Prolog Programming

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Text

Prolog Programming for Artificial Intelligence

by Ivan Bratko

Third Edition, Addison Wesley

References

- Artificial Intelligence by George F Luger, Fourth Edition, Addison-Wesley
- Prolog Help/References http://www.geocities.com/saviranid/
- Roman Barták, 1997 page http://ktiml.mff.cuni.cz/~bartak/prolog.old/intro.html

What is Prolog?

- **Pro**gramming in **Log**ic
- Developed in early 1970, by Robert Kowalski, Maarteen van Emden, and David D.H. Warren at Edinburgh, U.K., Alain Colmerauer at Marseilles
- For symbolic, non-numeric computation
- Suited for solving problems that involve objects and relations between objects

Language Design

- centered around a small set of basic mechanisms
- including pattern matching, tree-based data structuring and automatic backtracking

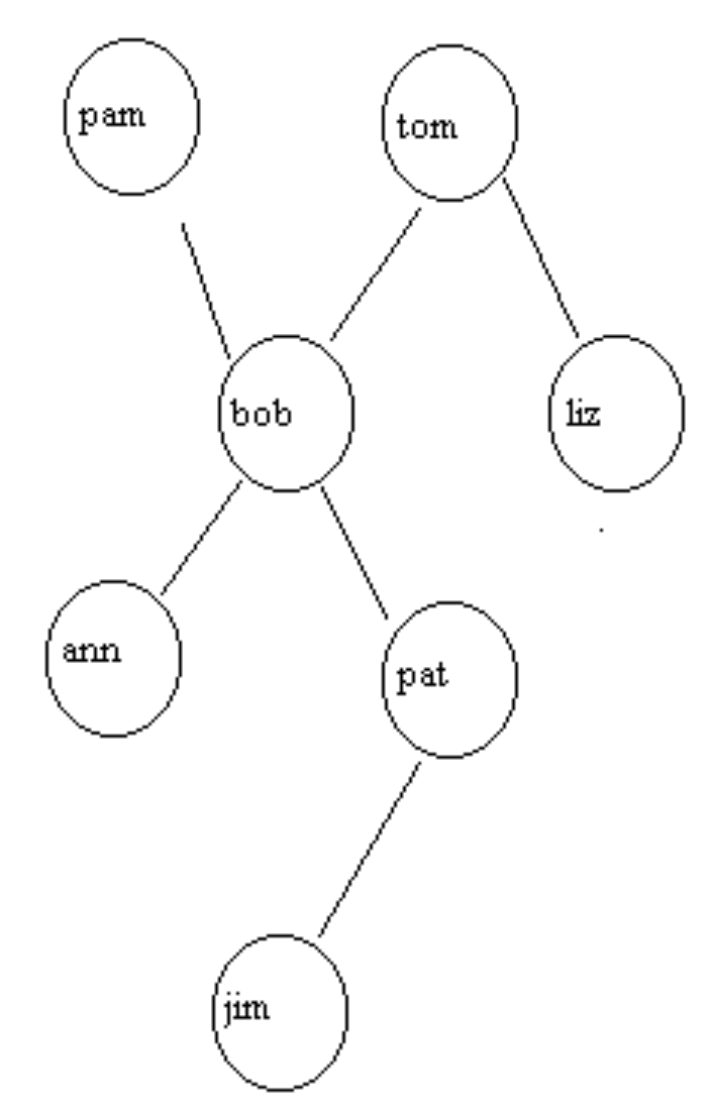
Chapter 1: Introduction to Prolog

- Defining relations by facts
- Defining relations by rules
- Recursive rules
- How Prolog answers questions
- Declarative and procedural meaning of programs

1.1 Defining relations by facts

- The fact that "Tom is a parent of Bob" can be written in Prolog as:
- parent(tom,bob).
- parent is the relation
- tom and bob are its arguments

A Family Tree



Prolog Program for the previous family tree

```
parent(pam,bob).
parent(tom,bob).
parent(tom,liz).
parent(bob,pat).
parent(bob,ann).
parent(pat,jim).
```

Clauses

- A clause declares one fact about a relation

For example,

- parent(tom,bob) is a particular instance of the parent relation
- an instance is also called a relationship
- a relation is defined as the set of all its instances

Question to Prolog

For example,

- Is Bob a parent of Pat?

In Prolog,

- ?- parent(bob,pat).

Prolog will answer:

- yes

More questions

A further query can be:

- ?- parent(liz,pat).

Prolog answers:

- no

More questions continue ---

Who is Liz's parent?

- ?- parent(X,liz).

So the answer is:

- X = tom

More questions continue ---

Who are Bob's children?

- ?- parent(bob,X).

The first answer is:

- X = ann

The another answer follows:

- X = pat

Broader Questions --

Who is a parent of whom?

In other words,

- Find X and Y such that X is a parent of Y.

In Prolog,

- ?- parent(X,Y).

Broader Questions Continue ---

The answers are output as:

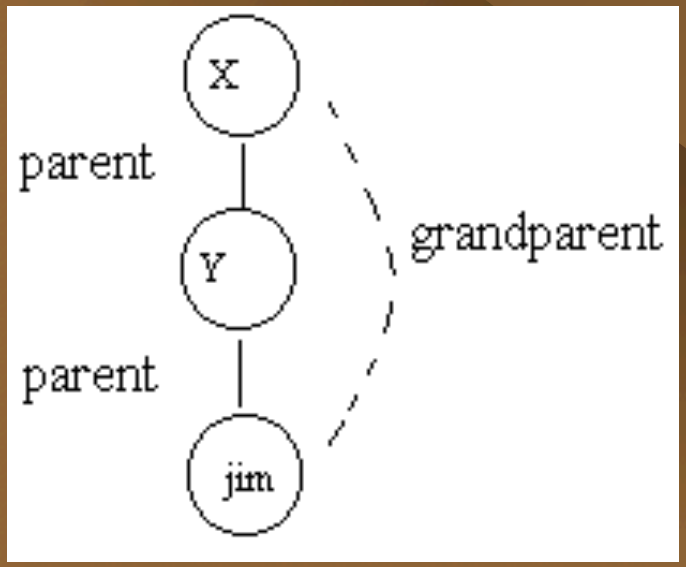
- X = pam
- Y = bob;

- X = tom
- Y = bob;

- X = tom
- Y = liz;
- ...

Composed Query in Prolog

- Who is a grandparent of Jim?



Composed Query in Prolog Continue --

To find a grandparent, we need two steps:

- Who is a parent of jim? Assume that there is some Y.
- Who is a parent of Y? Assume that there is some X.

In Prolog,

- ?- parent(Y, jim), parent(X,Y).

Composed Query in Prolog Continue --

Who are Tom's grandchildren?

- ?- parent(tom,X), parent(X,Y).

Do Ann and Pat have a common parent?

- ?- parent(X,ann), parent(X,pat).

Important Points

- Easy to define a relation, by stating the n-tuples of objects that satisfy the relation such as parent
- Easy to query the Prolog system about relations defined in the program
- A Prolog program consists of clauses. Each clause terminates with a full stop
- Arguments of relations can be concrete objects, or constants (such as tom and ann), or general objects such as X and Y

Important Points Continue ---

- Concrete objects or constants are called atoms and general objects are called variables
- Questions to the system consist of one or more goals that are to be satisfied in the program such as: ?- parent(X,ann), parent(X,pat).
- Answer can be positive (if satisfiable) or negative (if unsatisfable)
- If several answers satisfy the question then Prolog will find as many of them as desired by the user

1.2 Defining relations by rules

More relations

Unary relations	Binary relations
female(pam).	sex(pam,feminine).
male(tom).	sex(tom,masculine).
male(bob).	sex(bob,masculine).
female(liz).	sex(liz,feminine).
…	...

Unary relations are simple yes / no properties of objects.

More Relations

Example

- to define a relation offspring as the inverse of the parent relation as a fact
- offspring(liz, tom) is inverse of parent(tom, liz)

It is understood as

Liz is an offspring of Tom if Tom is a parent of Liz.

In general, we can say that

Y is an offspring of X if X is a parent of Y.

Relations are Defined Elegantly

- to define offspring relation using already defined parent relation

For all X and Y,

Y is an offspring of X if X is a parent of Y.

In Prolog,

- offspring(Y,X) :- parent(X,Y).

What is Rules?

For all X and Y,

if X is a parent of Y then

Y is an offspring of X

In Prolog,

- offspring(Y,X) :- parent(X,Y).

  is called a Rule.

Difference between facts and rules

- A fact like parent(tom,liz) is something always, unconditionally true.
- On the other hand, rules specify things that are true if some condition is satisfied.

Rules have

- body, a condition part (the right-hand side of the rule) and
- head, a conclusion part (the left-hand side of the rule)

The format is

```
offspring(Y,X)  :-  parent(X,Y).
-----------------      --------------
      head                 body
```

More Rules

To define mother relation by rule

For all X and Y,

X is the mother of Y if

X is a parent of Y and

X is a female.

In Prolog,

- mother(X,Y) :- parent(X,Y), female(X).

More Rules Continue ---

To define grandparent relation by rule

For all X and Y,

X is a grandparent of Y if

X is a parent of Z and

Z is a parent of Y.

In Prolog,

```
grandparent(X,Y) :-
        parent(X,Z),
        parent(Z,Y).
```

More Rules Continue ---

How do we define sister relation?

For all X and Y,

X is a sister of Y if

both X and Y have the same parent, and

X is a female.

In Prolog,

```
sister(X,Y) :-
        parent(Z,X),
        parent(Z,Y),
        female(X).
```

Question to prolog

Who is pat’s sister?

In Prolog,

- ?- sister(X,pat).

The answer to the previous program

- X = ann
- X = pat

- We need to modify the program since pat is a sister of herself

Some Important Points, So Far

- Prolog program can be added new clauses
- Clauses are of three types: facts, rules, and questions
- Facts declare things that are always, unconditionally true
- Rules declare things that are true depending on a given condition
- Questions are to be asked by the user

More Important Points

- Clauses consists of head and body
- Body is a list of goals separated by commas
- Facts have a head and the empty body
- Questions only have the body
- Rules have the head and the non-empty body
- A variable can be substituted by another object, that is called, variable is instantiated