Introduction to PROLOG

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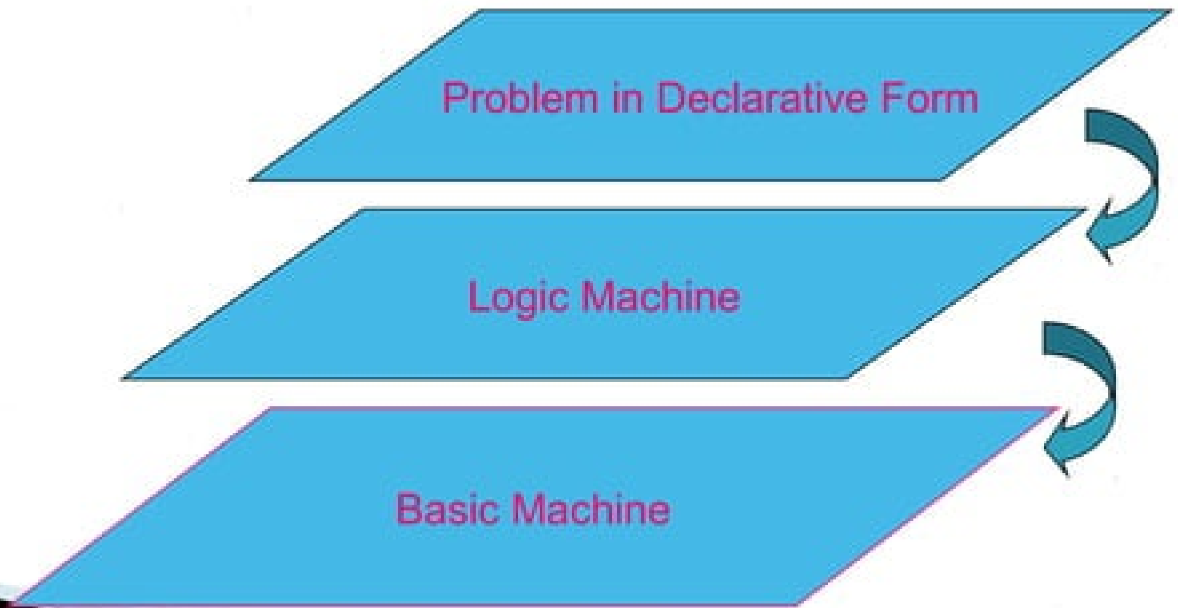
Open Source Softwares

Open source software is software that can be freely used, changed, and shared (in modified or unmodified form) by anyone.

Introduction

- **PRO**gramming in **LOG**ic
- Declarative language
- Emphasis on what rather than how
- It is widely used in the field of AI



SWI-Prolog

- SWI-Prolog offers a comprehensive *FREE SOFTWARE* Prolog environment.
- Link for downloading:

http://www.swi-prolog.org/download/stable

- A Self-installing executable for MS-Windows: **swipl-win.exe**
- Works on Windows XP
- LINUX versions are also available.

Fundamentals

- Facts
- Rules
- Query
- Unification
- Resolution
- Backtracing
- Cuts and negations

FACTS

- Facts are statements about what is true about a problem, instead of instructions how to accomplish the solution.
- The Prolog system uses the facts to work out how to accomplish the solution by searching through the space of possible solutions.
- It is defined by an identifier followed by an n-tuple of constants.
- A relation identifier is referred to as a predicate
- When a tuple of values is in a relation we say the tuple satisfies the predicate.

Syntax for fact declaration

- Names of relationship and objects must begin with a lower-case letter.
- Relationship is written *first* (typically the *predicate* of the sentence).
- *Objects* are written separated by commas and are enclosed by a pair of round brackets.
- The full stop character '.' must come at the end of a fact.

Examples

Predicate	Interpretation
valuable(gold)	Gold is valuable.
owns(john,gold)	John owns gold.
father(john,mary)	John is the father of Mary
gives (john,book,mary)	John gives the book to Mary

RULES

- Specifies under what conditions a tuple of values satisfies a predicate.

- The basic building block of a rule is called an *atom*

- Atom :- Atom1, ..., Atomn

If each of Atom1,...,Atomn is true, then Atom is also true.

Cont..

Rules specify:

- **If-then conditions**
  - I use an umbrella if there is a rain
  - use(i, umbrella) :- occur(rain).
- **Generalizations**
  - All men are mortal
  - mortal(X) :- man(X).
- **Definitions**
  - An animal is a bird if it has feathers
  - bird(X) :- animal(X), has_feather(X).

Syntax of rule

- <head> :- <body>
- Read **':-' as 'if'.**
- *likes(john,X) :- likes(X,cricket).*
  - *"John likes X if X likes cricket".*
  - *i.e., "John likes anyone who likes cricket".*
- ***Rules always end with '.'***

QUERIES

There are two types of queries:

- Ground Query
  - *edge(a,b)*
  - *This query is called a ground query because it consists only of value identifiers as parameters to the predicate.*
  - a ground query is posed we expect a yes/no answer.
- Non Ground Query
  - They have variables as parameters
  - tedge(a,X)

Variables

- Always begin with a capital letter
  - ?- likes (john,X).
  - ?- likes (john, Something).
- But not
  - ?- likes (john,something)

Example

- **Facts: ()**
  - likes(john,mary).
  - likes(john,X). % Variables begin with capital
- **Queries**
  - ?- likes(X,Y).
  - X=john, Y=Mary. % hit “;” for more
  - ?- likes(X,X).
  - X=john.

Example

- **Rules**
  - likes(john,X) :- likes(X,wine). % :- = if
  - likes(john,X):- female(X), likes(X,john).
- **Query:** ? - likes(john,Y).
  - Y = bill ;
  - no

Example

Predicate

Procedure for elephant

Facts

Clauses

```
elephant(george).
elephant(forge).
elephant(X) :- grey(X), mammal(X), hasTrunk(X).
```

Rule

Example

Queries

Replies

```
?- elephant(george).
yes
?- elephant(jane).
no
```

Conjunction & Disjunction

- **Conjunction** of predicates is represented as a sequence of structures, separated by commas",".
- It is referred as "AND"

sister_of (X,Y):- female (X), parents (X, M, F),

- **Disjunction** of predicates is represented as a sequence of structures, separated by semicolon";".
- It is referred as "OR"

friend(ram,shyam):-
friend(shyam,sita);friend(shyam,mohan).

Unification

- Questions based on facts are answered by matching
- Unification is the name given to the way **Prolog** does its matching.
- Two facts match if their predicates are same (spelt the same way) and the arguments each are same.
- If matched, prolog answers yes, else no.
- No does not mean falsity
- This means not provable from the given facts.

Question Answering in presence of rules

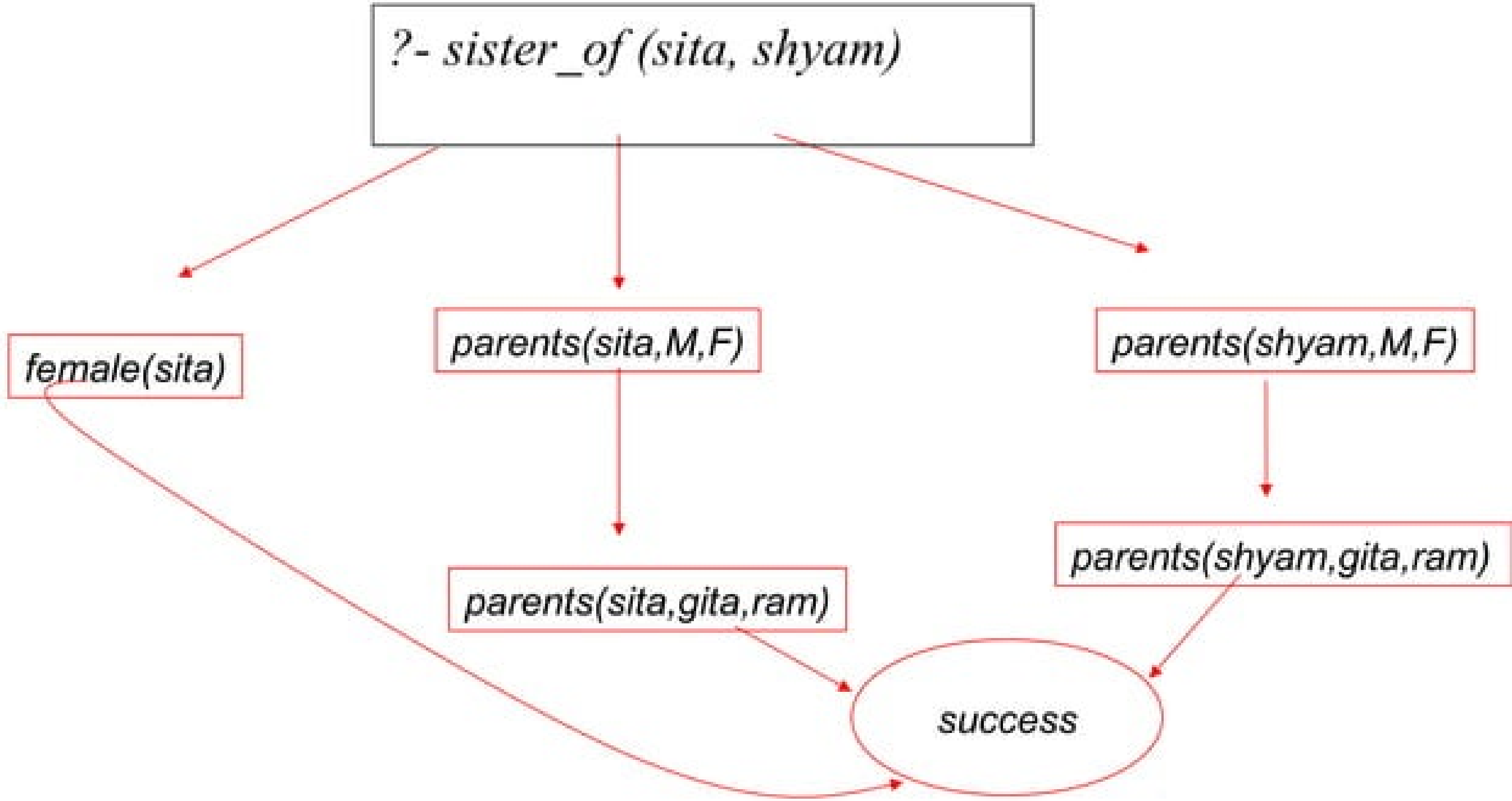
Facts

- male (ram).
- male (shyam).
- female (sita).
- female (gita).
- parents (shyam, gita, ram).
- parents (sita, gita, ram).

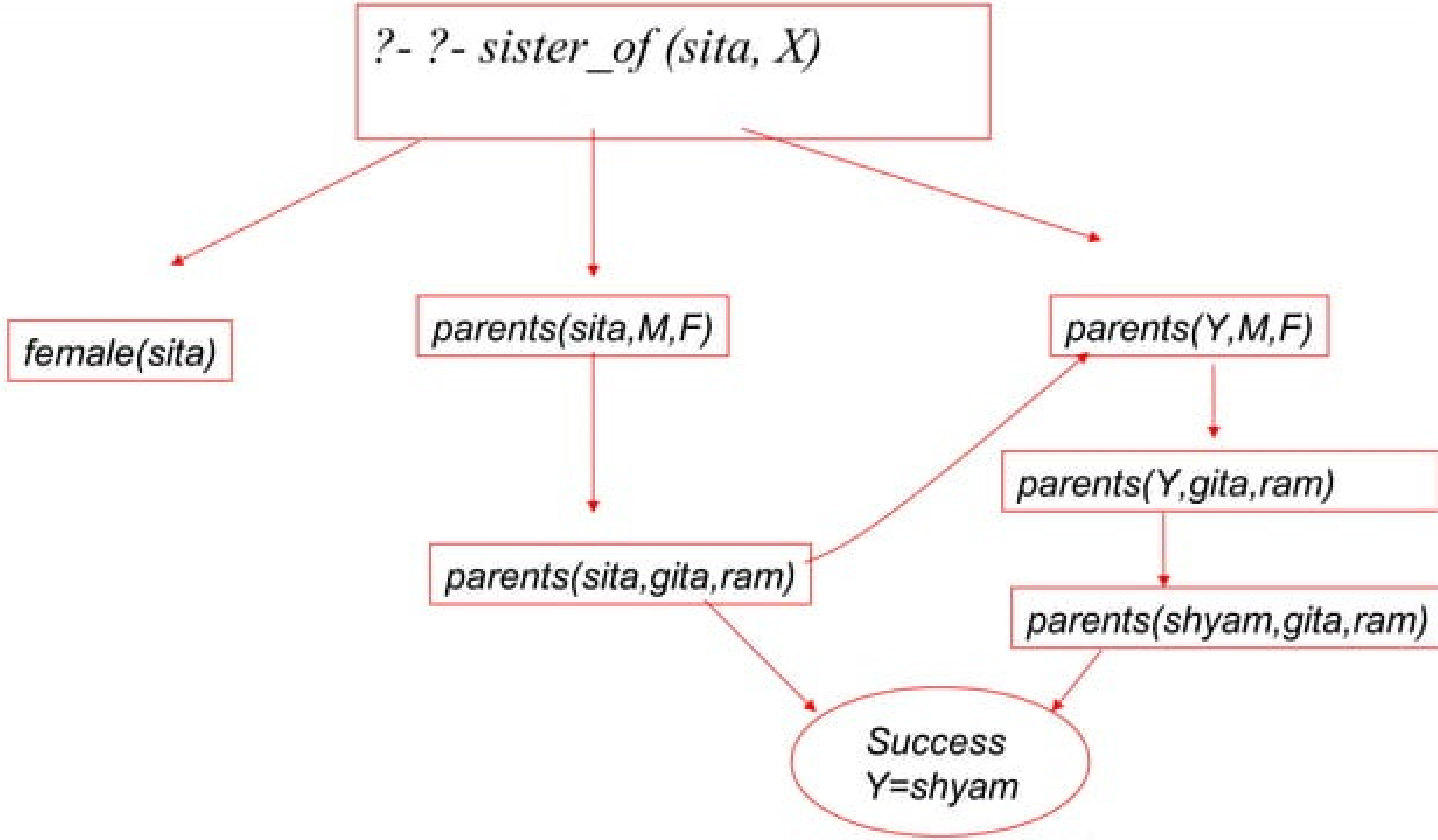
Rule:*sister_of (X,Y):- female (X), parents (X, M, F),parents (Y, M, F).*

X is a sister of Y is X is a female and X and Y have same parents

Backtracking



Question Answering: wh-type: *whose sister is sita?*



Arithmetic in prolog

- Prolog provides a number of basic arithmetic tools.
- **Arithmetic examples** **Prolog Notation**
- 6 + 2 = 8 8 is 6+2.
- 6 * 2 = 12 12 is 6*2.
- Answers to arithmetic questions by using ariables. For example:
- ?- X is 6+2.

  X=8

Prolog's computation

- Depth First Search
  - Pursues a goal till the end

- Conditional AND; *falsity* of any goal prevents satisfaction of further clauses.

- Conditional OR; *satisfaction* of any goal prevents further clauses being evaluated.

Control flow (top level)

Given

g:- a, b, c.   (1)

g:- d, e, f; g. (2)

If prolog cannot satisfy (1), control will automatically fall through to (2).

Control Flow within a rule

Taking (1),

g:- a, b, c.

If *a* succeeds, prolog will try to satisfy *b*, succeding which *c* will be tried.

For ANDed clauses, control flows forward till the '.', iff the current clause is *true*.

For ORed clauses, control flows forward till the '.', iff the current clause evaluates to *false*.

On Failure

REDO the immediately preceding goal.

Always place the more general rule AFTER a specific rule

Cuts and Negation

- Automatic backtracking is one of the most characteristic features of Prolog.
- Backtracking can lead to inefficiency.
- Prolog can waste time exploring possibilities that lead nowhere.
- Cut is a goal that always succeeds
- Commits Prolog to the choices that were made since the parent goal was called
- CUTS are used control over this aspect of its behaviour
- p(X):- b(X), c(X), !, d(X), e(X).

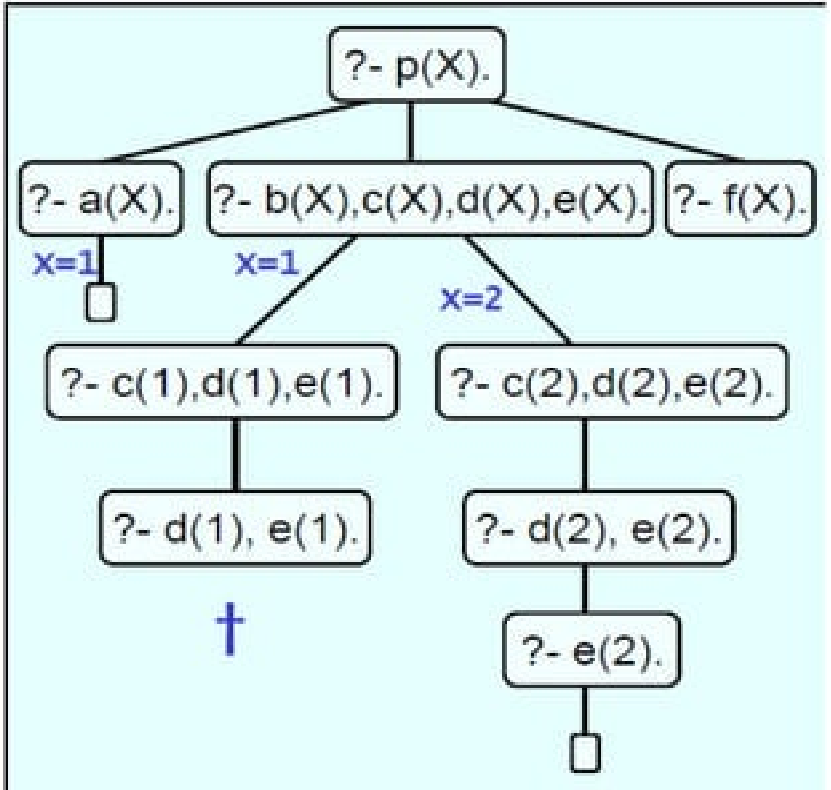
Example

- consider the following piece of cut-free code:
- ```
  p(X):-  a(X).
  p(X):-  b(X),  c(X),  d(X),  e(X).
  p(X):-  f(X).
  a(1).   b(1).    c(1).    d(2).   e(2).   f(3).
          b(2).    c(2).
  ```
- ***For query p(X) we will get the following responses:***
- ```
  X = 1 ;
  X = 2 ;
  X = 3 ;
  no
  ```
- Here is the search tree that explains how Prolog finds these three solutions. Note that it has to backtrack once, namely when it enters the second clause for p/1 and decides to unify the first goal with b(1) instead of b(2) .

Example: cut-free code

```
p(X):- a(X).
p(X):- b(X), c(X), d(X), e(X).
p(X):- f(X).
a(1).
b(1).   b(2).
c(1).   c(2).
d(2).
e(2).
f(3).
```

```
?- p(X).
X=1;
X=2;
```



- Suppose we insert a cut in the second clause:

```
p(X):- b(X), c(X), !, d(X), e(X).
```

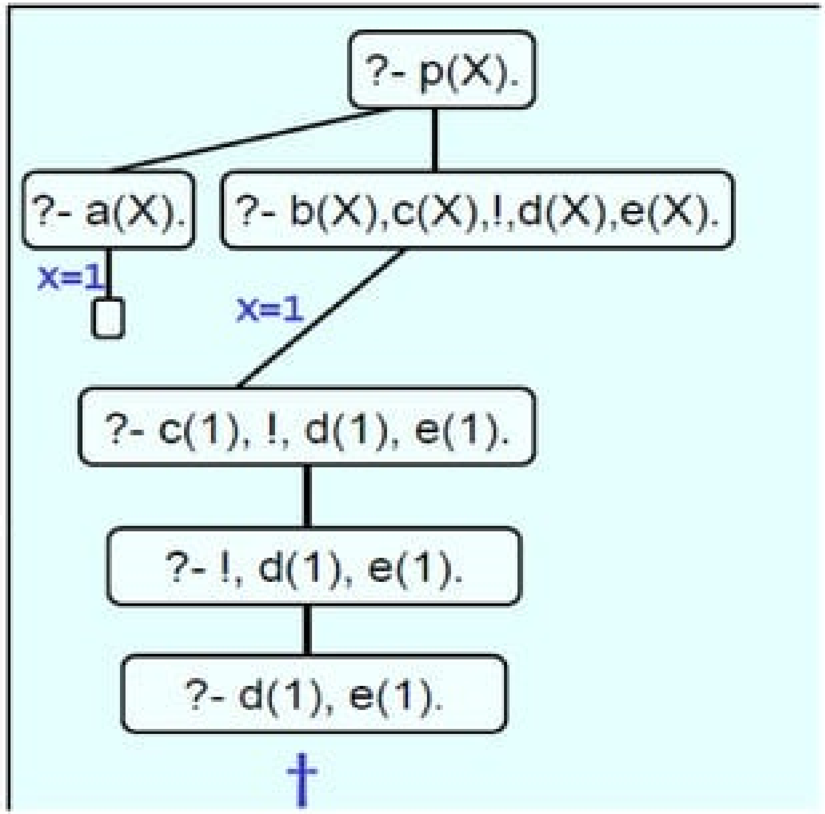
- If we now pose the same query we will get the following response:

```
?- p(X).
X=1;
no
```

Using CUT

```
p(X):- a(X).
p(X):- b(X),c(X),!,d(X),e(X).
p(X):- f(X).
a(1).
b(1).   b(2).
c(1).   c(2).
d(2).
e(2).
f(3).
```

```
?- p(X).
X=1;
no
```



Negation

- Consider the following code:
- ```
  enjoys(vincent,X)  :-  big_kahuna_burger(X),!,fail.
  enjoys(vincent,X)  :-  burger(X).
  burger(X)  :-  big_mac(X).
  burger(X)  :-  big_kahuna_burger(X).
  burger(X)  :-  whopper(X).
  big_mac(a).
  big_kahuna_burger(b).
  big_mac(c).
  whopper(d).
  ```
- **Using Negation**

  ```
  enjoys(vincent,X)  :-  burger(X), neg(big_kahuna_burger(X)).
  ```
  ```

Predicate Calculus

- Introduction through an example *(Zohar Manna, 1974):*
  - Problem: A, B and C belong to the Himalayan club. Every member in the club is either a mountain climber or a skier or both. A likes whatever B dislikes and dislikes whatever B likes. A likes rain and snow. No mountain climber likes rain. Every skier likes snow. *Is there a member who is a mountain climber and not a skier?*

- Given knowledge has:
  - Facts
  - Rules

A Typical Prolog program

- *Compute_length ([],0).*
- *Compute_length ([Head|Tail], Length):-*
- *Compute_length (Tail,Tail_length),*
- *Length is Tail_length+1.*
- High level explanation:
- *The length of a list is 1 plus the length of the tail of the list, obtained by removing the first element of the list.*
- **This is a declarative description of the computation.**

Applications

- Expert Systems (Knowledge Representation and Inferencing)

- Natural Language Processing

- Definite Clause Grammar
- http://www.learnprolognow.org/lpnpage.php?pagetype=html&pageid=lpn-htmlch8

References

- www.**swi-prolog**.org/
- http://www.learnprolognow.org/

THANKYOU