Logic Programming

Prolog as Language

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Prolog as Language

- Syntax
- Operators
- Equality
- Arithmetic
- Satisfying Goals

Syntax

Terms:

- constant
- variable
- structure

Constants

- Naming (specific objects, specific relationships)
  - `likes mary john book wine owns jewels can_steal`
  - `a`
  - `void`
  - `=`
  - `'george-smith'`
  - `-->`
  - `george_smith`
  - `ieh2304`
- Integers (size is implementation dependent)

Non-Constants

The following symbols are not constants:

- `2340ieh` – Begins with number.
- `george-smith` – Contains dash.
- `Void` – Begins with capital.
- `_alpha` – Begins with underscore.

Variables

Begin with capital or with underscore:

- Answer
- Input
- _3_blind_mice

Anonymous variable: A single underscore

- `likes(john,_).`
- Need not be assigned to the same variable `likes(_,_).`

Structures

- Collection of Objects, *Components*, grouped together in one object.
- Help Organize.
- Make code more readable.

Structures

Example: Index Card for Library

- Author's Name
- Title
- Date
- Publisher
- Name could be split also first, last, etc.

Examples

- `owns(john, book).`
- One Level:
  ```
  owns(john, wuthering_heights).
  owns(mary, moby_dick).
  ```
- Deeper:
  ```
  owns(john, book(wuthering_heights,bronte)).
  owns(john, book(wuthering_heights,
       author(emily,bronte))).
  ```

Questions

- Does John own a book by the Bronte sisters?
  `owns(john, book(X,author(Y,bronte))).`
- For the yes/no question
  `owns(john, book(_,author(_,bronte))).`
  (note that each _ could be different)

Equality

An infix operator =

- `X = Y`
  A match is attempted between expression `X` and expression `Y`
- PROLOG does what it can to match `X` and `Y`

Example: Instantiated

- `X` is uninstantiated.
- `Y` is an object.
- `X = Y`: `X` and `Y` will be matched.
- Thus X will be instantiated by the object Y.

```
?- rides(man,bicycle) = X.

X = rides(man,bicycle).
```

Example: Symbols

```
?- policeman = policeman.

Yes
?- paper = pencil.

No
?- 1066 = 1066.

Yes
?- 1206 = 1583.

No
```

Arguments Instantiated

- If the structures are equal then their arguments are matched.

```
?- rides(man,bicycle) = rides(man,X).

X = bicycle.
```

Arguments Instantiated

```
?- a(b,C,d(e,F,g(h,i,J))) =
   a(B,c,d(E,f,g(H,i,j))).

B = b
C = c
E = e
F = f
H = h
J = j
```

Equality

```
?- X = X.
true

?- Y = X.
Y = X
```

Equality

```
?- X = Y, X = 1200.
X = 1200, Y = 1200
?-
```

Arithmetic Comparisons

```
X = Y

X \= Y

X < Y

X > Y

X =< Y

X >= Y
```

Arithmetic

```
?- 123 > 14.
true

?- 14 > 123.
false

?- 123 > X.
ERROR: Arguments are not sufficiently
instantiated

?-
```

Example

- `Prince` was a prince during year, `Year` if `Prince` reigned between years `Begin` and `End`, and `Year` is between `Begin` and `End`.

```
prince(Prince, Year) :-
       reigns(Prince, Begin, End),
       Year >= Begin,
       Year =< End.

reigns(rhodri, 844, 878).
reigns(anarawd, 878, 916).
reigns(hywel_dda, 916, 950).
reigns(lago_ad_idwal, 950, 979).
reigns(hywel_ab_ieuaf, 979, 985).
reigns(cadwallon, 985, 986).
reigns(maredudd, 986, 999).
```

Runs

- Was Cadwallon a prince in 986?
- Is Rhodri a prince in 1995?

```
?- prince(cadwallon, 986).
true

?- prince(rhodri, 1995).
false

?-
```

Who was a Prince When

- Who was the prince in 900?
- Who was the prince in 979?

```
?- prince(Prince, 900).
Prince = anarawd ;
false

?- prince(Prince,979).
Prince = lago_ad_idwal ;
Prince = hywel_ab_ieuaf ;
false

?-
```

Invalid Question

- When was Cadwallon a prince?

```
?- prince(cadwallon, Year).
ERROR: Arguments are not sufficiently
instantiated
```

Calculating

- Calculating the Population Density of a Country: Population over the Area

```
density(Country, Density) :-
     pop(Country, Pop),
     area(Country, Area),
     Density is Pop/Area.

pop(usa, 305).
pop(india, 1132).
pop(china, 1321).
pop(brazil, 187).

area(usa, 3).
area(india, 1).
area(china, 4).
area(brazil, 3).
```

Questions

- What is the population density of USA?

```
?- density(usa, X).
X = 101.667 ;
false
```

Questions

- What Country has which density?

```
?- density(X, Y).

X = usa
Y = 101.667 ;

X = india
Y = 1132 ;

X = china
Y = 330.25 ;

X = brazil
Y = 62.3333 ;

false
?-
```

Arithmetic Operations

```
X + Y
X - Y
X * Y
X / Y
X mod Y
```

How Prolog Answers Questions

Program:

```
female(mary).

parent(C, M, F) :-
    mother(C, M),
    father(C, F).

mother(john, ann).
mother(mary, ann).

father(mary, fred).
father(john, fred).
```

Question:

```
?-female(mary),parent(mary,M,F),parent(john,M,F).
```

How does it work?

Matching

- An uninstantiated variable will match any object. That object will be what the variable stands for.
- An integer or atom will only match itself.
- A structure will match another structure with the same functor and the same number of arguments and all corresponding arguments must match

How Is this Matched

```
?- sum(X+Y) = sum(2+3).

X = 2,
Y = 3
```