Logic Programming and Constraints

Constraints: a Preview

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Prolog II geler/2 (Freeze)

:- writeln(X), writeln(2), X = 1.

The goal writeln(X) is frozen until X is instantiated
The output is 21
But this does not work in ECLiPSe

Prolog II geler/2 (Freeze)

:- freeze(X, writeln(X)), writeln(2), X = 1.

Delay Clause

delay mywriteln(X) if var(X).
mywriteln(X) :- writeln(X).

A delay clause is very similar to a normal Prolog clause. It has the form:
delay <Head> if <Body>.

A predicate may have one or more delay clauses. They have to be textually before and consecutive with the normal clauses of the predicate they belong to.

When a procedure with delay clauses is called, then the delay clauses are executed before executing the procedure itself. If one of the delay clauses succeeds, the call is suspended, otherwise they are all tried in sequence and, if all delay clauses fail, the procedure is executed as usual.

Delay clauses are used with pattern matching
For instance with:
delay p(a, X) if var(X).
the variables in the call cannot be bound by the matching, e.g. the head of the delay clause does not match the goal p(a, b) but it matches the goal p(a, X)

Freeze with Delay Clauses

/* freeze.pl */

delay freeze(X, Goal) if var(X).
freeze(_, Goal) :- call (Goal).

Suspensions

- suspend(+Goal, +Priority, +CondList)
  - Priority is an integer between 1 and 12 that determines the priority with which the Goal will be scheduled when woken (1 being the most urgent and 12 the least urgent), or it is 0, in which case the priority defaults to the priority setting of the predicate which is called in Goal.
  - CondList is one term or a list of terms of the form:
    Vars->Cond.
The condition Cond is the name of a predefined suspension list (can also be library or user defined triggers).
    - inst: wake when a variable gets instantiated
    - bound: wake when a variable gets instantiated or bound to another variable
    - constrained: wake when a variable gets instantiated or bound to another variable or becomes otherwise constrained
ECLiPSe Resolvant

Freeze with Suspend

```prolog
:- suspend(writeln(X), 1, X->inst), write(2), X=1.-
```

Freeze with Suspend

/* freeze.pl */

freeze(X, Goal):-
suspend(Goal, 1, X->inst).

Tracing Variables Life

```prolog
report(X) :-
suspend(report1(X), 1, X->constrained).
report1(X) :-
    ( nonground(X) ->
      (writeln(constrained(X)),
       term_variables(X, L),
       suspend(report1(L), 1, L->constrained) ) ;
      writeln(instantiated(X)) ).
```

Following a variable’s Life

```prolog
:- report([X]), X = f(Y, Z), Z=g(H), Y = 1.
```

Attributed Variables

Attributed variables or metaterms are variables that have attributes, e.g:

\[ X\{\text{attribute:value}\} \]

It is necessary to redefined unification for theses variables by defining a handler (the handler is called when the variable is unified)
**Attribute**

- `meta_attribute(+Name, +Handlers)`

  - Declares the variable attribute `Name` with the corresponding handlers and the procedures that implement them (unify, print, etc.)

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**Example**

/* Attributed Variables */

```prolog
:- meta_attribute(enum, [unify:unify_enum/2, print:print_enum/2]).
```

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**Enumeration Domain**

As an example, let us implement variables of enumerable types using attributes. We choose to represent these variables as attributed variables whose attribute is a list of possible values.

```prolog
:- module(enum).
:- meta_attribute(enum, [unify:unify_enum/2, print:print_enum/2]).
:- import setarg/3 from sepiakernel.
:-export enum/2.
enum(X, Y):- add_attribute(X, enum(Y)).
unify_enum(_, Attr) :- var(Attr).
unify_enum(Term, Attr) :- compound(Attr), unify_term_enum(Term, Attr).
unify_term_enum(Value, enum(ListY)) :- nonvar(Value), memberchk(Value, ListY).
unify_term_enum(Y{AttrY}, AttrX) :- -?-> unify_enum_enum(Y, AttrX, AttrY).
unify_enum_enum(_, AttrX, AttrY) :-
  var(AttrY), % no attribute for this extension
  AttrX = AttrY. % share the attribute
unify_enum_enum(Y, enum(ListX), AttrY) :-
  nonvar(AttrY), AttrY = enum(ListY), intersection(ListX, ListY, ListXY),
  ( ListXY = [Val] -> Y = Val ; ListXY = [], setarg(1, AttrY, ListXY)).
print_enum(_{enum(V)}, A) :- -?-> A = V.
```

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**Finite Domains Library**

```prolog
:- lib(fd).
```

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**Finite Domains**

- `?Vars :: ?Domain`

  - Terms in Vars have the domain Domain.

**Example:**

```prolog
:- X :: 23..54.
:- X :: 23..54, Y :: 36..100.
:- X :: 23..54, Y :: 36..100, X = Y.
```
Finite Domains

- \( ?X \neq ?Y \)
- \( X \) is equal to \( Y \)
- This constraint states that the two linear terms are equal.
- It is activated whenever the maximum or minimum of a domain variable is updated that might require updating other domains. When propagating domain updates, the system takes into account only maximum and minimum values of the whole domain and makes sure that these values are consistent with those of other domain variables.
- If one of the arguments is a non-linear polynomial, this predicate delays until it becomes linear.

Global Constraints

- \( \text{alldifferent}(\text{List}) \)
- The elements of the list \( \text{List} \) are pairwise different.

Finite Domains

```
/* */
/* domain */
d(X, Y, Z) :- X == Y, X =< Z.
different(L) :- different(X, L), different(L).

/* send */
send(L).
```

Finite Domains

```
/* */
/* domain */
d(X, Y, Z) :- d(X, Y, Z).

/* send */
send(L).
```

Finite Domains

```
/* */
:- lib(fd). % finite domains library
/* domain */
d(X, Y, Z) :- d(X, Y, Z).

/* send */
send(L).
```

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