolog application file itself, and is not alterable. If _Directoryname is instantiated then homedir succeeds if _Directoryname is the home directory.

**Fails:**

`homedir` fails if _Directoryname is neither a variable nor the name of the home directory.

**Examples:**

```prolog
/* Query the home directory */
?- homedir(_HD).
    homedir('MyDisk:Prologdir').
    YES

/* Cannot set homedir */
?- homedir('MyDisk:MyFolder').
    NO
```

**See Also:**

defaultdir in this chapter.
isdirectory(_Directoryname)

**generates directory names**

**Arguments:**

`isdirectory(?directory_name)`

**Succeeds:**

If _Directoryname is the name of a directory then `isdirectory` succeeds if _Directoryname exists in the default directory. If _Directoryname is a variable, `isdirectory` returns the name of a directory in the default directory. On backtracking, other directory names in the default directory will be generated.

**Fails:**

`isdirectory` fails if

- the _Directoryname is a not a variable or the name of a directory in the default directory.
- there are no directories in the default directory

**Examples:**

```
?- isdirectory(_).
?- isdirectory('NextFolder1').
?- isdirectory('NextFolder2').
YES
```
Chapter 12: Macintosh File System Access

isfile(_Filename, _Filecreator, _Filetype)
isfile(_Filename, _Filecreator, _Filetype, _Datastatus, _Rsrcstatus, _Created, _Modified)

generates file attributes

Arguments: isfile(?filename, ?filecreator, ?filetype)


Succeeds: The shorter form of isfile succeeds if a file exists in the default directory with name _Filename, creator _Filecreator, and type _Filetype. If any of the arguments are variables, backtracking will generate all matches to the specified argument pattern.

The extended form adds arguments for the current status of the data and resource fork of the file, as well as for the file creation and last modified dates. The status of each fork is given as a list of two elements: the first element is 1 if the fork is open, 0 if it's closed; the second element gives the current size of the fork in bytes. The creation and last modified dates are lists of the form [Year, Month, Day, Hour, Minute, Second, Weekday].

Fails: isfile fails if there are no files in the default directory matching the predicate argument pattern.

Examples:

?- isfile(Name, Creator, Type).
?- isfile('MyFile', APRO, TEXT).
?- isfile('AppFile', MYAP, APPL).
?- isfile('OtherFile', ????, TEXT).

YES

?- isfile('MyFile', _, _, _, _, _, _).

?- isfile('MyFile', APRO, TEXT, [0,280], [0,0], [1988,4,22,11,30,12,6], [1988,4,25,16,45,56,2]).

YES
isvolume(_Volumename)

**generates the names of physical disk volumes**

**Arguments:**

isvolume(?volume_name)

**Succeeds:**

If _Volumename is instantiated then isvolume succeeds if the volume _Volumename exists. If _Volumename is a variable then isvolume generates the names of all volumes in the system on backtracking.

**Fails:**

isvolume fails if _Volumename is not a variable or a valid Macintosh volume name for an existing volume.

**Examples:**

?- isvolume(_V).
?- isvolume('MyDisk').
?- isvolume('Floppyl').

YES
listdirectories(_Directorylist)

queries the list of directories in the default directory

Arguments: listdirectories(?list)

Succeeds: Unifies _Directorylist with the list of directory names in the default directory. If there are no directories in the default directory, _Directorylist is unified with the empty list.

Fails: listdirectories never fails.

Examples:

?- listdirectories(_L).
YES

?- listdirectories(['NextFolder1', 'NextFolder2']).
YES
**listfiles(_Filelist)**

*queries the list of files in the default directory*

**Arguments:**
listfiles(_Filelist)

**Succeeds:**
Unifies _Filelist with the list of filenames in the default directory. If there are no files in the default directory, _Filelist is unified with the empty list.

**Fails:**
listfiles never fails.

**Examples:**

?- listfiles(_F).
    ^- listfiles(["MyFile", "ApplFile", "OtherFile"]).

YES
listvolumes(_Volumelist)

queries the list of volumes in the default directory

Arguments:  listvolumes(?volumelist)
Succeeds:   Unifies _Volumelist with the list of volume names on the system.
Fails:      listvolumes never fails.
Examples:

?- listvolumes(_L).
    ?- listvolumes(["MyDisk", 'Floppy1']).
       YES
printfile(_Filename)

prints a file

Arguments:  
printfile(+filename)

Succeeds:  
Prints the file _Filename. A dialog is used to control printer operation.

Fails:  
printfile fails if
• _Filename does not exist
• the user 'cancels' while in the print setup dialog
• the printing manager returns an error code

Examples:

?- printfile('MyFile').
    ?- printfile('MyFile').
    YES
renamefile(_Oldfilename, _Newfilename)

renames a file

Arguments:  
renamefile(+filename, +filename)

Succeeds:  
Renames the file _Oldfilename to the name _Newfilename. Any affected window will be renamed.

Fails:  
renamefile fails if
• _Oldfilename is not the name of an existing file
• the file _Newfilename already exists.

Examples:

?- renamefile('MyFile', 'YourFile').
   ?- renamefile('MyFile', 'YourFile').
   YES
Two types of windows are supported by BNR Prolog: text windows (of type text) and graphics windows (of type graf). Windows of type text contain only single font text information and correspond, at least temporarily, to text files. Standard text editing operations can be applied to text windows. Most of these functions (scrolling, redrawing, moving) are done automatically by the system in order to support the BNR Prolog desktop. However, they can also be driven by Prolog predicates, in particular, dotext and inqtext.

Windows of type graf are much less restricted than text windows: they may contain graphics objects such as circles and rectangles with various kinds of pen and fill patterns, as well as text in various fonts and sizes. However, users are almost entirely responsible for maintaining the contents of a graphics window. For example, it is the user’s responsibility to update the contents of a graphics window when a part of it becomes visible.

This chapter is divided into three sections. The first covers generic window operations, such as the opening, closing, and dragging of both text and graphics windows. The second section describes the predicates for manipulating the contents of text windows, while the third describes the predicates for manipulating the contents of graphics windows. The text and graphics descriptors used with dotext, inqtext, dograf and inqgraf predicates are described in the chapters titled "Text Descriptors" and "Graphics Descriptors" in this manual.

Names and Types of Windows

The name and type of a window are often passed as arguments to the predicates described in this chapter. The name of a graphics window can be any symbol. However, all text windows are associated with disk files; when a text window is saved it is written to disk. The name of the text window is the same as that of the disk
file, and the usual naming rules for disk files apply also to text windows. See the chapter titled "Macintosh File System Access" for details on naming files.

**Predicates for Handling Windows**

This section describes predicates that apply to all types of windows.

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activewindow(_Windowname, _Windowtype)

queries or sets the currently active window

Arguments: activewindow(?symbol, ?symbol)

Succeeds: If the arguments _Windowname and _Windowtype specify the name and type (text or graf) of an existing window, then this window becomes the active window. If the window is hidden, it is made visible. If the arguments passed are variables, then they become instantiated to the name and type of the currently active window.

Fails: activewindow fails if
• _Windowname is not the name of a window
• _Windowtype is not the type of the window _Windowname

See Also: hidewindow in this chapter.
closewindow(_Windowname)

closes a window

Arguments: closewindow(+symbol)

Succeeds: Closes the window _Windowname. If the window is a text window, this predicate also closes the associated disk file, but does not write the contents of the window to the disk file before closure.

Fails: closewindow fails if
  • _Windowname is not the name of a window
  • _Windowname is the name of a text window which was explicitly opened as either a read_window or a read_write_window stream using the open predicate, and the stream has not been explicitly closed

Note: If a text window is opened which does not have a previously existing disk file, and if the contents of the window are not explicitly saved while the window is open, the associated disk file will disappear when the window is closed.

See Also: savetext in this chapter.
dragwindow(_Windowname, _Xglobal, _Yglobal, [_Xmin, _Ymin, _Xmax, _Ymax])

drags a window

Arguments:

| dragwindow(+symbol, +integer, +integer, [+integer, +integer, +integer, +integer]) |

Succeeds:

Drags an outline of the window _Windowname in response to movements of the mouse. When the mouse button is released the entire window moves to the final drag location, provided this is within the dragging limits of the boundary rectangle. The boundary rectangle is specified by the list consisting of the global coordinates _Xmin, _Ymin, _Xmax and _Ymax.

The principal use for this predicate is as a response to a userdrag event. When used in this way, the _Xglobal and _Yglobal coordinate pair should be the location where the mouse was pressed which can be obtained from the data parameters of a userdrag event (see the description of userevent in the chapter "User Events"). If a regular usermousedown event is used to get this drag start location, the coordinates must first be converted to the global coordinate system (see the predicate localglobal in the chapter titled "Macintosh System Utility Predicates").

Fails:

dragwindow fails if

- _Windowname is not the name of a window
- _Xglobal and _Yglobal are not integers corresponding to valid screen coordinates
- the last argument is not a list of four integers corresponding to valid screen coordinates
- the mouse button is released when the mouse is located outside the boundary rectangle defined by the last argument

Note:

It is advisable practice to have the list argument define a boundary rectangle 4 pixels smaller than the screen dimensions. This ensures that at least 4 pixels of a window are always visible as a future dragging handle.
Chapter 13: Windows

`growwindow(_, Windowname, _Xglobal, _Yglobal, [_Minwidth, _Minheight, _Maxwidth, _Maxheight])`

changes the size of a window

**Arguments:**

`growwindow(+symbol, +integer, +integer, [+integer, +integer, +integer, +integer])`

**Succeeds:**

Stretches or shrinks an outline of the window's borders by adjusting the bottom right-hand corner of the window in response to movements of the mouse, until the mouse button is released. When the mouse button is released the window's size is changed to the final grow size. The last list argument is a boundary rectangle defining the maximum and minimum dimensions allowed for adjusting the content portion of the named window.

The principle use for this predicate is as a response to a `growwindow` event, which is generated only for windows that have been created using `documentproc` or `zoomdocproc` window definition parameters (see the description of `openwindow` in this chapter). The global coordinate pair `_Xglobal` and `_Yglobal` define the location of the mouse when the mouse button was pressed. These coordinates can be obtained from the data parameters of a `userdrag` event (see the description of `userevent` in the chapter "User Events"). If a regular `usermousedown` event is used to get this drag start location, the coordinate must first be converted to the global coordinate system. (See the predicate `localglobal` in the chapter titled "Macintosh System Utility Predicates").

**Fails:**

`growwindow` fails if

- `_Windowname` is not the name of a window
- `_Xglobal` and `_Yglobal` are not integers corresponding to valid screen coordinates
- the last argument is not a list of four integers corresponding to valid screen coordinates
- the mouse button is released when the mouse is located outside the boundary rectangle defined by the last argument
Note: Only windows that have been created using `documentproc` or `zoomdocproc` window definition parameters (see the definition of `openwindow` in this chapter) will automatically resize the borders of the window as the mouse is being tracked (a Macintosh Operating System property). However, all windows will adjust their size when the mouse button is released.

See Also: The chapter titled "User Events" in this manual.
hidewindow(_Windowname)

_**hides a window**_

**Arguments:** hidewindow(+symbol)

**Succeeds:** Makes invisible the window _Windowname_. If that window is currently active, the window underneath it (that is, the window that was last active) is made active.

**Fails:** hidewindow fails if _Windowname is not the name of a window.

**See Also:** activewindow in this chapter.
iswindow(_Windowname, _Windowtype, _Visible)

generates the relationship between a window, its type and its visibility status

Arguments: iswindow(?symbol, ?symbol, ?symbol)

Succeeds: If all the arguments are instantiated, iswindow succeeds if
_Windowname is of _Windowtype (text or graf) and has the
specified visibility (visible or hidden). If any of the arguments
are variables, iswindow generates all solutions defined by the
argument instantiations.

Fails: iswindow fails if
• _Windowname is neither a variable nor the name of a window
• _Windowtype is neither a variable nor a valid type specification
• _Visibility is neither a variable nor one of the two symbols
  allowed (visible or hidden)
• there is no such relationship between the instantiated arguments

See Also: listwindows in this chapter.
listwindows(_Windowlist)

lists windows

Arguments: listwindows(?list)
Succeeds: Unifies _Windowlist with an ordered list of the names of open windows.
Fails: listwindows fails if _Windowlist is neither a variable nor a list which unifies with the ordered list of window names.
See Also: iswindow in this chapter.
openwindow(_Windowtype, _Windowname, pos(_Leftedge, _Topedge), size(_Width, _Height), options(_Options..))

opens a window

Arguments: openwindow(+symbol, ?filename, pos(?integer, ?integer), size(?integer, ?integer), options(+variadic))

Succeeds: Opens a window of the type specified by _Windowtype. If _Windowname is a symbol, the window is given that name. If it is a variable then it is instantiated to 'UntitledX' where X is an integer chosen to ensure uniqueness.

If _Windowtype is text then a text window is opened containing the contents of the disk file _Windowname. If the disk file _Windowname does not exist, a disk file is created first and the window on it is opened.

If _Windowtype is graf then a graphics window is opened. The top-left corner of the content portion of a graf window has local coordinates (0, 0), the x-axis increases to the right and the y-axis increases down.

The pos structure specifies the _Leftedge and _Topedge values which are pixel offsets from the top-left corner of the Macintosh screen to the top-left corner of the content portion of the window being opened. If either _Leftedge, _Topedge, or both are variables, a system default will be used and the variables will be instantiated to the default values. The _Width and _Height values of the size structure are the actual pixel width and height of the content portion of that window. If either one or both of the _Width and _Height arguments are variables, system defaults are calculated and the variables will be instantiated to those values.

The options structure is variadic. The options arguments can include a window definition, closebox, vscroll (vertical scroll), hscroll (horizontal scroll) and msgbutton. The last four options are disabled by noclosebox, novscroll, nohscroll and
nomsgbutton. The window definition argument may be any one of the Macintosh toolbox defined values (see Volume I and IV of *Inside Macintosh*). These have been made available by the options documentproc, dboxproc, plainbox, altdboxproc, nogrowdoproc, rdoproc, zoomdoproc and zoomnogrow.

The default options for text windows are zoomdocproc, closebox, vsroll, hscroll, and msgbutton. The defaults for graf windows are rdocproc and closebox. The vsroll, hscroll and msgbutton options for graf windows are not implemented.

**Fails:**

openwindow fails if

- a window of the same name and type is already open
- _WIndowtype is neither the symbol text nor graf
- _WIndowname is neither a symbol nor a variable
- _Leftedge and _Topedge are neither variables nor integers
- _Width and _Height are neither variables nor integers
- _Options... contains elements that are not supported

**Examples:**

/* this example opens a graf window with a specified name */
/* position and size, but with default options */
?- openwindow(graf, 'test graf window', pos(140, 140),
size(200, 200), options()).
?- openwindow(graf, 'test graf window', pos(140, 140),
size(200, 200), options()).
YES

/* this example opens a text window with default settings */
/* for name, position & size but without grow or close boxes */
?- openwindow(text, _, pos(_, _), size(_, _),
options(noclosebox, zoomnogrow)).
?- openwindow(text, 'Untitled1', pos(35, 60), size(566, 321),
options(noclosebox, zoomnogrow)).
YES

**See Also:**
closewindow, zoomwindow and growwindow in this chapter.
**positionwindow**(_Windowname, _Leftedge, _Topedge)

queries or sets the position of a window

**Arguments:** positionwindow(+symbol, ?integer, ?integer)

**Succeeds:** If the arguments _Leftedge and _Topedge are integers, then positionwindow moves the window _Windowname without changing its size or shape to the position specified. The _Leftedge and _Topedge values are the number of pixels offset from the top-left corner of the Macintosh screen to the top-left corner of the content portion of the window being opened. If _Leftedge and _Topedge are variables then positionwindow returns the position of the content portion of the window.

**Fails:** positionwindow fails if
- _Windowname is not the name of a window
- _Leftedge and _Topedge are neither variables nor integers

**See Also:** sizewindow in this chapter.
sizewindow(_Windowname, _Width, _Height)

queries or sets the size of a window

Arguments:  sizewindow(+symbol, ?integer, ?integer)
Succeeds:   If _Width and _Height are integers, sizewindow expands or
            shrinks the size of the window _Windowname to the width and height
            specified by _Width and _Height, which are the actual pixel width
            and height of the content portion of the window. If either _Width or
            _Height, or both are variables, then sizewindow returns the
            the width and height of the window _Windowname as specified by the
            argument.
Fails:      sizewindow fails if _Windowname is not the name of a window.
zoomwindow(_Windowname, _Xglobal, _Yglobal)

expands a window

Arguments: zoomwindow(+symbol, +integer, +integer)
Succeeds: Alternates the size and position of the window _Windowname between a user state and a standard state. The standard state is a large window that almost fills the entire screen. The user state is the last window position and size explicitly set by the user (or a program). The _Xglobal and _Yglobal coordinate pair should be the mouse click location returned from the data arguments of a userzoom event (see the description of userevent in the chapter "User Events").
Fails: zoomwindow fails if _Windowname is not the name of a window.
Note: This predicate should only be used in response to userzoom events, which in turn are only generated for windows created using zoomdocproc or zoomnogrow window definition parameters (see the definition for openwindow in this chapter).
See Also: The chapter titled "User Events" in this manual.
Manipulating Text Window Contents

Text in a text window is manipulated using a text structure. A text structure alters text in the same way as Apple TextEdit routines, and is used to provide the basic text editing facilities required by an application. This includes selecting, editing and inserting text.

A text structure consists of a text descriptor or a list of text descriptors chosen from the available set described in the chapter titled "Text Descriptors" in this manual. Text structures may be either attribute descriptors or output descriptors. Text attribute descriptors do not change the content of a text file, for example, the description of a piece of selected text. Text output descriptors change the contents of a text file, for example, inserting selected text.

Predicates for Manipulating Text Windows

This section describes the predicates dotext and inqtext which are used to manipulate text in text windows by means of a text structure argument (either a text descriptor or list of text descriptors). Also described are predicates which test for outstanding changes and discard these changes or save them.

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<td>savetext</td>
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</table>
changedtext(_Windowname)

tests for outstanding changes

Arguments: changedtext(+filename)

Succeeds: changedtext succeeds if there are outstanding changes in the window _Windowname (that is, changes which have not been written to the associated disk file _Windowname).

Fails: changedtext fails if
  • _Windowname is not the name of a text window
  • there are no outstanding changes in the window

See Also: savetext in this section
**dotext**(_Windowname, _Textstructure)

*applies text descriptors*

**Arguments:**
dotext(+filename, +textstructure)

**Succeeds:**
dotext takes a text descriptor or list of descriptors and applies them to the text window named _Windowname. Depending on the descriptor, this could result in text being edited, inserted or selected. Text descriptors in _Textstructure that contain variables are ignored.

**Fails:**
dotext fails if
- _Windowname is not the name of a text window
- _Textstructure is a valid text descriptor containing an invalid argument or a list of such descriptors

**Note:**
If a text descriptor or list of descriptors contains only partially instantiated terms or invalid descriptors these descriptors are ignored and only the instantiated descriptors are applied. This feature is particularly useful where descriptors are subject to passive or active constraints (see the chapters on constraints in the *BNR Prolog User Guide*).

**Example:**

```prolog
/*If the window 'hdisk:prolog:alice' contains only:
without pictures or conversation what is the use of a book
/* the following query selects the first 13 chars, cuts them */
/* into the clipboard and pastes them at the end of the file */
?- dotext('hdisk:prolog:alice',
   [selectcabs(0,33), % select the first 33 chars
    edit(cut), % cut & put them in the clipboard
    selectcabs(end_of_file,end_of_file), % go to eof
    edit(paste)]). % paste clipboard there
/* producing
what is the use of a book without pictures or conversation */
```

**See Also:**
The chapter titled "Text Descriptors" in this manual.

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**inquTEXT** (_Windowname, _Textstructure)

*inquires about text attribute descriptors*

**Arguments:**

inquTEXT(+symbol, +textstructure)

**Succeeds:**

inquTEXT unifies the text attribute descriptor or list of descriptors in _Textstructure with the appropriate values from the window _Window. inqtext can only query or verify the attributes of a text window, it cannot change these attributes. These attributes include the number of characters, the number of lines, the current selection positions and the current selection of text (see the chapter titled "Text Descriptors")

**Fails:**

dotext fails if

- _Windowname is not the name of a text window
- _Textstructure is a valid text descriptor containing an invalid argument or list of such descriptors

**Examples:**

/*If the window 'hdisk:prolog:alice' contains only:
"curiouser and curiouser" cried alice
/* and the word 'cried' is the current selection then
/* the query
?- inqtext('hdisk:prolog:alice',
[selectcabs(_Start, _End), % selection positions
selection(_Text), %what is the text
csize(Size)]). % how many characters in the file

/* * produces the answer
?- inqtext('hdisk:prolog:alice',
[selectcabs(26, 31), selection(cried) ,csize(37)]).
YES

**See Also:**

The chapter titled "Text Descriptors" in this manual.
reloadtext(_Windowname)

reloads a window

Arguments: reloadtext(+filename)
Succeeds: Reloads the window _Windowname with the contents of the current disk file. Any outstanding changes in the window are lost. If there are no outstanding changes reload succeeds and does nothing.
Fails: reloadtext fails if _Windowname is not the name of a text window.
See Also: savetext and changedtext in this chapter.
retargettext(_Windowname, _Newname)

*retargets a text window*

**Arguments:**
retargettext(+filename, +filename)

**Succeeds:**
Attaches the window _Windowname to an existing disk file _Newname. After a successful call to retargettext the window _Windowname is renamed to _Newname; the contents of the window are not changed and the file corresponding to _Windowname is closed but not saved. The original disk file of _Newname is not changed until the window, (now called _Newname) is saved.

**Fails:**
retargettext fails if
- _Windowname is not the name of a text window
- _Newname is not a valid file specification for an existing disk file, or is a partial filename and is not in the default directory
- _Newname is an open window

**Note:**
If the window _Windowname is such that changedtext(_Windowname) fails, then, after a successful call to retargettext, changedtext(_Newname) will also fail. This means that the File menu cannot be used to save a window that has been "retargeted". Such a window can be saved only with the savetext predicate.

**See Also:**
changedtext and reloadtext in this chapter.
savetext(_Windowname)

updates the disk file version of the window

Arguments: savetext(+filename)
Succeeds: Updates the contents of the disk file _Windowname to match those of its associated window _Windowname. The window remains active.

If there are no outstanding changes in the text, the predicate succeeds and does nothing.

Fails: savetext fails if

• _Windowname is not the name of a text window
• the disk write fails

See Also: changedtext and reloadtext in this chapter.
Manipulating Graph Window Contents

Graphical objects in BNR Prolog are displayed in graphics windows of type graf. These graphical objects are described in terms of graphics structures which operate within graphics windows.

A graphics structure is either a single graphics descriptor or a list of graphics descriptors chosen from the available set described in the chapter titled "Graphics Descriptors" in this manual. Graphics descriptors may be graphics output descriptors (for example, drawing a line) or graphics attribute descriptors (for example, the thickness of a line).

Predicates for Manipulating Graphics Windows

This section describes the predicates dograf and inqgraf which are used to manipulate and query graphics windows using a graphics structure argument (either a graphics descriptor or list of graphics descriptors). This section should be read in conjunction with the chapter titled "Graphics Descriptors" in this manual.

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**dograf(_Windowname, _Grafstructure)**

draws a structure

**Arguments:**

`dograf(+symbol, +grafstructure)`

**Succeeds:**

`dograf` takes a graphics descriptor or list of descriptors and applies them to the graf window named `_Windowname`. Graphics descriptors containing variables are ignored.

**Fails:**

`dograf` fails if

- `_Windowname` is not the name of a graphics window
- `_Grafstructure` is a valid graphics descriptor containing an invalid argument or a list of descriptors

**Note:**

`_Grafstructure` can consist of nested lists of graphics descriptors, to an implementation dependent limit. If it is a nested list, the graphics descriptors in `_Grafstructure` will be executed in the order determined by a depth-first traversal of the list. The effect of nesting in graphics structures is to preserve the graphics window's attributes set at each level. Each nesting level maintains its own attribute set which is stacked upon further nesting and restored upon return. This provides a convenient tool for localizing attribute changes without querying and remembering all the current attribute settings. For example, in the call

`dograf(test, [list_a, [list_b], [list_c], list_d])`

attribute changes in `list_a` will affect all subsequent drawing, whereas no changes in either `list_b` or `list_c` will affect any drawing in `list_d`, because the attributes which `list_a` left will be restored upon exit from the nested level `b` and `c`. The outermost structure level, whether this is a single descriptor or a list (as in the example), permanently alters the current attribute set.

If a graphics descriptor or list of descriptors contains only partially instantiated terms, these descriptors are ignored and only the instantiated descriptors are applied. This feature is particularly
useful where descriptors are subject to passive or active constraints
(See the chapters on constraints in the BNR Prolog User Guide.)

Examples:

```prolog
/* first open a graf window */
?- openwindow(graf, test, pos(10, 50), size(400, 300), options()).
?- openwindow(graf, test, pos(10, 50), size(400, 300), options()).
YES

/* draw a line */
?- dograf(test, [moveabs(75, 75), angle(-45), line(100)]).
?- dograf(test, [moveabs(75, 75), angle(-45), line(100)]).
YES

/* or draw a black rectangle and xor a line through it */
?- dograf(test, [backcolor(black), forecolor(white), fillpat(clear), rectabs(20, 40, 120, 140), penmode(xor), moveabs(75, 75), angle(90), line(100)]).
?- dograf(test, [backcolor(black), forecolor(white), fillpat(clear), rectabs(20, 40, 120, 140), penmode(xor), moveabs(75, 75), angle(90), line(100)]).
YES
```

See Also: The chapter titled "Graphics Descriptors" in this manual
inqgraf(_Windowname, _Attributedescriptor)

returns graphics attribute descriptors

Arguments:  inqgraf(+symbol, +attribute_descriptor)
Succeeds:  inqgraf unifies the specified list of graphics descriptors with their current values for the window _Windowname.
Fails:  inqgraf fails if _Windowname is not the name of a graphics window
Examples:

/* the query
?- inqgraf(test, [pensize(_Width, _Height),
textfont(_Font)]).

/* might return the answer
?- inqgraf(test, [pensize(1, 1), textfont(3)])

See Also:  The chapter titled "Graphics Descriptors" in this manual
The text contained in a text window can be examined and transformed by passing a text structure as the second argument to the \texttt{do\texttt{text}} and \texttt{inq\texttt{text}} predicates described in the chapter titled "Windows". A \textit{text structure} consists of a text descriptor or a list of text descriptors.

There are two types of text descriptors:

- text attribute descriptors
- text output descriptors

\textit{Text attribute descriptors} do not change the contents of the text window and may be used to query the attributes of text using the \texttt{inq\texttt{text}} predicate. They may also be passed as arguments to the \texttt{do\texttt{text}} predicate to modify the attributes of the text in the window without changing its contents.

\textit{Text output descriptors}, on the other hand, physically change the contents of a text window when they are passed as arguments to the \texttt{do\texttt{text}} predicate. These descriptors cannot be used with \texttt{inq\texttt{text}} for querying.

The position of a character, line, or selection of text in a text window is measured either in terms of the number of characters or lines from the beginning of the file, that is, the \textit{absolute} position, or as a \textit{relative} offset from the current selection position. The absolute position zero is the position of the first character in the file.

A selection of text manipulated by \texttt{inq\texttt{text}} or \texttt{do\texttt{text}} using text descriptors is either translated to a symbol (at most 255 characters long) or treated as a stream. Streams in this context are finite sequences of characters associated with a text file.
Text Attribute Descriptors

The following text attribute descriptors are described in this section.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>csize</td>
<td>queries or sets the number of characters in a text file</td>
</tr>
<tr>
<td>lsize</td>
<td>queries or sets the number of lines in a text file</td>
</tr>
<tr>
<td>scandirection</td>
<td>queries or sets the scan direction</td>
</tr>
<tr>
<td>selectcabs</td>
<td>selects text using absolute character positions</td>
</tr>
<tr>
<td>selectcrel</td>
<td>selects text relative to the current selection using character positions</td>
</tr>
<tr>
<td>selection</td>
<td>returns the current selection or finds the next occurrence</td>
</tr>
<tr>
<td>selectlabs</td>
<td>selects text using absolute line positions</td>
</tr>
<tr>
<td>selectlrel</td>
<td>selects lines of text using line positions relative to the current selection</td>
</tr>
</tbody>
</table>

Descriptions of the text attribute descriptors follow. The success and failure of these descriptors are only relevant when the descriptors are passed as arguments to the inqtext or dotext predicates, either as a single argument or as a member of a list of descriptors that is passed as an argument. The descriptors themselves cannot be executed directly. All the descriptors operate on windows of type text.
csize(_Size)

queries or sets *the number of characters in a text file*

**Arguments:**
csize(?integer)

**Succeeds:** If `csize` is passed as an argument to `inqtext`, `_Size` unifies with the number of characters in the text window. If `_Size` is an integer and `csize` is passed as an argument to `dotext`, it sets the number of characters in the text file to `_Size`.

**Fails:** `csize` fails if `_Size` is neither a variable nor an integer.

**See Also:** `lsize` in this chapter.
**1size(_Size)**

*queries or sets the number of lines in a text file*

**Arguments:**  
1size(?integer)

**Succeeds:**  
If 1size is passed as an argument to inqtext, _Size unifies with the number of lines in the text window. If _Size is an integer and csize is passed as an argument to dotext, it sets the number of lines in the text file to _Size.

**Fails:**  
1size fails if _Size is neither a variable nor an integer.

**See Also:**  
csize in this chapter.
scandirection

queries or sets the scan direction

**Arguments:**  
scandirection(?symbol)

**Succeeds:**  
If _Direction is a variable then scandirection unifies with the current scanning direction. If _Direction is specified (acceptable values are forward and backward) scandirection sets the current scanning direction.

**Fails:**  
scandirection fails if _Direction is neither a variable nor one of the allowed symbols (forward or backward).
selectcabs(_Startchar, _Endchar)

selects text using absolute character positions

Arguments: selectcabs(?integer, ?integer/end_of_file)

Succeeds: As an argument to dotext, selectcabs selects the sequence of characters between _Startchar and _Endchar, where _Startchar and _Endchar are absolute character positions, offset from character position zero (the position zero corresponds to the first character in the file). Position values less than zero or greater than the file character size are treated as referring to the beginning and end of the file respectively. The end of file may be specified using the symbol end_of_file.

If selectcabs is used as an argument to inqtext, _Startchar and _Endchar unify with the absolute character positions of the selection. If no text is selected _Startchar equals _Endchar.

Fails: selectcabs fails if
- _Startchar does not unify with an integer
- _Endchar does not unify with either an integer or the symbol end_of_file
- the value of _Startchar is greater than the value of _Endchar

Examples:

    /* Consider a window 'hdisk:prolog:test' consisting of: */
    /* the following text: */
    The big brown fox jumped over the lazy dog.
    /* if the cursor is between j and u in window then */
    /* selection in 'hdisk:prolog:test' is at position 19 */
    ?- inqtext('hdisk:prolog:test', selectcabs(Start, End)).
    ?- inqtext('hdisk:prolog:test', selectcabs(19, 19)).
    YES
/* now select 5 chars ig br between pos 5 and 10 */
?- dotext('hdisk:prolog:test', selectcabs(5, 10)).
    dotext('hdisk:prolog:test', selectcabs(5, 10)).
YES
/* now inquire where the selection is */
?- inqtext('hdisk:prolog:test', selectcabs(Start, End)).
    inqtext('hdisk:prolog:test', selectcabs(5,10)).
YES

/* now position the cursor at the beginning of the file */
?- dotext('hdisk:prolog:test', selectcabs(0,0)).
    dotext('hdisk:prolog:test', selectcabs(0,0)).
YES

See Also: selectcrel and selectlabs in this chapter.
selectcrel(_Startchar, _Endchar)

select text relative to the current selection using character positions

Arguments: selectcrel(?integer, ?integer/end_of_file)

Succeeds: As an argument to dotext, selectcrel selects the sequence of characters between _Startchar and _Endchar, where _Startchar and _Endchar are relative character positions offset from the current selection. _Startchar is the number of characters measured backwards from the beginning of the current selection, and _Endchar is the number of characters measured forward from the end of the current selection. Relative position values resulting in absolute positions less than zero or greater than the file character size are treated as referring to the beginning and end of the file respectively. The end of file may be specified using the symbol end_of_file. If selectcrel is used as an argument to inqtext, _Startchar and _Endchar unify with zero.

Fails: selectcrel fails if
• _Startchar is not an integer
• _Endchar is neither an integer nor the symbol end_of_file

Examples:

/* Consider a window 'hdisk:prolog:test' consisting of */
/* the following text: */
The big brown fox jumped over the lazy dog.
/* Position the cursor at the beginning of the file */
/* with selecttabs and then select brown */
?- dotext('hdisk:prolog:test',
            [selectcabs(0,0), selectcrel(8, 13)]).
    ?- dotext('hdisk:prolog:test', [selectcabs(0,0), selectcrel(8, 13)]).
    YES
See Also: selectcabs and selectlrel in this chapter.
**selection(_Text)**

*returns the current selection or finds the next occurrence*

**Arguments:**

`selection(?symbol/integer)`

**Succeeds:** If `selection` is passed as an argument to `inqtext`, then `_Text` is unified with the symbol formed by the concatenation of the characters in the current selection, provided the current selection is less than or equal to 255 characters. If `_Text` is the stream identifier of a writable stream, the selection will be output to that stream. If the stream is the default input stream, zero, the selection will also be entered to the Prolog system.

If `_Text` is a symbol and `selection(_Text)` is passed as an argument to the `dotext` predicate, the next occurrence of `_Text` is made the current selection. The position may then be determined by means of one of the select descriptors. This search for `_Text` is case sensitive.

**Fails:** `selection` fails if
- `selection(_Text)` is passed to `dotext` and `_Text` is not instantiated to a symbol
- the current selection is longer than 255 characters,
  `selection(_Text)` is passed to `inqtext` and `_Text` is not the stream identifier of a writable stream

**Examples:**

```prolog
/* If the window 'hdisk:prolog:test' consists of the */
/* two lines: The first query is '?- write(hello_world).'. and */
/* the second occurrence of it is '?- write(hello_world).'. */
/* and the first occurrence of '?- write(hello_world).' is */
/* selected, then */
?- inqtext('hdisk:prolog:test', selection(_Text)).
   inqtext('hdisk:prolog:test', selection('?- write(hello_world).')).
YES
```

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/* if _Text is the stream O (console) and the following query is executed */
?- inqtext('hdisk:prolog:test', selection(0)).
    inqtext('hdisk:prolog:test', selection(0)).
YES
?- write(hello_world). hello_world
  write(hello_world).
YES
/* if the first occurrence of '?- write(hello_world).' is selected */
/* then this query finds the next occurrence */
?- dotext('hdisk:prolog:test', selection('?- write(hello_world).')).
selectlabs(_Startline, _Endline)

selects text using absolute line positions

Arguments: selectlabs(?integer, ?integer/end_of_file)

Succeeds: As an argument to dotext, selectlabs selects the text between _Startline and _Endline, which are are absolute offsets from line position zero (the line position zero corresponds to the line in which first character in the file resides). _Startline specifies a number of lines measured backwards from the beginning of the current selection and _Endline specifies a number of lines measured forward from the end of the current selection. Position values less than zero or greater than the number of lines in the file are treated as referring to the first and last lines of the file respectively. The last line of the file may be specified using the symbol end_of_file. If _Startline is greater than _Endline the selection is null and begins on _Startline.

If selectlabs is used as an argument to inqtext, _Startline and _Endline unify with the absolute line positions of the current selection. If no text is selected _Startline equals _Endline.

Fails: selectlabs fails if

• _Startline does not unify with an integer
• _Endline does not unify with either an integer or the symbol end_of_file

Examples:

/* If the file 'hdisk:prolog:test' consists of the */
/* two lines: */
This is the first line
This is the second line
*/
/* then this query selects the second line */
?- dotext('hdisk:prolog:test', selectlabs(1,2)).
?- dotext('hdisk:prolog:test', selectlabs(1,2)).
YES

/* and this one queries which lines are selected */
?- inqtext('hdisk:prolog:test', selectlabs(_X,_Y)).
?- inqtext('hdisk:prolog:test', selectlabs(1, 1)).
YES

See Also: selectlrel and selectcabs in this chapter.
**selectlrel(_Startline, _Endline)**

*select lines of text using line positions relative to the current selection*

**Arguments:**

selectlrel(?integer, ?integer/end_of_file)

**Succeeds:**

As an argument to do_text, selectlrel selects the section of text between the positions _Startline and _Endline which are offset relative to the current selection. _Startline specifies a number of lines measured backwards from the beginning of the current selection and _Endline specifies a number of lines measured forward from the end of the current selection. Relative position values resulting in absolute positions less than zero or greater than the number of lines in the file are treated as referring to the first and last lines of the file respectively. The end of the file may be specified using the symbol end_of_file.

**Fails:**

selectlrel fails if
- _Startline does not unify with an integer
- _Endline does not unify with either an integer or the symbol end_of_file

**See Also:**

selectlrels and selectcrel in this chapter.
Text Output Descriptors

The success and failure of the text output descriptors is relevant only when they are passed as arguments to the dotext predicate, either as a single argument or as a member of a list of descriptors that is passed as an argument. The descriptors themselves cannot be executed directly. All the descriptors operate on windows of type text.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>edit</td>
<td>performs an edit action</td>
</tr>
<tr>
<td>insert</td>
<td>inserts a text string</td>
</tr>
<tr>
<td>replace</td>
<td>replaces text</td>
</tr>
</tbody>
</table>
**edit**(_-Editaction_)  

*performs an edit action*

**Arguments:**  
edit(+symbol)

**Succeeds:**  
Performs the action _Editaction_ using the current selection and clipboard contents. _Editaction_ can be one of cut, copy, paste or clear. These use the system scrapbook or clipboard, and provide a means of easily transferring textual data in and out of the Prolog environment.

**Fails:**  
edit fails if
- _Editaction_ is not a valid edit action
- the result of a paste produces a window greater than 32 Kilobytes

**Examples:**

```prolog
/* If the window 'hdisk:prolog:test' is: */
The big brown fox jumped over the lazy dog.
/* */
/* this query selects the first 13 chars, copies them to */
/* the clipboard and pastes them at the end of the file */
?- dotext('hdisk:prolog:test',
    [selectcabs(0,13), edit(copy),
     selectcabs(end_of_file, end_of_file),
     edit(paste)]).
/* producing */
The big brown fox jumped over the lazy dog. The big brown
/* */
```

**See Also:**  
insert and replace in this chapter
**insert(_Text)**

**inserts a text string**

**Arguments:**  
`insert(+symbol/integer)`

**Succeeds:**  
Inserts the text _Text at the beginning of the current selection. The current selection is not affected. _Text must be a symbol or the stream identifier of a writable stream. If _Text is a stream, all printable characters in the stream up to the end of the stream are inserted.

**Fails:**  
`insert` fails if _Text is not one of the following: a symbol, a valid stream identifier for a writable stream, a variable or a tail variable.

**Note:**  
This descriptor is semantically equivalent to a series of calls to the Macintosh Toolbox TEInsert routine described in Volume I of *Inside Macintosh*.

**See Also:**  
edit in this chapter.
replace(_Text)

replaces text

Arguments: replace(+symbol/integer)

Succeeds: Replaces the current selection with the text _Text. _Text must be a symbol or the stream identifier of a writable stream. In the latter case, all the text in the stream up to the end of the stream is written to the window. Any characters (including nonprintable characters) may be written to the window. These are interpreted as if they had been entered from the keyboard.

Fails: replace fails if _Text is not one of the following: a symbol, a valid stream identifier for a writable stream, a variable or a tail variable.

See Also: edit and insert in this chapter.
The contents and attributes of a graphics window can be examined and modified by passing a graphics structure as the second argument to the `inqgraf` and `dograf` predicates described in the chapter titled "Windows".

A graphics structure consists of a graphics descriptor or a list of graphics descriptors. Graphics structures are not executed directly but are passed as arguments to either the `inqgraf` or `dograf` predicates which execute them. There are two types of graphics descriptors:

- graphics attribute descriptors
- graphics output descriptors

Graphics attribute descriptors, like text attribute descriptors, do not physically change the contents of the graphics window and can be used to examine the attributes using the `inqgraf` predicate. These descriptors can also be executed by the `dograf` predicate to modify the way a graphics object is subsequently drawn.

Graphics output descriptors, like text output descriptors, physically change the contents of the graphics windows. These descriptors define the graphics structure to be drawn and are executed by the `dograf` predicate. Graphics output descriptors will be ignored by `inqgraf`.

The "absolute" coordinate parameters used by any graphics descriptors such as `position(_X,_Y)` and `rectabs(_X1,_Y1,_X2,_Y2)` are relative to the (0,0) coordinates in the top-left-hand corner of the graphics window. The x-axis increases to the right and the y-axis increases downwards.

The `dograf` and `inqgraf` predicates are described in more detail in the Chapter titled "Windows" in this manual. Further information on using the descriptors is available the chapter titled "User Interfaces" in the BNR Prolog User Guide.
Graphics Attribute Descriptors

Attribute descriptors may be used with either the inqgraf or dograf predicates. The attributes that these descriptors query or modify always pertain to the window named in the inqgraf or dograf predicates.

A call to inqgraf with an attribute descriptor that contains a variable will succeed by unifying the variables with values that pertain to the graphics window's attributes. If the attribute descriptors are ground terms, a call to inqgraf will act as a filter. Since attribute descriptors with inqgraf are always used either as queries or filters, the attribute descriptors in this section are explained principally in terms of the action of a fully instantiated descriptor by dograf.

A call to dograf with an attribute descriptor that contains a variable always succeeds and leaves the variables unbound. This can be useful when such variables are subject to constraints imposed by freeze and related predicates (See the chapters titled "Control" and "Passive Constraints" in the BNR Prolog User Guide and the chapter titled "Control" in this manual.) On the other hand, if dograf is called with an attribute descriptor that is ground, the attributes of the window can be set to new values. Although an attribute change does not have any visible effect on the contents of the window, it may affect how subsequent drawing operations are performed.

One way to modularize the effects of a list of graphics attribute descriptors is for the list to be nested. With a nested list of attribute descriptors, dograf only uses the attributes at the top level of the list to cause permanent changes to the window's attributes. All the changes caused by sublists of attribute descriptors are temporary (see the description of dograf in the chapter titled "Windows"). A list of sublists of descriptors will be executed in the order determined by a depth-first traversal of the list. Lists of graphics descriptors can be nested to an arbitrary depth.
The following is a list of the attribute descriptors.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>queries or sets the angle of movement of the drawing pen</td>
</tr>
<tr>
<td>backcolor</td>
<td>queries or sets the background color</td>
</tr>
<tr>
<td>backpat</td>
<td>queries or sets the background pattern</td>
</tr>
<tr>
<td>fillpat</td>
<td>queries or sets the fill pattern</td>
</tr>
<tr>
<td>forecolor</td>
<td>queries or sets the foreground color</td>
</tr>
<tr>
<td>penmode</td>
<td>queries or sets the pen transfer mode</td>
</tr>
<tr>
<td>penpat</td>
<td>queries or sets the drawing pen's pixel pattern</td>
</tr>
<tr>
<td>pensize</td>
<td>queries or sets the size of the drawing pen</td>
</tr>
<tr>
<td>position</td>
<td>queries or sets the current drawing pen position</td>
</tr>
<tr>
<td>scale</td>
<td>queries or sets a scale factor</td>
</tr>
<tr>
<td>textface</td>
<td>queries or sets the text face characteristics</td>
</tr>
<tr>
<td>textfont</td>
<td>queries or sets the text font</td>
</tr>
<tr>
<td>textmode</td>
<td>queries or sets the text transfer mode</td>
</tr>
<tr>
<td>textsize</td>
<td>queries or sets the text size</td>
</tr>
<tr>
<td>userpat</td>
<td>loads a pattern resource</td>
</tr>
</tbody>
</table>
angle(_Degrees)

queries or sets the angle of movement of the drawing pen

Argument: angle(?number)

Succeeds: If _Degrees is a number and angle is used with dograf, it sets the drawing pen's movement angle in degrees. Pen angles are measured positively starting from zero degrees at the 3:00 o'clock position. This attribute is used only by the turtle graphics descriptors.

The initial value is zero degrees.

If angle is used with inqgraf, then _Degrees unifies with the current angle of the drawing pen in the graphics window.

Fails: angle fails if _Degrees is neither a number nor a variable.
backcolor(_Color)

queries or sets background color

Arguments: backcolor(?integer/symbol)

Succeeds: If _Color is of one of the following color numbers or equivalent symbols

<table>
<thead>
<tr>
<th>Color</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>white</td>
</tr>
<tr>
<td>33</td>
<td>black</td>
</tr>
<tr>
<td>205</td>
<td>red</td>
</tr>
<tr>
<td>341</td>
<td>green</td>
</tr>
<tr>
<td>273</td>
<td>cyan</td>
</tr>
<tr>
<td>409</td>
<td>blue</td>
</tr>
<tr>
<td>137</td>
<td>magenta</td>
</tr>
<tr>
<td>69</td>
<td>yellow</td>
</tr>
</tbody>
</table>

then backcolor, used with dograf, sets the background color of the graphics window.

The background of a graphics window does not automatically change color when this descriptor is invoked. Rather, all subsequent output descriptors which make use of the background color will use this new value. For example, the shape descriptors, like rectangle, use the background color when clear is in effect as the current fill pattern.

The initial background color is white.

If backcolor is used with inqgraf then _Color unifies with the current background color of the graphics window.

Fails: backcolor fails if _Color is not a variable or a valid color number, or one of the predefined symbols listed above.

Note: If you specify a color other than white on a black-and-white output device, it will appear in black.

See Also: forecolor in this chapter.
backpat(_Backpattern)
backpat(_PatResId, _PatResIndex)

queries or sets the background pattern

Arguments: backpat(?symbol)
backpat(?symbol/[?integer, ?integer])

Succeeds: If _Backpattern is one of the following symbols
          white,
          lightgray,
          gray,
          or
          darkgray

then backpat, used with dograf, sets the background pattern of the
graphics window.

The background of the graphics window does not automatically
change pattern when this descriptor is invoked. Rather, all
subsequent output descriptors which make use of the background
pattern will use this new value. For example, the shape descriptors,
like rectangle, use the background pattern when clear is in effect
as the current fill pattern.

If backpat(_Backpattern) is used with inqgraf then
_Backpattern unifies with the current background pattern of the
graphics window.

backpat(_PatResId, _PatResIndex) sets the graphics window's
background pattern to the pattern resource specified. The pattern
resource may be either of type 'PAT ' or 'PAT#'. A resource of type
'PAT ' loads a single pattern identified by a unique resource ID. A
resource of type 'PAT# ' is a list of patterns. The list is identified
by a unique resource ID. A particular pattern in the list is
identified by an index. The arguments are interpreted as follows:
If the _PatResIndex = 0, then a pattern resource of type 'PAT '
whose pattern resource ID is _PatResId is loaded. However, if
_PatResIndex > 0, then a pattern list resource of type 'PAT#' and
resource ID _PatResId is loaded. In this case _PatResIndex specifies the pattern in the list to be used.

If backpat(_PatResId, _PatResIndex) is used with inqgraf then _PatResId unifies with the current background pattern of the graphics window. If a resource of type 'PAT ' or 'PAT#' is currently loaded, _PatResId unifies with the symbol resourcepattern and _PatResIndex is ignored.

Fails:

backpat(_Backpattern) fails if _Backpattern is neither a variable nor a symbol specifying a valid pattern

backpat(_PatResId, _PatResIndex) fails if
- _PatResId is neither a variable nor an integer specifying a valid pattern resource ID nor a valid pattern symbol
- _PatResIndex is neither a variable nor an integer specifying a valid pattern list index
- the pattern resource cannot be loaded
**fillpat(_Fillpattern)**

*queries or sets the fill pattern*

**Arguments:**

`fillpat(?symbol)`

**Succeeds:**

`fillpat`, used with `dograf`, sets the fill pattern in the graphics window. If `_Fillpattern` is one of the following symbols:

- `hollow`
- `pentype`, (that is, the initial pen setting)
- `usertype`, (current `penpat` or `userpat`)
- `clear`, or
- `invert`,

then `fillpat` sets the fill pattern in the graphics window.

The initial fill pattern is `pentype`.

If `fillpat` is used with `inqgraf` then `_Fillpattern` unifies with the current fill pattern of the graphics window.

**Fails:**

`fillpat` fails if `_Fillpattern` is neither a variable nor a symbol specifying a valid fill pattern.

**Note:**

The fill pattern is used in conjunction with shape output descriptors. These include the descriptors for rectangles, ovals, rounded rectangles, circles and arcs, regions and polygons.

**See Also:**

`penpat` and `userpat` in this chapter.
forecolor(_Color)

queries or sets the foreground color

Arguments: forecolor(?integer/symbol)

Succeeds: If _Color is of the following color numbers or equivalent symbols

30 = white,
33 = black,
205 = red,
341 = green,
273 = cyan,
409 = blue,
137 = magenta, or
69 = yellow,

then forecolor, used with dograf, sets the foreground color of the graphics window.

The foreground color is the color used to render all graphic descriptors unless clear is used as either a fill pattern or a pen bit combination mode, in which case the background color is used (see the output descriptor penmode in this chapter).

The initial forecolor is black.

If forecolor is used with inqgraf then _Color unifies with the current foreground color of the graphics window.

Fails: forecolor fails if _Color is not a variable, or an integer which is a valid color number, or one of the predefined symbols listed above.

See Also: backcolor in this chapter.
Chapter 15: Graphics Descriptors

penmode(_Transfermode)

queries or sets the pen transfer mode

Arguments: penmode(?symbol)

Succeeds: penmode, used with dograf, sets the drawing pen's bit combination mode for the graphics window. _Transfermode is one of the eight boolean combination functions:

- copy
- or
- xor
- clear
- notcopy
- notor
- notxor
- notclear

If penmode is used with inqgraf then _Transfermode unifies with the pen's current bit combination mode.

Fails: penmode fails if _Transfermode is neither a variable nor a valid transfer mode.

Note: The pen mode determines how the pen pattern affects whatever is already in the bit image when it subsequently draws lines and shapes into that image. The penmode does not affect the way text is drawn. (The descriptor textmode performs that function). The transfer mode which is passed as an argument to the penmode descriptor specifies a boolean operation which determines how the pixels from the source and destination are combined. Each pixel (or bit) in the drawing is paired off with its corresponding destination pixel; the specified Boolean operation is performed, and the result is stored in the destination.

The copy operation simply copies each pixel from the source to the destination. The or, xor and clear operations leave destination pixels which correspond to white pixels in the source unchanged, and then perform the appropriate boolean operation on destination pixels which correspond to black pixels in the source. or changes those pixels to black, xor inverts them and clear changes them to white. notcopy, notor, notxor and notclear are variants of the operations described above and simply invert each pixel in the
pattern source before performing the basic boolean operations. The eight boolean operations are shown in Figure 15-1.

![Diagram showing eight boolean operations](image)

**Figure 15-1** Transfer modes
penpat(_Penpattern)
penpat(_PatResId, _PatResIndex)

queries or sets the drawing pen's pixel pattern

Arguments: penpat(?symbol)
            penpat(?integer, ?integer)

Succeeds: If _Penpattern is one of the following symbols
           white,
           lightgray,
           darkgray, or
           black

           then penpat, used with dograf, sets the drawing pen's pixel pattern
           in the graphics window.

penpat(_PatResId, _PatResIndex) sets the drawing pen's pixel pattern
in the pattern resource specified by _PatResId and
_PatResIndex. The pattern resource may be either of type 'PAT '
or 'PAT#'. A resource of type 'PAT ' loads a single pattern
identified by a unique resource ID. A resource of type 'PAT#' is a
list of patterns. The list is identified by a unique resource ID. A
particular pattern in the list is identified by an index. The
arguments are interpreted as follows: If the _PatResIndex = 0 a
pattern resource of type 'PAT ' whose pattern resource ID is
_PatResId is loaded. If, however, _PatResIndex > 0 a pattern list
resource of type 'PAT#' and resource ID _PatResId is loaded. In
this case _PatResIndex specifies the pattern in the list to be used.

If penpat(_PatResId, _PatResIndex) is used with inqgraf then
_PatResId unifies with the current pen pattern of the graphics
window. If a resource of type 'PAT ' or 'PAT#' is currently loaded,
_PatResId unifies with the symbol resourcepattern and
_PatResIndex is ignored.
Fails:  
penpat fails if Penpattern is neither a variable nor a symbol specifying a valid pen pattern.

penpat(_PatResId, _PatResIndex) fails if
• _PatResId is not a variable, or an integer specifying a valid pattern resource ID, or a valid pen pattern symbol
• _PatResIndex is neither a variable nor an integer specifying a valid pattern list index
• the pattern resource cannot be loaded

Note:  
A pattern is a bit image which is 8 pixels wide and 8 pixels high and is used to define a repetitive pattern or tone. These tones are actually progressively denser pixel patterns which result in a progressively darker appearance of the color in use. Thus, lightgray, when used while drawing red actually gives light red.
penSize(_Width, _Height)

queries or sets the size of the drawing pen

Arguments: pensize(?integer, ?integer)

Succeeds: If _Width and _Height are integers then pensize, used with dograf, sets the width and height of the drawing pen (measured in pixels). The initial pen size is (_Width = 1, _Height = 1).

If pensize is used with inqgraf then _Width and _Height unify with the current size of the pen.

Fails: pensize fails if _Width and _Height are neither variables nor integers.

Note: If either of the dimensions specified is zero or a negative value, the pen will not draw.
position(_X, _Y)

queries or sets the current drawing pen position

Arguments: position(?number, ?number)

Succeeds: If _X and _Y are instantiated to absolute coordinates in the graphics window, then position, used with dograf, moves the current drawing pen to that position. The initial value is (_X = 0, _Y = 0).

If position is used with inqgraf then _X and _Y unify with the current coordinates of the pen.

Fails: position fails if _X and _Y are neither variables nor numbers (that is, of type integer or float).

Note: This descriptor is functionally identical to the moveabs output descriptor.
Chapter 15: Graphics Descriptors

scale(_Xscale, _Yscale)

queries or sets a scale factor

Arguments: scale(?number, ?number)

Succeeds: If _Xscale and _Yscale are integers or floats, then scale, used with dograf, sets a scale factor to be applied to all subsequent positional and size related graphic descriptors. The initial scale factor is (_Xscale = 1.0, _Yscale = 1.0)

If scale is used with inqgraf then _Xscale and _Yscale unify with the current scale factors of the graphics window.

Fails: scale fails if _Xscale and _Yscale are neither numbers (that is, not of type integer or float) nor variables.
textface(_Styles..)

queries or sets the text face characteristics

Arguments: textface(?variadic)

Succeeds: Sets the text face characteristics (style) to a sequence of style characteristics specified by the argument _Styles... This sequence can include any combination from the following set:

- bold
- italic
- underline
- outline
- shadow
- condense
- extend

The initial text face is plain (that is, no style or textface()). If textface is used with inqgraf then the sequence _Styles.. unifies with the current sequence of text styles of the window.

Fails: textface fails if _Styles.. is neither void nor a sequence (or a partially instantiated sequence) of one or more symbols from the above set, nor a tail variable.

Note: Some of the style characteristics applied to the courier font are shown below:

- plain
- bold
- italic
- underline
- shadow
- condense
- extend
- underlined italic
- bold italic

See Also: textfont and textsise in this chapter.
textfont(_Font)

queries or sets the text font

Arguments: textfont(\texttt{?integer/symbol})

Succeeds: If _Font is one of the following predefined font numbers or equivalent symbols

\begin{verbatim}
0 = systemfont (chicago) \\
1 = applfont (geneva) \\
2 = newyork \\
3 = monaco \\
4 = venice \\
5 = london \\
6 = athens \\
7 = sanfran \\
8 = toronto \\
9 = cairo \\
11 = losangeles \\
20 = times \\
21 = helvetica \\
22 = courier \\
23 = symbol \\
24 = mobile
\end{verbatim}

then textfont, used with dograf, sets the text font in the graphics window. If the requested font is not available the applfont is substituted and will be used by the application unless a font is specified. The initial text font is applfont.

If textfont is used with inqgraf then _Font unifies with the symbol corresponding to the current text font for the graphics window.

Fails: textfont fails if _Font is not a valid font number or a predefined symbol specifying a valid font (see list above), or a variable.
textmode(_Transfermode)

queries or sets the text transfer mode

Arguments:  textmode(?symbol)

Succeeds:  textmode, used with dograf, sets the text transfer mode of the window. _Transfermode is one of the following symbols:

    or
    xor
    clear

If textmode is used with inqgraf then _Transfermode unifies with the current text transfer mode of the window.

Fails:  textmode fails if _Transfermode is neither a variable nor a valid text transfer mode symbol.

Note:  The text mode determines how text will appear in the graphics window's bit image. The transfer mode which is passed as an argument to the textmode descriptor specifies a boolean operation which determines how the pixels from the source and destination are combined. Each pixel (or bit) in the drawing is paired off with the corresponding pixel in the destination; the Boolean operation is performed and the result stored in the destination.

    or leaves the pixels in the destination unchanged if they correspond to a white pixel in the source. Destination pixels which correspond to black pixels in the source are combined using an or operation.

    xor leaves the pixels in the destination unchanged if they correspond to a white pixel in the source. Black pixels in the source select the destination pixels in the source to be inverted.

    clear sets every pixel in the destination to white if the corresponding pixel in the source is black.

See also:  textface, textfont and textsize in this chapter.
Chapter 15: Graphics Descriptors

`textsize(_Pointsize)`

*queries or sets the text size*

**Argument:** `textsize(?integer)`

**Succeeds:** If `_Pointsize` is an integer between one and 127, `textsize`, used with `dograf`, sets the point size of text in the graphics window to that value. The initial text size is the system font size of 12 points which is selected by specifying a size of zero.

If `textsize` is used with `inqgraf` then `_Pointsize` unifies with the current text point size of the graphics window.

**Fails:** `textsize` fails if `_Pointsize` is neither a variable nor an integer in the range zero to 127 inclusive.

**Note:** There are 72 points per inch.

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userpat(_PatResId, _PatResIndex)

queries or loads a pattern resource

Arguments: userpat(?integer, ?integer)
Succeeds: If _PatResId and _PatResIndex are integers and userpat is used with dograf, it loads a pattern resource of type either 'PAT' or 'PAT#'. A resource of type 'PAT' loads a single pattern identified by a unique resource ID. A resource of type 'PAT#' is a list of patterns. The list is identified by a unique resource ID. A particular pattern in the list is identified by an index. The arguments are interpreted as follows: If the _PatResIndex = 0 a pattern resource of type 'PAT' whose pattern resource ID is _PatResId is loaded. If, however, _PatResIndex > 0 a pattern list resource of type 'PAT#' and resource ID _PatResId is loaded. In this case the _PatResIndex'th pattern in the list will be used.

If userpat is used with inqgraf then _PatResId and _PatResIndex unify with the resource ID and index of the currently loaded pattern resource. If no resource pattern is loaded _PatResId = 0 and _PatResIndex = 0.

Fails: userpat fails if
• _PatResId is neither a variable nor an integer specifying a valid pattern resource ID
• _PatResIndex is neither a variable nor an integer specifying a valid pattern list index
• the pattern resource cannot be loaded

Note: userpat does not actually set the pattern, it simply loads the resource file. However, the pattern can subsequently be used as fill pattern for shapes if usertype is specified by the fillpat descriptor.

See Also: fillpat in this chapter.
Chapter 15: Graphics Descriptors

Graphics Output Descriptors

Graphics output descriptors are passed as arguments to the `dograf` predicate which executes them. As with attribute descriptors, output descriptors containing variables will be ignored by `dograf` and `dograf` will always succeed. If an output descriptor is passed to `inquery`, the call to `inquery` will fail.

Graphics output descriptors are divided into three general classes:
- turtle (supports turtle graphics)
- relative (draws relative to the current pen position)
- absolute (draws relative to the local origin of the window)

Two other descriptors `polygon` and `region` are used to define arbitrary enclosed spaces and fill them.

Drawing always takes place in the graph window named in the `dograf` predicate.

Numbers may be specified in either integer or floating point format. Numerics include integers, floats and intervals.

Rectangle specifications may be expressed in any order as long as the x, y, x, y pairing is maintained.

Turtle Graphics

The descriptors listed below support turtle graphics. The position of the graphics pen is updated after each drawing position.

```
| line       | - draws a line       |
| move       | - moves the drawing pen  |
| turn       | - changes the movement angle of the drawing pen |
```

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### Relative Output Descriptors

The relative output descriptors draw relative to the current position of the pen.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>arcrel</td>
<td>draws an arc</td>
</tr>
<tr>
<td>circlerel</td>
<td>draws a circle</td>
</tr>
<tr>
<td>iconrel</td>
<td>draws an icon</td>
</tr>
<tr>
<td>linerel</td>
<td>draws a line</td>
</tr>
<tr>
<td>moverel</td>
<td>moves the pen</td>
</tr>
<tr>
<td>ovalrel</td>
<td>draws an oval</td>
</tr>
<tr>
<td>pictrel</td>
<td>draws a picture</td>
</tr>
<tr>
<td>rectrel</td>
<td>draws a rectangle</td>
</tr>
<tr>
<td>rrectrel</td>
<td>draws a rounded rectangle</td>
</tr>
<tr>
<td>textrel</td>
<td>draws a text symbol</td>
</tr>
</tbody>
</table>

### Absolute Output Descriptors

The absolute descriptors draw relative to the local origin of the window.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>arcabs</td>
<td>draws an arc</td>
</tr>
<tr>
<td>circleabs</td>
<td>draws a circle</td>
</tr>
<tr>
<td>iconabs</td>
<td>draws an icon</td>
</tr>
<tr>
<td>lineabs</td>
<td>draws a line</td>
</tr>
<tr>
<td>moveabs</td>
<td>moves the pen</td>
</tr>
<tr>
<td>ovalabs</td>
<td>draws an oval</td>
</tr>
<tr>
<td>pictabs</td>
<td>draws a picture</td>
</tr>
<tr>
<td>rectabs</td>
<td>draws a rectangle</td>
</tr>
<tr>
<td>rrectabs</td>
<td>draws a rounded rectangle</td>
</tr>
<tr>
<td>textabs</td>
<td>draws a text symbol</td>
</tr>
</tbody>
</table>

### Miscellaneous Graphics Descriptors

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>polygon</td>
<td>draws an enclosed polygon</td>
</tr>
<tr>
<td>region</td>
<td>draws an enclosed region</td>
</tr>
</tbody>
</table>
Argument Types for the Descriptors

The arguments passed to the graphics descriptors described in this chapter represent different types of graphical data. The argument may specify a point represented by an x and y coordinate or a rectangle represented by its four sides. The coordinates describing the point or rectangle may in turn be relative to the current pen position or absolute with respect to the local origin. They may also be expressed in interval format. Table 15-1 shows the argument types and their variants.

Table 15-1 Argument types for the graphic descriptors

<table>
<thead>
<tr>
<th>Argument</th>
<th>Relative</th>
<th>Absolute</th>
<th>Descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>point</td>
<td>ΔX, ΔY</td>
<td>ΔX, ΔY</td>
<td>circle, line</td>
</tr>
<tr>
<td></td>
<td>_ΔXinterval, _ΔYinterval</td>
<td>_Xinterval, _Yinterval</td>
<td>move, text</td>
</tr>
<tr>
<td>rectangle</td>
<td>ΔX1, ΔY1, ΔX2, ΔY2</td>
<td>ΔX1, ΔY1, ΔX2, ΔY2</td>
<td>arc, icon</td>
</tr>
<tr>
<td></td>
<td>_ΔXinterval, _ΔYinterval</td>
<td>_Xinterval, _Yinterval</td>
<td>oval, rect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>_Xinterval, _Yinterval</td>
<td>rrect, pict</td>
</tr>
</tbody>
</table>
Chapter 15: Graphics Descriptors

arcrel(\(\Delta X_1, \Delta Y_1, \Delta X_2, \Delta Y_2, \text{Startangle}, \text{Arcangle}\))
arcrel(\(\Delta X_i, \Delta Y_i, \text{Startangle}, \text{Arcangle}\))

draws an arc (relative)

arcabs(\(X_1, Y_1, X_2, Y_2, \text{Startangle}, \text{Arcangle}\))
arcbabs(\(X_i, Y_i, \text{Startangle}, \text{Arcangle}\))

draws an arc (absolute)

Arguments:

arcrel(+number, +number, +number, +number, +number, +number)
arcrel(+interval, +interval, +number, +number)
arcbabs(+number, +number, +number, +number, +number, +number)
arcbabs(+interval, +interval, +number, +number)

Succeeds:

Both these descriptors draw an arc of an oval using the current fill pattern. The oval is bounded by the rectangle whose sides are specified. \(\text{Startangle}\) determines where the arc begins and \(\text{Arcangle}\) determines its extent relative to \(\text{Startangle}\).

The oval defined by \(\text{arcrel}\) is bounded by the rectangle having sides specified by \(X_1, Y_1, X_2\) and \(Y_2\), which are offsets from the current pen position. The oval drawn by \(\text{arcabs}\) is bounded by the rectangle whose sides are specified by the absolute coordinates \(X_1, Y_1, X_2\) and \(Y_2\). If interval format is used, the arc is bounded by the rectangle which has x and y axis sides at the boundaries of the intervals specified.

Neither \(\text{arcrel}\) nor \(\text{arcabs}\) change the current pen position.
Fails: 

\( \text{arcrel} \) fails if
- \(_{\text{Startangle}}\) and \(_{\text{Arcangle}}\) are not numbers
- \(_{\Delta X1}, \_\Delta Y1, \_\Delta X2\) and \(_\Delta Y2\) are not numbers
- \(_{\Delta Xi}, \_\Delta Yi\) are not intervals

\( \text{arcabs} \) fails if
- \(_{\text{Startangle}}\) and \(_{\text{Arcangle}}\) are not numbers
- \(_{X1}, _Y1, _X2\) and \(_Y2\) are not numbers
- \(_{Xi}, _Yi\) are not intervals.

Note 1: Angles are measured positively, starting from zero degrees at the 3:00 o'clock position.

Note 2: Angle measures are relative to the enclosing rectangle, that is, a line from the center of the rectangle through the bottom right corner is defined to be at a 45 degree angle even if the rectangle is not a square.

Examples:

\[
\text{:- dograf(test, arcrel(10, 80, 110, 10, 45, 90)).}
\]

/* describes an arc in the graphics window "test" */
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circlerel(_ΔXcenter, _ΔYcenter, _Radius)

draws a circle (relative)

circleabs(_Xcenter, _Ycenter, _Radius)

draws a circle (absolute)

Arguments:  
circlerel(+numeric, +numeric, +number)
circleabs(+numeric, +numeric, +number)

Succeeds:  
Draws a circle of given radius _Radius using the current fill pattern.

The center of the circle drawn by circlerel is specified by the offsets _ΔXcenter and _ΔYcenter which are measured from the current drawing pen position. The center of the circle drawn by circleabs is specified by the absolute coordinates _Xcenter and _Ycenter. If either of the coordinate pairs _ΔXcenter, _ΔYcenter, or _Xcenter, _Ycenter are intervals, the center of the circle will be located at their midpoint.

Neither circlerel nor circleabs change the current pen position.

Fails:  
circlerel and circleabs fail if _Radius is not a number.
circlerel fails if _ΔXcenter and _ΔYcenter are not numerics.
circleabs fails if _Xcenter and _Ycenter are not numerics.
iconrel(ΔX1, ΔY1, ΔX2, ΔY2, _IconId)
iconrel(ΔXi, ΔYi, _Iconid)

draws an icon (relative)

iconabs(X1, Y1, X2, Y2, _IconId)
iconabs(_Xi, _Yi, _Iconid)

draws an icon (absolute)

Arguments: iconrel(+number, +number, +number +number, +integer)
iconrel(+interval, +interval, +integer)
iconabs(+number, +number, +number, +number, +integer)
iconabs(+interval, +interval, +integer)

Succeeds: Draws the icon whose resource ID is _IconId in the specified rectangle.

The icon drawn by iconrel is bounded by the rectangle whose sides are specified by _ΔX1, _ΔY1, _ΔX2 and _ΔY2, which are offset from the current pen position. The icon drawn by iconabs is bound by the rectangle whose sides are specified by the absolute coordinates _X1, _Y1, _X2 and _Y2. If interval format is used, the icon is bounded by the rectangle which has x and y axis sides at the boundaries of the intervals specified by _ΔXi, _ΔYi (iconrel), or _Xi, _Yi (iconabs)

Fails: iconrel fails if
• _ΔX1, _ΔY1, _ΔX2 and _ΔY2 are not numbers
• _ΔXi, _ΔYi are not intervals

iconabs fails if
• _X1, _Y1, _X2 and _Y2 are not numbers
• _Xi, _Yi are not intervals
line(\_Distance)

draws a line (turtle)

linerel(\_Ax1, \_Ay1, \ldots, \_Axn, \_Ay_n)

draws a line (relative)

lineabs(_X1, _Y1, \ldots, _Xn, _Yn)

draws a line (absolute)

Argument:

<table>
<thead>
<tr>
<th>function</th>
<th>arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>line</td>
<td>+(numeric)</td>
</tr>
<tr>
<td>linerel</td>
<td>+(numeric, +numeric, \ldots, +numeric, +numeric)</td>
</tr>
<tr>
<td>lineabs</td>
<td>+(numeric, +numeric, \ldots, +numeric, +numeric)</td>
</tr>
</tbody>
</table>

Succeeds: line draws a line as it moves the pen a distance \_Distance from the current position along a path determined by the current pen angle. If \_Distance is an interval, the midpoint of the interval is used. linerel and lineabs draw a line by connecting, in order, each of the specified coordinates. If the coordinates are specified in interval format, then the midpoints of the interval pairs are used. The coordinates specified by the arguments for linerel are relative to the current pen position while those for lineabs are absolute.

line, linerel and lineabs update the current position of the pen.

Fails: line fails if \_Distance is not a numeric.

linerel and lineabs fail if the arguments specified are not numerics.
move(_ΔDistance)

*moves the drawing pen (turtle)*

moverel(_ΔX, _ΔY)

*moves the drawing pen (relative)*

moveabs(_X, _Y)

*moves the drawing pen (absolute)*

**Arguments:**

move(+number)
moverel(+numeric, +numeric)
moveabs(+numeric, +numeric)

**Succeeds:**

move moves the pen along a path determined by the current pen angle. The pen is moved a distance _ΔDistance from the current position. If _ΔDistance is an interval, the midpoint of the interval is used. moverel moves the pen to a position described by the coordinates _ΔX, _ΔY measured relative to the current pen position. moveabs performs an absolute movement of the pen to the location specified by the _X, _Y coordinates. If either of the coordinate pairs _ΔX, _ΔY or _X, _Y are specified as intervals, moverel and moveabs move the drawing pen's location to the midpoints of the specified interval pair.

move, moverel and moveabs update the current position of the pen.

**Fails:**

move fails if _ΔDistance is not a numeric.
moverel fails if _ΔX and _ΔY are not numerics.
moveabs fails if _X and _Y are not numerics.
**Chapter 15: Graphics Descriptors**

---

**ovalrel**

\[
\text{ovalrel}(\Delta x_1, \Delta y_1, \Delta x_2, \Delta y_2)
\]

**ovalrel**

\[
\text{ovalrel}(\Delta x_i, \Delta y_i)
\]

**draws an oval (relative)**

**ovalabs**

\[
\text{ovalabs}(X_1, Y_1, X_2, Y_2)
\]

**ovalabs**

\[
\text{ovalabs}(X_i, Y_i)
\]

**draws an oval (absolute)**

---

**Arguments:**

ovalrel(+number, +number, +number, +number)
ovalrel(+interval, +interval)
ovalabs(+number, +number, +number, +numeric)
ovalabs(+interval, +interval)

**Succeeds:**

Draws an oval using the current fill pattern. The oval is bounded by the rectangle whose sides are specified.

The oval drawn by ovalrel is bounded by the rectangle whose sides are specified by \(\Delta x_1, \Delta y_1, \Delta x_2\) and \(\Delta y_2\), which are offsets from the current pen position. The oval drawn by ovalabs is bound by the rectangle whose sides are specified by the absolute coordinates \(X_1, Y_1, X_2\) and \(Y_2\). If interval format is used, the oval is bounded by the rectangle which has x and y axis sides at the boundaries of the intervals specified by \(\Delta x_i, \Delta y_i\) (ovalrel) and \(X_i, Y_i\) (ovalabs).

Neither ovalrel nor ovalabs change the current pen position.

**Fails:**

ovalrel fails if
- \(\Delta x_1, \Delta y_1, \Delta x_2\) and \(\Delta y_2\) are not numbers
- \(\Delta x_i\) and \(\Delta y_i\) are not intervals

ovalabs fails if
- \(X_1, Y_1, X_2\) and \(Y_2\) are not numbers
- \(\Delta x_i\) and \(\Delta y_i\) are not intervals

**Examples:**

---

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:- dograf(test, ovalrel(10, 90, 70, 10) ).
YES
/* describes an oval in the graphics window "test" */
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pictrel(\( \Delta X_1, \Delta Y_1, \Delta X_2, \Delta Y_2, _\text{PictureID} \))
pictrel(\( \Delta X_i, \Delta Y_i, _\text{PictureID} \))

draws a picture (relative)

pictabs(_X_1, _Y_1, _X_2, _Y_2, _\text{Picturename})
pictabs(_X_i, _Y_i)

draws a picture (absolute)

Arguments:  
pictrel(+number, +number, +number, +number, +symbol)  
pictrel(+interval, +interval, +symbol)  
pictabs(+number, +number, +number, +number, +symbol)  
pictabs(+interval, +interval, +symbol)

Succeeds:  
Both these descriptors draw a picture whose ID is _\text{PictureID} in the area bounded by the rectangle specified. (This ID is assigned by the beginpicture predicate described in this manual in the chapter titled "Pictures").

pictrel draws the picture in the area bounded by the rectangle whose sides are specified by _\Delta X_1, _\Delta Y_1, _\Delta X_2 and _\Delta Y_2, which are offsets from the current pen position. pictabs draws the picture in the area bounded by the rectangle whose sides are specified by the absolute coordinates _X_1, _Y_1, _X_2 and _Y_2. If interval format is used, the picture is bounded by the rectangle which has x and y axis sides at the boundaries of the intervals specified by _\Delta X_i, _\Delta Y_i (pictrel) or _X_i, _Y_i (pictabs).

Fails:  
pictrel and pictabs fail if _\text{Picturename} is not the name of a valid picture.

pictrel fails if  
• _\Delta X_1, _\Delta Y_1, _\Delta X_2, _\Delta Y_2 are not numbers  
• _\Delta X_i and _\Delta Y_i are not intervals

pictabs fails if  
• _X_1, _Y_1, _X_2 and _Y_2 are not numbers  
• _X_i and _Y_i are not intervals

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**polyon(_Grafstructures..)**

*draws an enclosed polygon*

**Arguments:**  
polyon(+variadic_grafstructures)

**Succeeds:**  
Draws an enclosed polygon starting from the current pen position in terms of a sequence of graphics descriptors and current fill and pen attributes. Descriptors other than move and line descriptors are ignored.

**Fails:**  
polyon fails if _Grafstructures.. is a sequence containing one or more valid graphics descriptors containing invalid parameters.

**Examples:**

```prolog
/* the call */
:- dograf(test,polygon(lineabs(0,0,140,50,110,180,39,240,0,0))).
YES
/* draws the polygon above in graf window "test" */
```
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\[
\text{rectrel}(\Delta X_1, \Delta Y_1, \Delta X_2, \Delta Y_2) \\
\text{rectrel}(_\Delta X_1, _\Delta Y_1)
\]

draws a rectangle (relative)

\[
\text{rectabs}(X_1, Y_1, X_2, Y_2) \\
\text{rectabs}(X_1, Y_1)
\]

draws a rectangle (absolute)

Arguments: rectrel(+number, +number, +number, +number) \\
\quad rectrel(+interval, +interval) \\
\quad rectabs(+number, +number, +number, +number) \\
\quad rectabs(+interval, +interval)

Succeeds: Both these descriptors draw a rectangle in the graphics window. The sides of the rectangle drawn by \text{rectrel} are specified by \_\Delta X_1, \_\Delta Y_1, \_\Delta X_2 and \_\Delta Y_2, which are offsets from the current pen position. The sides of the rectangle drawn by \text{rectabs} are specified by the absolute coordinates \_X_1, \_Y_1, \_X_2 and \_Y_2. If interval format is used, the rectangle has x and y axis sides at the boundaries of the intervals specified by either \_\Delta X_1, \_\Delta Y_1 (\text{rectrel}) or by \_X_1, \_Y_1 (\text{rectabs}).

Neither \text{rectrel} nor \text{rectabs} change the current pen position.

Fails: rectrel fails if 
- \_\Delta X_1, \_\Delta Y_1, \_\Delta X_2 and \_\Delta Y_2 are not numbers 
- \_\Delta X_1 and \_\Delta Y_1 are not intervals 

rectabs fails if 
- \_X_1, \_Y_1, \_X_2 and \_Y_2 are not numbers 
- \_X_1 and \_Y_1 are not intervals 

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*draws a rounded rectangle (relative)*

- `rrectrel(ΔX1, ΔY1, ΔX2, ΔY2, Ovalwidth, Ovalheight)`
- `rrectrel(ΔXi, ΔYi, Ovalwidth, Ovalheight)`

*draws a rounded rectangle (absolute)*

- `rrectabs(X1, Y1, X2, Y2, Ovalwidth, Ovalheight)`
- `rrectabs(Xi, Yi, Ovalwidth, Ovalheight)`

**Arguments:**

- `rrectrel(+number, +number, +number, +number, +number, +number)`
- `rrectrel(+interval, +interval, +number, +number)`
- `rrectabs(+number, +number, +number, +number, +number, +number)`
- `rrectabs(+interval, +interval, +number, +number)`

**Succeeds:** Both these descriptors draws a rectangle with rounded corners using the current fill pattern. The sides of the rectangle are specified and the curvature of the corners is determined by an oval having the specified dimensions.

The sides of the rectangle drawn by `rrectrel` are specified by `ΔX1`, `ΔY1`, `ΔX2` and `ΔY2`, which are offsets from the current pen position. The sides of the rectangle drawn by `rrectabs` are specified by the absolute coordinates `X1`, `Y1`, `X2` and `Y2`. If interval format is used, the rectangle has x and y axis sides at the boundaries of the intervals specified by `ΔXi`, `ΔYi (rectrel)` or `Xi`, `Yi (rectabs)`.

Neither `rrectrel` nor `rrectabs` change the current pen position.
Fails:  

rrectrel and rrectabs fail if _Ovalwidth and _Ovalheight exceed the width and height of the rectangle

rrectrel fails if
• _ΔX1, _ΔY1, _ΔX2 and _ΔY2 are not numbers
• _ΔX_i and _ΔY_i are not intervals

rrectabs fails if
• _X1, _Y1, _X2 and _Y2 are not numbers
• _X_i and _Y_i are not intervals

Examples:

(10, 100)

ovalwidth

ovalheight

(130, 10)

Rounded Rectangle

:- dograf(test, rrectabs(10, 100, 130, 10, 15, 20))
YES
/* describes a rounded rectangle in the graphics window "test" */
region(_Grafstructures..)

draws an enclosed region

Arguments: region(+variadic_grafstructures)

Succeeds: Draws an enclosed region from the current pen position using a sequence of graphics descriptors, and current fill and pen attributes. Arc descriptors are ignored.

Fails: region fails if _Grafstructures.. is a sequence containing one or more valid graphics descriptors containing invalid arguments.

Examples:

/* the call */
:- dograf(test, region(lineabs(0,0,140, 50, 110, 180, 39, 240, 0, 240, 0, 0), ovalabs(100, 100,150, 150))).
/* draws the above region in the graphics window "test" */
textrel(_ΔXpos, _ΔYpos, _Symbol)

draws a text symbol (relative)

textabs(_Xpos, _Ypos, _Symbol)

draws a text symbol (absolute)

Arguments:   textrel(+numeric, +numeric, +symbol)  
textabs(+numeric, +numeric, +symbol)

Succeeds:    Draws the text symbol _Symbol using the current text attributes.

The starting point of the text drawn by textrel is specified by _ΔXpos and _ΔYpos which are offsets from the current pen position. The starting point of the text drawn by textabs is specified by the absolute coordinates _Xpos and _Ypos. If interval format is used, the starting point of the text is at the midpoint of the interval pair specified. The current position is updated to reflect the rightmost edge of the text as it is drawn. The text is drawn horizontally and to the right.

textrel and textabs update the current position of the pen.

Fails:       textrel and textabs fail if _Symbol is not of type symbol.

textrel fails if _ΔXpos and _ΔYpos are not numerics

textabs fails if _Xpos and _Ypos are not numerics.
turn(\(\Delta\)degrees)

*changes the movement angle of the drawing pen*

**Arguments:**  
turn(+number)

**Succeeds:**  
Changes the drawing pen's movement angle by an amount \(\Delta\)degrees relative to its current value.

**Fails:**  
turn fails if \(\Delta\)degrees is not a number.

**Note 1:**  
Pen angles are measured positively from zero degrees at the 3:00 o'clock position.

**Note 2:**  
This attribute value is referenced only by the turtle graphic output descriptors.

**See Also:**  
angle in this chapter.
Chapter 16: Pictures

About Quickdraw Pictures

The predicates documented in this chapter allow the creation and manipulation of Quickdraw pictures. Pictures are sequences of drawing commands which can be saved and replayed later with a single predicate call. This provides an easy way to transmit graphical information between Macintosh applications.

Internally, a picture is assigned an integer identifier (ID) (usually, when a call is made to the beginpicture predicate) which identifies the picture. Pictures may also be stored as 'PICT' resources in the resource fork of a file. Resources are identified by type, and either an ID or a name. 'PICT' is a standard Macintosh resource type for Quickdraw pictures. Users are referred to Volume I of Inside Macintosh for further information on resources and Quickdraw.

Creating and Manipulating Pictures

To create a picture, first define it by making a call to the beginpicture predicate. This begins the definition of a picture resource in memory and assigns a picture ID to it. When a picture is defined, the rectangle that surrounds it is specified. This rectangle is called the frame of the picture, and it defines the boundaries of the picture in local coordinates. The local origin (0,0) is the top-left corner of the window's boundary rectangle. The contents of the picture are then created by calls to the dograf predicate and its associated descriptors which are described in the chapters titled "Windows" and "Graphics Descriptors" in this manual. Those calls do not produce any visible results. Instead, a picture structure is created which can be drawn later (by executing the picture graphics descriptors pictrel or pictabs by means of subsequent calls to dograf) or exported to another application by means of the clipboard or scrapbook. Once the picture has been defined, the creation of the picture resource in memory is
terminated by making a call to the `endpicture` predicate. The picture can then be saved using the predicate `savepicture` and played back using `loadpicture`. Memory used by the picture resource can be reclaimed using `deletpicture`. Two other predicates, `attachpicture` and `detachpicture`, logically connect and disconnect a picture to a specified graphics window. Once a picture is attached to a graphics window, any updates for the window are handled by the operating system; no update events are generated.

Refer to the chapter titled "User Interfaces" in the *BNR Prolog User Guide* for further information on using pictures.

### Predicates for Manipulating Pictures

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<td>beginpicture</td>
<td>begins the creation of a picture</td>
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<td>saves a picture</td>
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<tr>
<td>scraptopict</td>
<td>loads a picture from scrap</td>
</tr>
</tbody>
</table>
attachpicture(_PictureId, _Windowname)

attaches a picture to a graphics window

Arguments: attachpicture(+integer, +symbol)
Succeeds: Logically connects the picture identified by the picture ID _PictureID to the graphics window _Windowname. Updates for this graphics window, occurring subsequent to this attachment, are handled by the operating system.
Fails: attachpicture fails if
• _PictureId is not a valid picture ID
• _Windowname is not the name of a graphics window
• the graphics window _Windowname is already attached to a picture
Note: Only one picture can be attached to a graphics window at any time.
See Also: beginpicture and detachpicture in this chapter.
beginpicture(_Windowname, frame(_Top, _Left, _Bottom, _Right), _PictureId)

begins the creation of a picture

Arguments: beginpicture(+symbol, frame(+integer, +integer, +integer, +integer), -integer)

Succeeds: Creates a picture resource in memory that has the current attributes of the graphics window _Windowname. The structure, frame, defines the boundaries of the picture in local coordinates. A new picture ID is created and bound to _PictureId. The contents of the picture may then be created by dograf calls. Those calls do not produce visible results, but will create the picture structure which can later be drawn into the graphics window using the dograf graphics descriptors pictrel or pictabs.

Fails: beginpicture fails if
• _Windowname is not the name of a graphics window
• _Top, _Bottom, _Right and _Left are not integers that correspond to window coordinates
• _PictureId is not a variable

See Also: endpicture in this chapter.
deletepicture(_PictureId)

**deletes picture from memory**

**Arguments:**

deletepicture(+integer)

**Succeeds:**

Deletes the picture structure identified by _PictureId and its associated contents.

**Fails:**

deletepicture fails if _PictureId is not a valid picture ID.

**Note:**

Delete a picture resource from memory only when you have finished with it and need to reclaim the space in memory. Use savepicture to save the picture on disk prior to deleting it.

**See Also:**

savepicture in this chapter.
detachpicture(_PictureId)

disconnects a picture from a graphics window

Arguments: detachpicture(+integer)

Succeeds: Logically disconnects the picture identified by the picture ID _PictureId from the graphics window to which it was previously attached. The operating system will no longer update the window as required; update events will be generated.

Fails: detachpicture fails if _PictureId is not a valid picture ID or the picture is not attached to a window.

See Also: attachpicture in this chapter.
endpicture(_PictureId)

ends the creation of a picture

Arguments: endpicture(+integer)
Succeeds: End the creation of the picture identified by the picture ID _PictureId.
Fails: endpicture fails if _PictureId is not a valid picture ID.
See Also: beginpicture in this chapter.
ispicture(_PictureId, _Windowname, frame(_Left, _Top, _Right, _Bottom))

defines a relation between a picture, a window and its boundaries


Succeeds: ispicture succeeds if a relationship exists between the arguments specified. If one or more of the arguments are variables, ispicture generates values which define the relation.

Fails: ispicture fails if
- _PictureId is neither a variable nor a valid picture ID
- _Windowname is neither a variable nor the name of a graphics window
- _Left, _Top, _Right, _Bottom are neither variables nor integers representing valid window coordinates
- a relationship does not exist between the arguments specified
listpictures(_Picturelist)

*Lists defined pictures*

**Arguments:**  
listpictures(?list)

**Succeeds:**  
Unifies _Picturelist with the list of defined picture ID.

**Fails:**  
listpictures fails if _Picturelist does not unify with the ordered list of picture IDs.
Chapter 16: Pictures

loadpicture(_Filename, _ResourceId, _PictureId, frame(_Top, _Left, _Bottom, _Right))

loads the picture from a file


Succeeds: Loads the picture resource with resource ID _ResourceId from the resource fork of the file _Filename and instantiates _PictureId with its picture ID making it available for use. The structure frame defines the boundaries, in local coordinates, in which the picture was originally drawn.

Fails: loadpicture fails if
• _Filename is not a valid file specification for an existing file, or is a partial filename and is not in the default directory
• _ResourceId is not a valid 'PICT' resource ID
• _ResourceId is not a variable
• _Top, _Left, _Bottom, and _Right do not unify with the picture's frame dimensions

See Also: savepicture in this chapter.
picttoscrap(_PictureId)

**writes a picture to scrap**

**Arguments:**
- picttoscrap(+integer)

**Succeeds:**
- Write the picture specified by _PictureId to the clipboard.

**Fails:**
- picttoscrap fails if _PictureId is not a valid picture ID.

**See Also:**
- scartopict in this chapter.
### savepicture(_Filename, _ResourceID, _Pictname, _PictureID)

**Saves a picture**

**Arguments:**

```
savepicture(+filename, +integer, +symbol, +integer)
```

**Succeeds:** Writes the picture identified by _PictureID as a 'PICT' resource, with resource ID _ResourceID to the resource fork of the file _Filename. The resource is assigned the name _Pictname. (This name is not meaningful to the Prolog system, but may be significant to other utilities such as resedit). If a 'PICT' resource with same resource ID already exists, it will be overwritten.

**Fails:**

- _Filename is not a valid Macintosh file specification
- _ResourceID is not a valid resource ID
- _Pictname is not a symbol
- A disk write error occurs

**See Also:** loadpicture in this chapter.
\texttt{scrapTopict}(_\texttt{PictureId})

\emph{loads a picture from scrap}

\begin{itemize}
  \item \textbf{Arguments:} \texttt{scrapTopict}(-integer)
  \item \textbf{Succeeds:} Loads a picture from the clipboard and assigns it an ID of _\texttt{PictureId}.
  \item \textbf{Fails:} \texttt{scrapTopict} fails if _\texttt{PictureId} does not unify with the assigned ID.
\end{itemize}
This chapter describes the predicates provided to support the creation, installation, manipulation and deletion of programmer-defined and system-supplied menus.

The menu bar, which always appears at the top of the Macintosh screen, contains the titles of all menus associated with the current application. Each application has its own set of titles. When BNR Prolog is loaded, the menu bar contains the set of menus associated with the BNR Prolog system. These include the File, Edit, Find, Window and Context menus. Each menu consists of a vertical list of menu items displayed inside a rectangle (See Figure 17-1).

![File menu of the BNR Prolog desktop](image)

**Figure 17-1** File menu of the BNR Prolog desktop
Each of the menu items may have any of the following attributes:

- An icon on the item's left which is a symbolic representation of the item.
- A mark, either a check mark or some other character which denotes the status of an item.
- The command-key sequence used to invoke the command from the keyboard.
- A character style such as italic, bold or underline.
- A dimmed appearance indicating that the item is disabled and cannot be selected by the user.

The menu items of the **File**, **Edit** and **Find** menus in the BNR Prolog system may not be deleted or have their text changed. However, their attributes may be changed and new items may be added to, or deleted from, the end of these menus. The system supplied version of the **Window** menu may not be altered at all.

All the menus can be deleted and replaced by user-defined menus.

The addition of new menus should be accompanied by rules for the `menuselect` predicate that define the actions for that menu. (See the chapter titled "Menus" in the *BNR Prolog User Guide* for examples and further details.)

### Predicates for Handling Menus

There are two methods for creating a menu in BNR Prolog. One method is to add a menu to the menu bar with `addmenu` and then to add menu items with `additem`. Every menu created in this way must be given a title and a unique identifying number, its menu ID. This ID number is used both to add items to the menu and to place other menus relative to it. Each menu item has an associated name and item ID (its position from the top), as well as a symbol that defines its attributes, such as its associated keyboard command sequence. A special item ID is the symbol `end_of_menu` which refers to the ID of the last item in the menu. Items can also be added to a menu from resources with the predicate `addresitems`.

A menu can be built by creating a menu resource in the resource fork of the application file using a software development environment such as *Macintosh Programmer’s Workshop (MPW).*
These kinds of menus can be installed with the predicate addresmenu. The addresmenu predicate takes a resource ID argument which identifies the menu resource to be installed. The menu resource ID should be known in advance.

The symbols 'Apple', 'File', 'Edit', 'Find', 'Window' and 'Contexts' can be used to refer to the system menu IDs or the resource IDs in all the menu predicates that expect these arguments. Use of these symbols explicitly designates the system versions of the menus, and not programmer provided versions, even if the name and contents of the menus are identical. Items within a menu are fully specified by the menu ID and the item ID. For all the menu predicates the resource ID, menu ID and Item ID arguments must be valid, that is, they must be integers corresponding to valid resources, menus and items respectively.

BNR Prolog also supports hierarchical menus and popup menus. Refer to Volume V of *Inside Macintosh* for more information on these types of menus.

The predicates discussed in this chapter are:

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<td>installs a menu</td>
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<td>addresitems</td>
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<td>addresmenu</td>
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<tr>
<td>deleteitem</td>
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<tr>
<td>deletemenu</td>
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<td>lastmenudata</td>
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<tr>
<td>menuitem</td>
<td>sets or queries a menu item</td>
</tr>
<tr>
<td>popupmenu</td>
<td>displays a popup menu</td>
</tr>
</tbody>
</table>
additem(_Item, _Attributes, _MenuId, _After_itemId, _ItemId)

adds a menu item to an existing menu

Arguments: additem(+symbol, +symbol, +integer,
+integer/end_of_menu, ?integer)

Succeeds: Adds a menu item having the name _Item with display attributes
_Attributes to the existing menu _MenuId after the item _ItemId.
A value of zero for _After_itemId places the new item at the top
of the menu before any existing items. The predefined symbol
end_of_menu may used for _After_itemId to place the new item at
the end of the menu after any existing menu items.

_ItemId is unified with the ID of the new item. This value will be
one greater than _After_itemId if the insertion point is a specified
integer, but it may be a new piece of information if the item was
added to the end of a menu using the end_of_menu symbol. The
item ID is required to subsequently manipulate menu items using
the predicates deleteitem and menuitem.

The special character hyphen (-) may be used as item to create a
dividing line across the full width of the menu. Typically, this
dividing line is also disabled using the attribute specifications
described below. An item attribute specification is a symbol
containing the menu metacharacters: ^, !, <, /, ( and ). Attributes
accumulate within an additem call and are applied in order. The
absence of a particular attribute specification results in the default
value for that attribute.

^<char>
adds the icon having a resource ID equal to the ASCII value of
<char> to the item. (Note that this limits menu icons to those having
resource IDs <= 255.) The default icon value is none.

!<char>
marks the item with <char> on the left of the menu item name. The
default value is none.
<<char>
where <char> is one of P, B, I, O, U or S sets the character style to plain, bold, italic, underline or shadow respectively. Attributes of this kind may be used multiple times to specify more than one character style for a particular menu item (for example, '<B<I<S>'). The value P (plain) signifies no style attributes, canceling any previously defined style attributes. The default character style is plain.

/<char>
associates <char> with the item, allowing the item to be invoked from the keyboard as a command-key sequence. The default command key equivalent is none.

() is a single character metacharacter. It disables the item.

) is also a single character metacharacter. It enables the item. Since menu items are default enabled, this metacharacter is not required for additem. However, it is useful in the menuitem predicate to enable a disabled menu item.

Fails: additem fails if
• _Item is not a symbol
• _Attributes is not a symbol constructed out of one or more of the menu metacharacters
• _MenuId is not a valid menu ID number or system menu symbol
• _After_itemId is neither the integer zero, the symbol end_of_menu nor a valid item ID for an item in the menu specified.

Note: The characters semicolon (;) and return, while defined as metacharacters in Inside Macintosh, are not supported.
Examples:

/* adds the item "Place" in bold italics to the end of the */
/* menu Status (whose menu ID is 1). Using the command-key */
/* sequence KP is equivalent to selecting 'Place' from the */
/* menu */

?- additem('Place', '!✓<B<I/P', 1, end_of_menu, _ItemId).

?- additem('Place', '!✓<B<I/P', 1, end_of_menu, 3).

See Also: addresitems in this chapter.
**addmenu**(_MenuId, _Title, _Before_menuId)

*adds a menu*

**Arguments:**

`addmenu(+integer, +symbol, +integer)`

**Succeeds:**

Installs a menu having the name _Title into the menu bar ahead of the existing menu _Before_menuId. _MenuId must be instantiated to an integer which is the new menu ID. If _Before_menuId is zero the new menu is placed at the right-hand end of any existing menus in the menu bar. Hierarchical and popup menus are created (but not displayed) if _Before_menuId has value of -1 (minus one).

**Fails:**

`addmenu` fails if

- _MenuId or _Title are not symbols
- _Before_menuId is neither zero nor -1, nor an integer corresponding to a valid menu ID, nor a system menu symbol

**Examples:**

```prolog
/* Installs a new menu Test (whose menu ID is 2 before */
/* the menu Status (whose menu ID is 1) */
:- addmenu(2, 'Test', 1).
YES
```

See Also:

`addresmenu` in this chapter. For more information on popup and hierarchical menus see Volume V of *Inside Macintosh*. 

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addresitems(_Resource_type, _MenuId, _After_itemId)

adds an item from a resource file

Arguments: addresitems(+symbol, +integer, +integer)

Succeeds: Adds the names of all resources of type _Resource_type, found in all open resource forks, to the existing menu _MenuId after the item _After_itemId. The resource type is a four character symbol corresponding to a Macintosh resource type. A value of zero for _After_itemId places the new items at the top of the menu before any existing items. The predefined symbol end_of_menu may be used for _After_itemId to place the new items at the end of the menu.

Fails: addresitems fails if
• _Resource_type is not a valid resource type
• _MenuId is not an integer corresponding to a valid menu ID number
• _After_itemId is not the integer zero, the symbol end_of_menu or the valid ID for an item in the menu specified

Note 1: Resource types are case sensitive.

Note 2: addresitems is used to install the names of all the desk accessories in the Apple menu using the resource type 'DRVR'. It can also be used to build a font selection menu using a resource type of 'FONT' or a picture selection menu using the resource type 'PICT'.

Examples:

/* Installs all the 'FONT' resources in the system file to the user-defined menu 'Test' whose menu ID is 1, to the bottom of the menu. */
:- addresitems('FONT',1,end_of_menu )
YES

See Also: additem in this chapter.
**addresmenu**(_ResourceId, _Before_menuId)

adds a menu from a resource file

**Arguments:**

addresmenu(+integer/+symbol, +integer)

**Succeeds:**

Installs a menu from a resource in the application file's resource fork. The resource is identified by the resource ID _ResourceId. The menu will be placed in front of the previously installed menu whose menu ID is _Before_menuId. If _Before_menuId is zero, the new menu is placed at the right-hand end of any existing menus in the menu bar.

**Fails:**

addresmenu fails if

- _ResourceId is neither an integer corresponding to a valid resource ID number nor a system menu symbol
- _Before_menuId is not an integer corresponding to valid menu ID number

**Note:**

Menu resources can be created using a software development environment like MPW. The system provided versions of the File, Edit and Find menus exist as resources and may be used as templates for making custom menu resources using a resource editor such as resedit in the MPW. The resource ID of an edited system menu resource must be changed before it is customized.

**Examples:**

```prolog
/* Installs a new menu Edit before the menu File. */
/* Has the effect of interchanging the file and edit menus. */
:- addresmenu(32130, 'File').
YES
/* The same effect is achieved by the question */
:- addresmenu('Edit', 'File').
YES
```

**See Also:**

addmenu in this chapter.
deleteitem(_MenuId, _ItemId)

*deletes a menu item*

---

**Arguments:**

`deleteitem(+integer, +integer)`

**Succeeds:**

Deletes the item `ItemId` from the existing menu `MenuId`. The predefined symbol `end_of_menu` may be used as `ItemId` to identify the last item in the menu.

**Fails**

`deleteitem` fails if
- `MenuId` is not an integer identifying an existing, nonsystem menu
- `ItemId` is neither an integer identifying an item in the menu identified by `MenuId` nor the symbol `end_of_file`.

**Note:**

The menu ID and item ID are obtained when calls are made to the predicates `addmenu` and `additem` respectively.
deletemenu(_MenuId)

**deletes menu**

**Arguments:** deletemenu(+integer/symbol)

**Succeeds:** Deletes the entire menu _MenuId.

**Fails:** deletemenu fails if _MenuId is neither an integer identifying an existing menu nor a system menu symbol.

**Note:** Any of the menus, File, Find, Edit, or Window can be deleted (the Contexts menu can also be deleted. Its ID is 32120). The menu ID is obtained when the menu is added using the predicate admmenu.
lastmenudata(_MenuId, _ItemId)

returns the menu ID and item ID of the last menu selection

Format: lastmenudata(_MenuId, _ItemId)

Arguments: lastmenudata(?integer, ?integer)

Succeeds: Unifies _MenuId and _ItemId with the menu and item IDs that were last selected with a menuselect event.

Fails: lastmenudata fails if either _MenuId and _ItemId are not variable, or do not unify with the ID integers of the last menu selection.

Note: The userevent predicate returns this data in symbol form. However, it is sometimes necessary to get the actual unambiguous selection integer values in order to resolve a selection, particularly if a menu contains multiple items with the same textual symbol.
Chapter 17: Menus

\textbf{menuitem(\_MenuId, \_ItemId, \_Item, \_Attributes)}

\textit{sets or queries the item text and attributes}

\begin{itemize}
\item \textbf{Arguments:} \texttt{menuitem(+integer/symbol, +integer, -symbol, ?attributes)}
\item \textbf{Succeeds:} Sets or queries the name and attributes of the item \_ItemId in the menu \_MenuId. If one or both of the arguments \_Item and \_Attributes are variables, they will be instantiated to the corresponding menu item's value.
\end{itemize}

If \_Item is a single hyphen (-) a dividing line is drawn across the full length of the menu. The dividing line may be disabled by using the appropriate metacharacters used to specify the attributes of an item. Refer to the predicate description of \texttt{additem} in this chapter for information on the metacharacters. However, the following variations are applicable to this predicate:

- Only nondefault value attributes will be reported in an attribute query.
- When setting an item's attributes, the attributes accumulate within a \texttt{menuitem} call and are applied in order.
- Unspecified attributes are not altered.
- Any existing icon, mark character or command key may be deleted by specifying the ASCII character null (zero, h00) as the character value for that attribute.
- Any character style specification replaces the existing style.
- An entire menu may be disabled or enabled by either specifying zero as both the item ID and as the attribute specification, or by specifying 0 (zero) as the attribute specification (no other attributes may be specified for menu titles). The \_Item argument must be a variable in this case, since menu titles cannot be altered once defined.
- A hierarchical menu may be attached to any menu item by specifying the ASCII character ESC (27, h1B) as the character value for the command-key attribute of that item, and the ASCII character equivalent of the menu ID of the hierarchical menu as
the character value for the item-mark attribute of that item. (This limits hierarchical menu IDs to the range 0 to 255). The existence of a hierarchical menu and its menu ID may be determined by querying these attributes for the item in question.

**Fails:**

`menuitem` fails if

- `_MenuId` is neither an integer corresponding to a valid menu ID number nor a system menu symbol
- `_After_itemId` is neither the integer zero, the symbol `end_of_menu`, nor a valid item ID for an item in the menu specified
- `_Item` is not a variable
- `_Attributes` is neither a variable nor the symbol of attributes of the item `_ItemId`

**Examples:**

```prolog
/* Add a tick mark to the 'Find Same' (item # 2) item in */
/* the menu Find */

?- menuitem('Find', 2, _, '✓').
?- menuitem('Find', 2, 'Find Same', '✓').
YES
```

BNR Prolog Reference Manual
popupmenu(_MenuId, _ItemId, _Top, _Left)

displays a popup menu

Arguments: popupmenu(+integer, +integer, +integer, +integer)

Succeeds: Initiates and handles the display of a previously added popup menu having an ID _MenuId. The menu will be presented with the top-left corner of the item _ItemId located at the specified _Top, _Left absolute window coordinates when the mouse is pressed at that location.

Fails: popupmenu fails if
- _MenuId is not an integer corresponding to a valid menu ID number
- _ItemId is not an integer corresponding to the ID of an existing item in the menu _MenuId
- _Top and _Left are not integers specifying valid window coordinates
- the mouse is not pressed down when popupmenu is called

Note: This kind of menu can be used to respond to mouse clicks on user-defined buttons. If the button is in a graphics window, _Top is the y-axis and _Left is the x-axis.

Since mouse events are not detected by BNR Prolog in text windows, popupmenu will not work if the window coordinates are coordinates of a text window.
Examples:

?- addmenu(1, joe, -1), % create a popupmenu
    addresitems('FONT', 1, end_of_menu),
    % add a list of fonts
    openwindow(graf, N, pos(_,_), size(_,_),
                options(zoomdocproc)),
    % open a graf window
    activewindow(N,graf), % make sure its active
    repeat,
    userevent(usermousedown, _, _X, _Y),
    % where's the mouse
    localglobal(N, _X, _Y, _Xa, _Ya),
    % translate to absolute coordinates
    popupmenu(1, 1, _Ya, _Xa),
    % pop up the menu
    fail. % exit with CTRL-<.>
Effective Macintosh applications must be able to detect the occurrence of events created by the user (user events) from devices, such as the mouse or the keyboard, and then respond with some appropriate action. An event driven application in BNR Prolog does likewise: it polls the Macintosh for events and dispatches them to Prolog rules called event handlers. This chapter describes the predicates for polling user events. For further information on how to write event handlers refer to the chapter titled "User Interfaces" in the BNR Prolog User Guide.

Event Types

There are 13 distinct kinds of user events that fall into four categories:

Mouse events occur when the user presses (usermousedown) or releases (usermouseup) the mouse button in the content region of a graphics window. Other mouse events occur when the mouse is pressed in the drag, grow, zoom or close region of a (graphics or text) window (userdrag, usergrow, userzoom and userclose), or when a menu item is selected (menuselect).

Keyboard events occur when the user presses or releases a key (userkey).

Window events are generated when an active window is made inactive (userdeactivate), an inactive window is made active (useractivate) or when all or part of a graphics window is redrawn (userupdate).

Idle or null events are reported when there are no events pending (userupidle and userdownidle).
Event Reporting Priority

Some events have a higher reporting priority than others. Events generated by the system in order of reporting priority are:

- userdeactivate
- useractivate
- menuselect, usermousedown, usermouseup, userdrag, usergrow, userzoom and userclose (all these have the same priority and are returned on a first come basis)
- userkey
- userupdate
- userupidle
- userdownidle

Predicates for Detecting User Events

There are two predicates for detecting user events:

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lasteventdata</td>
<td>returns information on the last user event</td>
</tr>
<tr>
<td>userevent</td>
<td>detects a user event</td>
</tr>
</tbody>
</table>
lasteventdata(_Event, _Window, [_Mousegx, _Mousegy], _When, [_Control, _Option, _Capslock, _Shift, _Command, _Mouseup])

returns information on the last user event


Succeeds: Returns information on the event which terminated the last userevent predicate call. _Event is unified with the event. _Mousegx, _Mousegy are unified with the mouse coordinate pair, expressed in global coordinates. The _When argument is unified with the event's time stamp in processor clock ticks and the last list argument reflects the state of the modifier keys at the time the key is pressed. A "1" in the corresponding position indicates that the modifier key was pressed, otherwise the value is zero.

Fails: lasteventdata fails if any of the arguments do not unify with the data from the last event.

Examples:

/* Get information about the last event polled by the listener */
?- lasteventdata(_a, _b, _c, _d, _e).
?- lasteventdata(userkey, 'HDISK:Console', [181, 194], 678256, [0, 0, 0, 0, 0, 1]).
YES
Chapter 18: User Events

userevent(_Event, _Windowname, _Data1, _Data2)
userevent(_Event, _Windowname, _Data1, _Data2, noblock)

detects a user event

Arguments:  
userevent(?symbol, ?symbol, ?event_specific_type, ?event_specific_type)
userevent(?symbol, ?symbol, ?event_specific_type, ?event_specific_type, +noblock)

Succeeds:  
The userevent predicates return user events when they occur. It can be invoked as a blocking or nonblocking call. If the userevent predicate without the noblock parameter is called, then Prolog execution is suspended until a user event occurs. Otherwise, if the symbol noblock is present as the fifth argument, an idle event (userupidle or userdownidle depending on the state of the mouse button) is returned if no user related event is pending and execution is continued. When an event occurs, all the information regarding the event is returned by means of the first four arguments: _Event is unified with the event which occurred; _Windowname is unified either with the window in which the event occurred or with the active window; _Data1 and _Data2 are event specific and their values depend on each of the events types described below.

userdeactivate
• _Event is unified with userdeactivate when the active window (the one in the foremost positions) is deactivated.
• The name of the window that was deactivated is unified with _Windowname.
• _Data1 and _Data2 are left unchanged.

useractivate
• _Event is unified with useractivate whenever a window is made active.
• The name of the window that was made active is unified with _Windowname.
• _Data1 and _Data2 are left unchanged.
menuselect
• _Event is unified with menuselect whenever a menu item is selected.
• _Windowname is unified with the active window.
• The menu name is unified with _Data1 and the menu item is unified with _Data2.

usermouseup
• _Event is unified with usermouseup when the mouse button is released in an active window of type graf.
• _Windowname is unified with the name of the graphics window.
• _Data1 and _Data2 are unified with the x and y coordinate values (expressed in the local window coordinates) of the mouse respectively. Note that for a mouse-up event the coordinates may be less than zero or greater than the window's width or height, since the mouse button need not be released inside the window's content region.

usermousedown
• _Event is unified with usermousedown when the mouse button is pressed in the content region of an active window of type graf.
• _Windowname is unified with the name of the graphics window.
• _Data1 and _Data2 are unified with the x and y coordinate values (expressed in the local window coordinates) of the mouse respectively. These coordinate values will always be greater than zero and less than the window's width and height. If the window in which the mouse click occurs is not the active window then the window will be made active and the associated mouse-down and mouse-up events will be consumed internally (see useractivate and userdeactivate above).

userdrag, usergrow, userzoom, userclose
• _Event is unified with one of the above values when a mouse down event is detected in the drag, grow, zoom or close regions of the active window.
• _Windowname becomes unified with the name of the active window.
• _Data1 and _Data2 are unified with the x and y coordinates (expressed in global coordinates) of the mouse-down position of the event.
userkey
- Event is unified with userkey when a keyboard key is pressed.
- Windowsname is unified with the name of the active window.
- _Data1 is unified with the single character symbol.
- _Data2 is unified with a list of six elements defining the state of the modifier keys at the time the key is pressed. It has the form [_Control, _Option, _Capslock, _Shift, _Command, _Mouseup]. A "1" in the corresponding position indicates the modifier key was pressed, otherwise, the value is "0" (zero). Key events are generated for all keyboard keys except the modifier keys (control, shift, caps locks, option and command) which internally alter the key code values of the keys before they are passed on.

userupdate
- Event is unified with userupdate when a previously covered portion of a graphics window is uncovered for any reason. This includes the time when a graph window is first opened and displayed, since, by definition, the window is uncovered for the first time and therefore needs to have its contents updated. The normal response to a userupdate event is to redraw the contents of the window (using dograf); the system automatically restricts the effects of redrawing to the update region of the affected window until the next call to userevent, at which time the entire window is updated.
- Windowsname is unified with the name of the graphics window.
- _Data1 and _Data2 are left unchanged.

userrdownidle, userrupidle
- Event is unified with either userrdownidle or userrupidle when the noblock symbol is specified and no other user event has occurred.
- Event will unify with userrdownidle if the mouse button is currently pressed down, otherwise it will unify with userrupidle.
- Windowsname is unified with the name of the active window.
- _Data1 and _Data2 are unified with the x and y coordinate values (expressed in the local window coordinate system) of the mouse respectively. The coordinates may be less than zero or greater than the window's width or height since the mouse need not be inside the window's content region.
Fails: \begin{itemize}
  \item \texttt{userevent} fails if
  \begin{itemize}
    \item \_Event is neither a variable nor a symbol representing one of the event types
    \item \_Windowname is neither a variable, nor a symbol which is the name of the active window or the name of window in which the event occurred
    \item \_Data1 and \_Data2 are neither variables nor valid event specific values
  \end{itemize}
\end{itemize}

Note 1: \texttt{usermouseup}, \texttt{usermousedown} and \texttt{userupdate} are reported only if they occur in a window of type \texttt{graf}.

Note 2: \texttt{userdownidle} or \texttt{userupidle} is returned any time a nonblocking call is made and no other user event is pending.

Note 3: A \texttt{userupdate} event can occur at any time.

Examples:

\begin{verbatim}
/* The following example shows that opening a graphics window causes 3 events to occur. The fourth call to \texttt{userevent} is satisfied by clicking in the window */
?- [openwindow(graf,test,pos(_,_),size(_,_),options()),
    userevent(_a, _b, _c, _d),
    userevent(_e, _f, _g, _h),
    userevent(_i, _j, _k, _l),
    userevent(_m, _n, _o, _p)].

?- [openwindow(graf,test,pos(40,80),size(566,321),options()),
    userevent(userdeactivate, 'HDISK:Console', _c, _d),
    userevent(useractivate, test, _g, _h),
    userevent(userupdate, test, _k, _l),
    userevent(usermousedown, test, 146, 138)].

YES

/* this example polls for user events until the mouse is clicked on the window drag region and beeps otherwise */
:- [repeat, ([userevent(userdrag, _, _, _),!]
    ; [beep, fail])].
\end{verbatim}
Chapter 19: Predefined Dialogs

Dialog boxes are used by an application to convey important information to the user, or to request information needed to complete a command from the user.

Dialogs can be either modal or modeless.

A modal dialog restricts the user's action. The user must respond to the dialog before proceeding with the application. Clicking the mouse outside the dialog causes the system to beep. The user is usually provided with the option of cancelling the dialog box, typing some text from the keyboard or manipulating controls within the dialog box with the mouse. All of the predefined dialogs operate in this mode.

A modeless dialog does not require the user's immediate response and behaves in the same way as any other document window. The user can open another window and work with it, or execute another command. The process that created the modeless dialog is suspended until the user reactivates it by choosing its OK or CANCEL button.

Predicates for Creating Dialogs

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>confirm</td>
<td>displays a message requiring confirmation</td>
</tr>
<tr>
<td>message</td>
<td>displays a message</td>
</tr>
<tr>
<td>nameafile</td>
<td>displays a file specification dialog</td>
</tr>
<tr>
<td>query</td>
<td>displays a dialog prompting a read</td>
</tr>
<tr>
<td>select</td>
<td>displays a list of items for multiple selection</td>
</tr>
<tr>
<td>selectafile</td>
<td>displays a file selection dialog</td>
</tr>
<tr>
<td>selectone</td>
<td>displays a list of items for single selection</td>
</tr>
</tbody>
</table>

BNR Prolog Reference Manual
confirm(_Prompt, _Cancel_enabled, _Default_response, _Response)

displays a message requiring confirmation

Arguments:
confirm(+symbol, +symbol, +symbol, ?symbol)

Succeeds:
Displays the text _Prompt in a dialog box containing OK and NO buttons, and optionally a CANCEL button. The CANCEL button is displayed if the value of the argument _Cancel_enabled is the symbol 'YES'.

The button designated by _Default_response is outlined in bold and is the response entered if either the enter or return key is pressed. The values allowed for _Default_response are the symbols 'YES', 'NO' and 'CANCEL'. The default response button may be user selected by either clicking the mouse on them, or by typing in the first character of the desired response.

The values allowed for _Response are the symbols 'YES' and 'NO'.

confirm succeeds if the user selects either the YES or NO button and _Response is unified with the selected value.

Fails:
confirm fails if
• _Prompt is not a symbol
• _Cancel_enabled is neither the symbol 'YES' nor the symbol 'NO'
• _Default_response is not one of the allowed symbols ('YES', 'NO' and 'CANCEL')
• _Response is neither variable nor the symbol 'YES' or 'NO'
• the user selects the CANCEL button
Examples:

/* This call */
:- confirm('Please confirm !','YES','NO',_Response).
YES
/
will display the following dialog box
Please confirm!

[Diagram of a dialog box with buttons YES, NO, and CANCEL]
message(_Text)

displays a message

**Arguments:**

message(+symbol)

**Succeeds:**

A modal dialog is displayed. The dialog box contains the text _Text and an OK button. The user must click on the OK button or press either the enter or return key to continue.

**Fails:**

message fails if _Text is not a symbol.

**Examples:**

```prolog
/* This call */
:- message('This is a message').
YES
/* will display the following dialog box */

This is a message !  OK
```

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nameafile(_Doit_label, _Filefield_label, _Default_response, _Response)

displays a file specification dialog

Arguments: nameafile(+symbol, +symbol, +filename, ?fullfilename)
Succeeds: Displays a file specification dialog containing a directory browser and an editable filename field. Users may browse through the disk file directories and eventually either specify a file or select CANCEL. The Doit button in the dialog is given the label _Doit_label (for example, 'Save' or 'Delete') and the filename field is given the label _Filefield_label and primed with the default response _Default_response. The default response should be a filename, not a full filename. Any leading directory name components in the default response will be stripped out before being displayed. The response output _Response is the full filename of the user specified file. This file may or may not exist. If it does, an explicit subdialog will be used to confirm the selection.

Fails: nameafile fails if
• _Doit_label is not a symbol
• _Filefield_label is not a symbol
• _Default_response is not a valid Macintosh file name
• CANCEL is selected
Examples:

```c
/* This call */
:- nameafile('Select', 'Enter a file name:', 'Untitled', _Response).
YES
/* displays the following dialog box */
```

![Diagram of dialog box](image-url)
query(_Prompt, _Default_response, _Response)

display a dialog box prompting a read

Arguments: query(+symbol, +symbol, ?symbol)

Succeeds: Displays a modal dialog box with a text box containing a prompt message _Prompt, an editable text box containing a default response _Default_response, an OK button and a CANCEL button. The default response may then be edited to produce the desired response _Response. query succeeds when the user clicks on the OK button, or presses either the enter or return key.

Fails: query fails if
• _Prompt is not a symbol
• _Default_response is not a symbol
• the user selects the CANCEL button

Examples:

/* This call */
:- query('Is this a query?','YES, it is!',_Response).
YES
/* displays the following dialog box */

Is this a query?

Yes! This is a query!

OK                 CANCEL
select(_Title, _Choicelist, _Selection)
select(_Title, _Choicelist, _Selection, _Initialselection)

displays a list of items for multiple selection

Arguments:

select(+symbol, +list, ?list)
select(+symbol, +list, ?list, +list)

Succeeds:
Displays a dialog box containing the list of the items in _Choicelist, and an OK and CANCEL button. _Selection is unified with the list of items selected by the user from _Choicelist.

If an initial selection list _Initialselection is specified, then these items are initially highlighted, otherwise the first item is highlighted. A single item may be highlighted by clicking on the item. Multiple items are highlighted by pressing the command key (also called the Apple key) while clicking on the items. A block of items can be selected by either clicking on the first item and then pressing the shift key while clicking on the last item, or by dragging the mouse across the items while holding the mouse button down. The highlighted items may be selected by clicking on the OK button, or by pressing enter or clicking on it. A single item may also be selected directly by double clicking on it.

Fails:
select fails if
• _Title is not a symbol
• the elements of the list _Choicelist are not symbols
• _Initialselection is not a sublist of the list _Choicelist
Examples:

/* This call */
:- select('Make a selection', [fred, bob, dick, jerry, bert, mike], _Selection, [dick, mike]).
YES
/* displays the following dialog box */

See Also: selectone in this chapter.
selectafile(_Filetype, _Doit_label, _Selection)

displays a file selection dialog

Arguments: selectafile(+filetype/list_of_filetypes, +symbol, ?fullfilename)

Succeeds: Displays a file selection dialog containing a list of files of the designated file types (for example, 'TEXT', 'APPL'). Users may browse through the disk file directories and eventually select a file or select CANCEL. The argument _Filetype may be either a single item or a list of items. Each item should be a four-character symbol specifying a Macintosh file type. A single null symbol or an empty list is interpreted as any or all file types. The Doit button is given the label specified by the argument _Doit_label. _Selection is unified with the full filename of the selected file.

Fails: selectafile fails if
• _Filetype is neither a null symbol, a Macintosh file type or a list of zero or more file types
• _Doitlabel is not a symbol
• the user selects CANCEL
Examples:

/* This call */
:- selectafile(['APPL', 'APWS'], 'Select', _Selection).
YES
/* displays the following dialog box */

![Dialog Box]

BNR Prolog Reference Manual
selectone(_Title, _Choicelist, _Selection)
selectone(_Title, _Choicelist, _Selection, _InitialSelection)

**displays a list of items for single selection**

**Arguments:**
- selectone(+symbol, +list, ?symbol,)
- selectone(+symbol, +list, ?symbol, +list)

**Succeeds:**
Displays a dialog box containing the list of the items in _Choicelist, an **OK** button and a **CANCEL** button. _Selection is instantiated to the item selected by the user from _Choicelist.

If an initial selection _InitialSelection is specified then this item is initially highlighted, otherwise the first item is highlighted. An item may be highlighted by clicking on the item. The highlighted item is then selected by clicking on the **OK** button, or by either pressing the **enter** key or clicking on the item. A single item may also be selected directly by double clicking on it.

**Fails:**
- selectone fails if
  - _Title is not a symbol
  - the elements of the list _Choicelist are not symbols
  - _InitialSelection is not a sublist of the list _Choicelist
Examples:

`/* This call */
:- selectone('Make a selection' [fred, bob, dick, jerry, bert, mike], _Selection, mike).
YES
/* displays the following dialog box */

See Also: selectone this chapter.

BNR Prolog Reference Manual
This chapter documents predicates which provide access to miscellaneous Macintosh system facilities.

**System Utility Predicates**

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<thead>
<tr>
<th>Predicate</th>
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<td>beep</td>
<td>causes an audible beep</td>
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<tr>
<td>deskaccessory</td>
<td>invokes a desk accessory</td>
</tr>
<tr>
<td>doubletime</td>
<td>queries or sets the mouse double-click time</td>
</tr>
<tr>
<td>getappfiles</td>
<td>queries the list of files selected at application launch</td>
</tr>
<tr>
<td>invalidrect</td>
<td>invalidates a rectangular region in a window</td>
</tr>
<tr>
<td>isfont</td>
<td>defines a font</td>
</tr>
<tr>
<td>listfonts</td>
<td>queries the list of installed font numbers</td>
</tr>
<tr>
<td>localglobal</td>
<td>translates between global and local window coordinates</td>
</tr>
<tr>
<td>mbarheight</td>
<td>queries the height of the menu bar</td>
</tr>
<tr>
<td>messagebutton</td>
<td>sets or queries the label on the activity button</td>
</tr>
<tr>
<td>scrapcontents</td>
<td>queries the type of data in the scrap</td>
</tr>
<tr>
<td>scrndimensions</td>
<td>queries the dimensions of the Macintosh monitor screen</td>
</tr>
<tr>
<td>setcursor</td>
<td>sets the cursor ID</td>
</tr>
<tr>
<td>validirect</td>
<td>validates the rectangular region in a window</td>
</tr>
</tbody>
</table>

Descriptions of the predicates follow.
beep

causes an audible beep

Arguments: None.

Succeeds: beep causes the system to beep. The volume of the beep depends on the current setting of the speaker which is adjusted by means of the Control Panel desk accessory. If the volume of the speaker is set to zero, no sound is heard and the menu bar flashes instead.

Fails: Never fails.
deskaccessory(_Name)

**invokes a desk accessory**

**Arguments:**

deskaccessory(+symbol)

**Succeeds:**

Invokes the desk accessory _Name. (The Macintosh operating system gives no notification that the desk accessory was successfully run.) The names of desk accessories are normally acquired from the ⦁ menu selections. By convention, these names have a null character (\00,) as the first character of their name.

**Fails:**

deskaccessory fails if _Name is not a symbol.

**Examples:**

?- deskaccessory('\00Calculator').
    ?- deskaccessory('Calculator').
    YES
**Chapter 20: Macintosh System Utility Predicates**

**doubletime(_Deltatime)**

queries the mouse double-click time

**Arguments:**

doubletime(?integer)

**Succeeds:**

Unifies _Deltatime with the mouse double-click time which has been set by the Macintosh control panel.

**Fails:**

doubletime fails if _Deltatime does not unify with the mouse double-click time.

**Examples:**

?- doubletime(_).  
    ?- doubletime(32).  
    YES

?- doubletime(32).  
    ?- doubletime(32).  
    YES
getappfiles(_Filelist)

queries the list of files selected at application launch

Arguments: getappfiles(?list)
Succeeds: Unifies _Filelist with a list of the full filenames of any files selected in the finder when the application was launched. getappfiles is used mainly by applications written in Prolog.
Fails: getappfiles fails if _Filelist does not unify with the list of start-up file names.
Examples:

?- getappfiles(_).
   ?- getappfiles([appfile1, appfile2]).
      YES

?- getappfiles([appfile1, appfile2]).
   ?- getappfiles([appfile1, appfile2]).
      YES

?- getappfiles([appfile2, appfile1]).
   NO
invalidrect(_Windowname, _Left, _Top, _Right, _Bottom)

invalidates a rectangular region in a window

Arguments: invalidrect(+symbol, +integer, +integer, +integer, +integer)

Succeeds: Invalidates the rectangular region specified by _Left, _Top, _Right and _Bottom in the window _Windowname. This region is accumulated into the current update region for that window and will cause an update event to be generated for the window.

Fails: invalidrect fails if
• _Windowname is not the name of a window
• _Left, _Top, _Right and _Bottom are not integers
**isfont(_Number, _Point_size, _Name, _Size_detail)**

defines a font

**Arguments:**
isfont(?integer, ?integer, ?symbol, ?list)

**Succeeds:**
Defines a relationship between a font number _Number, a point size _Point_size, a font name _Name and the size detail _Size_detail at that point size. _Size_detail is a list of the form [Ascent, Descent, Leading, Max_width]. _Point_size can be of any value and the Macintosh toolbox will scale the nearest available size of a "real" font of that name to the requested size to get the size detail.

**Fails:**
isfont fails if
- _Number is neither a variable nor an integer
- _Point_size is neither a variable nor an integer
- _Name is neither a variable nor a symbol
- _Size_detail is neither a variable nor a list
- no such relationship exists between the arguments specified

**Examples:**

```prolog
/* generate all font information */
?- isfont(_..).
?- isfont(2, 9, 'New York', [10, 2, 0, 10]).
?- isfont(2, 10, 'New York', [10, 2, 0, 10]).
?- isfont(2, 12, 'New York', [12, 3, 1, 13]).
.
.
.
YES
```

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/* generate all font number 2 information */
?- isfont(2, _).
  ?- isfont(2, 9, 'New York', [10, 2, 0, 10]).
  ?- isfont(2, 10, 'New York', [10, 2, 0, 10]).

YES

/* generate all fonts with a point size of 18 */
?- isfont(_, 18, _).
  ?- isfont(2, 18, 'New York', [17, 14, 2, 20]).
  ?- isfont(3, 18, 'Geneva', [18, 4, 1, 18]).
  ?- isfont(20, 18, 'Times', [14, 4, 1, 18]).

YES

/* generate information about New York fonts */
?- isfont(_, _, 'New York', _).
  ?- isfont(2, 9, 'New York', [10, 2, 0, 10]).
  ?- isfont(2, 10, 'New York', [10, 2, 0, 10]).

YES

/* generate information about a scaled font */
?- isfont(2, 100, _).
  ?- isfont(2, 100, 'New York', [88, 21, 13, 108]).

YES

See also: listfonts in this chapter.
listfonts(_Fontlist)

queries the list of installed fonts numbers

Arguments:  listfonts(?list)
Succeeds:   Unifies _Fontlist with the list of installed font numbers.
Fails:      listfonts fails if _Fontlist does not unify with the list of installed font numbers.
Examples:

/* generate all font information */
?- listfonts(_).
   ?- listfonts([2, 5, 0, 3, 4, 20, 22]).
      YES

?- listfonts([2, 5, 0, 3, 4, 20, 22]).
   ?- listfonts([2, 5, 0, 3, 4, 20, 22]).
      YES

?- listfonts([2, 0, 5, 3, 4, 20, 22]).
      NO

See Also:  isfont in this chapter.
localglobal(_Windowname, _Xlocal, _Ylocal, _Xglobal, _Yglobal)

translates between global and local window coordinates

Arguments:  
localglobal(+symbol, ?number, ?number, ?number, ?number)
Succeeds: Translates between the local coordinates of the named window and the global coordinates of the Macintosh screen.
Fails: localglobal fails if  
• _Windowname is not the name of a window  
• both _Xlocal and _Xglobal are variables  
• both _Ylocal and _Yglobal are variables  
• _Xlocal, _Ylocal, _Xglobal, _Yglobal are neither variables nor numbers  
• the local coordinates specified do not correspond to the global coordinates specified
Examples:

?- localglobal(fred,30,40,_,_).
   yes

?- localglobal(fred,30,40,60,194).
   yes

?- localglobal(fred,_,_,60,194).
   yes

?- localglobal(fred,30,_,194).
   yes

?- localglobal(fred,30,_,60,_).
   no
**mbarheight(_Height)**

*queries the height of the menu bar*

**Arguments:**  
mbarheight(?integer)

**Succeeds:**  
Unifies _Height with the height of the menu bar in pixels.

**Fails:**  
mbarheight fails if _Height is neither an integer equal to the height of the menu bar, nor a variable.
messagebutton(_Label, _Key)

**sets or queries the label on the activity button**

**Arguments:** 
messagebutton(?symbol, ?symbol)

**Succeeds:** 
If _Label or _Key is a variable then messagebutton unifies with the current system activity button label or key. If _Label or _Key is a single character symbol, then messagebutton sets the label or key.

The system activity label is the string displayed activity field in the bottom-left corner of the active text window. When the mouse is clicked on the activity field, an event of type userkey is generated and the value of the key is set by the _Key argument to messagebutton.

**Fails:** 
messagebutton fails if
- _Label is neither a variable nor a symbol
- _Key is neither a variable nor a single character symbol

**Examples:**

```prolog
/* query current status */
?- messagebutton(_L,_K).
    ?- messagebutton(running,'').
    YES

/* set message to up and key to up cursor */
?- messagebutton(up, '\1E').
    ?- messagebutton(up, ' ').
    YES

?- messagebutton(_,ab).
    NO
```

**See Also:** 
userevent in the chapter titled "User Events".

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scrapcontents(_Type)

queries the type of data in the scrap

**Arguments:**
scrapcontents(?symbol)

**Succeeds:**
Unifies _Type with the type of data in the scrap: 'TEXT' or 'PICT'. If the scrap contains both types of data, _Type is unified with 'PICT'.

**Fails:**
scrapcontents fails if
- _Type is neither a variable nor one of the symbols 'TEXT' or 'PICT'
- there is no data in the scrap
Chapter 20: Macintosh System Utility Predicates

scrndimensions(_Width, _Height)

generates the dimensions of the Macintosh monitor

Arguments: scrndimensions(?integer, ?integer)

Succeeds: Unifies _Width and _Height with the dimensions (in pixels) of the Macintosh monitor.

Fails: scrndimensions fails if _Width and _Height are neither variables nor the dimensions of the monitor.

Examples:

/* query current status */
?- scrndimensions(_W, _H).
    ?- scrndimensions(512, 342).
YES

/* set message to up and key to up cursor */
?- scrndimensions(512, 342).
    ?- scrndimensions(512, 342).
YES
setcursor(_Id)

*sets the cursor ID*

**Arguments:**

setcursor(+integer/symbol)

**Succeeds:**

If _Id is an integer (interpreted as the resource ID of a cursor resource) or one of the predefined symbols, cross, plus, ibeam, watch or arrow, then the cursor ID will be set to that value. The cursor displayed will be changed accordingly.

**Fails:**

setcursor fails if _Id is not one of the predefined symbols, or the ID of a cursor resource.
validrect(_Windowname, _Left, _Top, _Right, _Bottom)

validates the rectangular region in a window

Arguments: validrect(+symbol, +integer, +integer, +integer, +integer)

Succeeds: validrect validates the rectangular region specified by _Left, _Top, _Right and _Bottom in the window _Windowname. This removes the region from the current update region for that window if there was any intersection of the two regions.

Fails: validrect fails if
• _Windowname is not the name of a window
• any of the coordinates specified by _Left, _Top, _Right and _Bottom are not integers.

See Also: invalidrect in this chapter.
Primitives can be written in other languages (for example, Pascal and C), and called directly from BNR Prolog. To facilitate the interface between languages, the primitives must be compiled as code resources, and then placed in the resource fork of a file with the resource type 'PEXT' (Prolog EXTernal). *Macintosh Programmer's Workshop* and the *Lightspeed* family of language products are examples of development environments which provide tools for generating code resources.

Pascal and C examples which use the external language interface are provided in the Chapter titled "Foreign Language Interface" in the *BNR Prolog User Guide*.

**Calls to Foreign Languages**

**Accessing External Primitives**

External primitives are defined to the Prolog system by using the `defexternal` predicate. This predicate loads the code resource into memory and creates a Prolog clause to call it. The code resource will remain in memory until the context containing the associated Prolog clause is removed.
defexternal(_Clausehead, _Filename, _Resourcename, _In, _Out)

allows a code resource to be called as a Prolog goal

Arguments: defexternal(+clausehead, +filename, +symbol, +list, +list)

Succeeds: Loads the resource _Resourcename of type 'PEXT' from the resource fork of the file _Filename, and binds _Clausehead to the external definition. _Clausehead is of the form _Procname(_Variables...) where _Procname is the name by which Prolog clauses can call the external and _Variables... are the arguments to the external. If _Filename is the null symbol ('"'), then the current applications file is searched for the specified resource. _In and _Out are lists defining the input and output arguments and their types. Items in these lists are of the form _Name : _Type, where _Name is the name of an argument in _Variables and _Type is integer, float, symbol or bucket.

Fails: defexternal fails if
• _Clausehead is not a valid clause head
• _Resourcename does not reside in the file _Filename
• the elements of _In and _Out are not of the correct form

Examples:

/* loads a code resource "freemem" from the application file */
/* and creates a clause name "free_memory" which is used to */
/* call it. The routine returns two integers. */

defexternal(free_memory(_LargestFree, _TotalFree),
    '', 'freemem', [],
    [_TotalFree : integer, _LargestFree : integer]).

/* An example of a call to free memory */
?- free_memory(_Largest, _Total).
    YES

?- free_memory(102488, 148796).
    YES
Currently the following types of data are available to external routines:

- integer
- float
- symbol
- bucket

An integer is passed as a 32-bit value that is of type longint in Pascal, or type long in C. The value of the integer must be representable in 29 bits, including the sign, which is in the range of -26843556 to 268435455.

A float is passed as a 32-bit pointer to an 80-bit extended Standard Apple Numerics Environment (SANE) format number that is represented as an ^extended in Pascal, and a *extended in C. The value of the number is maintained internally as an 8-bit exponent with a 20-bit mantissa, so some accuracy may be lost in conversions.

A symbol is passed as a 32-bit pointer to a Pascal string which contains a length byte followed by up to 255 characters in the string, with each character using a byte. In Pascal, the declaration is ^string[255].

A bucket is passed as a 32-bit value that is of type longint in Pascal, and type long in C. Buckets are not the same as integers and do not unify with them.
Parameter Interface

Each external definition is passed a pointer to a structure that contains the result, a user definable handle, the input parameters, and the output parameters. The input and output parameters are passed in the order specified inside the input and output lists and not by the order inside the clause-head. The structure for `free_memory` described in the example would be as follows (Pascal interface):

```pascal
StackFrame = RECORD
  Result    : LONGINT;
  Reserved  : LONGINT;
  UserHandle: HANDLE;
  TotalFree : LONGINT;
  LargestFree: LONGINT;
END;
```

where

- `Result` is initially zero which indicates failure. Nonzero indicates success of the procedure call.
- `Reserved` is a field saved for future use.
- The value of the `UserHandle` is initially NIL, but may be updated by the external, and is maintained by the system between calls to the external. It is passed to the procedure with every call and can be used by a procedure to maintain global data structures. When the context containing the external procedure call clause is exited, the space pointed to by `UserHandle` is freed. `UserHandle` should only be used as a handle.
- In the case of both input and output parameters, the space for all strings and floating point numbers is allocated by BNR Prolog before calling the routine.
In either Pascal or C, the structure appears as the lone parameter to the external procedure, as follows:

```pascal
PROCEDURE Proc(VAR P : StackFrame);
```
or

```c
void Proc(P)
    struct StackFrame *P;
```

**Restrictions**

External procedures that are accessed from BNR Prolog cannot have global data. Any data that is intended as global should be defined and manipulated through the UserHandle in the StackFrame. UserHandle must be maintained as a handle, if it is to be used at all.

External procedures need not be concerned with popping parameters off the stack on return. BNR Prolog will restore the stack if necessary.

External routines must be procedures rather than functions. There must be no more than one parameter to an external procedure, the pointer to the parameter structure. If the external procedure is defined as a function or more parameters are used, unexpected results may occur.

Pointer parameters should not be modified. Such action will result in unrecoverable space in memory.
## Appendix A: Macintosh Extended Character Set

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Run Errors

Below is a list of run time errors. These errors are output from BNR Prolog when an execution error occurs. The errors are ordered by error number for easy searching.

1: Global stack dangling reference
2: World stack dangling reference
3: Bad record on global stack
4: Bad record on world stack
5: Global stack full
6: World stack full
7: Control stack full
8: Bad record
9: Structure too deep
10: Invalid tag
11: Division by zero
13: User aborted execution
14: Bad primitive
15: Buffer length exceeded
16: Non executable term
17: Integer overflow
18: Bad clause
19: Not yet implemented
20: Looped list
22: Odd number of parser classes
24: Too many variables in clause
41: State space full
42: Cannot extend state space
43: State space double limit
44: Cannot write structure
47: Operator not yet defined for INFIX call
48: Unable to make infix operator
49: Unable to find strings for comparison
50: Unable to find string for hashing
51: File does not contain a valid state space
52: Bad item in loaded state space
53: Total size of state space inconsistent
54: Attempt to allocate cell too small
55: Free list in state space corrupted
57: Attempt to unreference a non-string
58: Attempt to reference a non-string
59: Attempt to dissolve variable list
60: Attempt to dissolve unrecognized term
61: Could not find string
62: Could not lookup string
63: Attempt to copy variadic structure
64: Unable to find string to compare
65: Unable to forget item
67: Unable to copy intervals
68: Real number overflow
69: State Space: Unable to release memory
70: State Space: Unable to obtain memory
Syntax Errors

The following is a list of syntax errors output by BNR Prolog.

2: Waiting for rest of term.
3: Expecting atom, variable or anonymous as functor name
4: Operand stack underflow
5: Operator stack underflow
6: Too many variables in clause - limit is 255
7: Parser bug. Please report.
8: Integer overflow
9: Integer expected to follow unary minus
10: Digit expected
11: Maximum nesting depth exceeded for lists and structures - limit is 40
12: Too many right parentheses ')' for expression
13: Need an operand before this last symbol
14: Empty pair of parentheses '()' 
15: Illegal use of parentheses '()' 
16: Bad character in this symbol
17: Not a tail variable
18: Clause being parsed is too big
19: No operand between pair of operators
20: This symbol not an operator, so a comma needed before it
21: Comma needed before left parenthesis '('
22: Comma needed before current list or structure
23: Comma or operator needed before left parenthesis '('
24: Mismatch of bracket types
25: This symbol is not a real number
26: String length cannot exceed 255 characters
27: No predicate after comma
28: Need comma, prefix or infix operator, ( or [ before this symbol
29: Need operand, ), ], or postfix operator before this symbol
30: This operator and previous one have incompatible types or precedences
31: This variable name is reserved
32: Token is too long
33: Character in current token cannot be interpreted
34: Incomplete expression
35: Abandoned parsing of this structure
36: Unrecognized parsing action
37: Ignoring extra right brackets/parentheses at end of clause
38: Adding matching right brackets/parentheses at end of clause
39: Need closing right bracket for |{-list
40: Use right bracket ] to end lists
41: Use right parenthesis ) to end structures
Appendix B: Error Messages

System Errors

A complete list of the Macintosh file system error codes is presented in Appendix A of Volume III of *Inside Macintosh*. Examples of this type of error include: I/O error, too many files open, bad filename, file is locked, and disk is full. In addition to the Macintosh file system error codes, a number of additional codes have been defined by the Prolog system. These are listed below:

- **MaxDocErr** = -200; [Maximum # of documents exceeded]
- **UserWindErr** = -201; [Illegal operation on a user defined window]
- **UnkEvErr** = -202; [Unknown or unexpected event type seen]
- **WinOflwErr** = -203; [Implementation restriction, Windows <= 32k]
- **UnImplErr** = -204; [Unimplemented or inaccessible routine]
- **IntMMIerr** = -205; [Internal MMI error]
- **ConsOpErr** = -206; [Illegal operation on the Console window]
- **ProBusyErr** = -207; [Open prolog stream can't be closed]
- **UserCanErr** = -208; [User 'Cancel'.]
Although BNR Prolog is largely compatible with other Prologs in the Edinburgh family, there are some syntactic and semantic differences. The following is a brief description of the differences that may affect the execution of programs. Please refer to the chapter titled "Prolog Compatibility Issues" in the BNR Prolog User Guide for further details.

Clause Bodies

Clause bodies in BNR Prolog are lists, rather than comma-structures. Thus the clause

\[ p :- a, b, c. \]

in BNR Prolog unifies with the term

\[ :- (p, [a, b, c]). \]

not with

\[ :- (p, (' , ' (a, ' , ' (b, c)))). \]

Lists

The variable remainder of a list in BNR Prolog is a tail variable. The term \([A|B]\) unifies with \([A, B..]\) and \(B\) unifies with the list \([B..]\), which contains a tail variable. Thus the questions

\[ ?- [a|Tail], Tail=x. \]

\[ ?- [a|Tail], var(Tail). \]

will fail because \(Tail\) must be a list.

Nonempty lists in BNR Prolog do not unify with the structure \((Head . Tail)\) as they do in some other Prologs. The period (.) is not an operator.
Operators

Operators in BNR Prolog are declared by adding op/3 facts in the clause space, rather than executing them as goals or directives.

An operator that is declared infix must have the same precedence number as its prefix or postfix form. The same operator cannot be both prefix and postfix.

To mention an operator in a program, it may need to be quoted. Since it must be possible to use operators without the quote marks, symbols that must always be quoted (for example, 'a b c') cannot be declared as operators.

The operator "==" in BNR Prolog is synonymous with the arithmetic comparison operator "=:=". All programs that expect "==" to perform a term comparison should use the operator @= instead. The operators "\==" and "@ \= " are synonymous, as are "\=:=" and "\= ".

Comma, ",," is treated as a separator unless it is specifically declared as an operator and used with explicit parentheses.

Strings

There are no strings in BNR Prolog: the term "Hello" does not unify with the list of characters [72, 101, 108, 108, 111]. Instead "Hello" unifies with the symbol 'Hello'. All predicates that might be expected to handle strings (for example, concat), handle quoted symbols instead.

Note that the escape character for quoted symbols is the backslash character "\". Thus the quoted symbol '\\=' unifies with the unquoted symbol \=.

Input and Output

All the Edinburgh I/O predicates such as see, seeing, seen and tell, telling and told are not supported. To some extent they are subsumed by BNR Prolog's stream based I/O that use explicit stream identifiers such as open, close and stream.
Appendix C: Compatibility with other Prologs

Assert and Retract

The predicate assert in BNR Prolog has the same effect as asserta (rather than assertz). The assertion and retraction of clauses is possible only in the top-most context. If only consult and reconsult are used to add clauses to the clause space, this should make no difference to the behavior of programs that use assert and retract. However, if these same programs are loaded into contexts, they may behave differently.

All Solutions Predicates

The predicates setof and bagof are not supported. Instead the predicates findset and findall are provided.

Database Predicates

The database predicates recorda, recordz, recorded and erase are not supported. Instead their functions can be performed with the state space predicates remembera, rememberz, recall, recallz, forget, forget_all and update.

Metalogical Predicates

The metalogical predicates "=.." and functor are unnecessary in BNR Prolog because structures can be built and decomposed with unification.

Compatibility File

The following predicates and operators, found in many Edinburgh Prologs are not supported in BNR Prolog but are defined in a loadable file titled Edinburgh found on the release disk.

Operators: , \+ not =..

Other Predicates:

abolish arg
assert atom
bagof call
clause/2 functor
get get0
name put
setof skip
tab

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