KIIS: Artificial Intelligence and Intelligent Systems
Lecture 11 sep 2007
Henning Christiansen

More Prolog

Hacks and features of Prolog making it into a full programming language:

- General data structures and lists
- Control facilities
- Arithmetic in Prolog
- Syntactic extensibility: Operator notation
- (Self-inspection and modification)

That's really all of it!

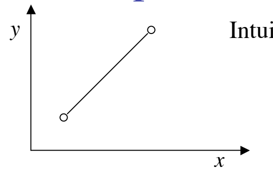
Basic notions, now adding *structures*

- *predicates:* **`parent`**
  - defines a *relation*
  - given by *facts*, *rules*, coll. called *clauses*
- *constants:* **`tom`**, **`bob`**, **`x`**, **`y`**
- *variables*: **`X`**, **`Y`**, **`Tom`**
- *atoms:* **`parent(A,a)`**
- Arguments to predicates can also be *structures:*

```
point(1,1)
line_segment(point(1,1),point(
```

NB: Looks like pred's with arguments, ...

An example of using structures



Intuitive interpretation of structure:

```
line_segment(point(1,1),point(3,3))
```

How many lines of Java is needed to produce a similar functionality????

This is a program:

```
vertical(   line_segment(point(X,Y), point(X,Y1))).
horizontal( line_segment(point(X,Y), point(X1,Y))).
```

Querying it:

```
?- vertical(line_segment(point(1,1),point(2,Y))).
no
?- horizontal(line_segment(point(1,1),point(2,Y))).
Y = 1 ?
```

Lists, an important sort of structures

List syntax ≈ syntactic sugar; no new semantics

```
?- write([1,2,3,4,5,6]).
[1,2,3,4,5,6]
?- write_canonical([1,2,3,4,5,6]).
'.'(1,'.'(2,'.'(3,'.'(4,'.'(5,'.'(6,[]))))))
?- [1,2,3,4,5,6] = [Head | Tail].
Head = 1, Tail = [2,3,4,5,6]
?- [First, Second | Tail2] = [a,b,c,d,e,f].
First = a, Second = b, Tails = [c,d,e,f]
```

Working with lists; the member predicate

A built-in predicate; in SICStus (v. 3, not 4, sic!) remember this:

```
:- use_module(library(lists)).

?- member(a,[a,b,c]).
yes
```

Member is also a list *constructor:*

```
?- member(a,L), member(b,L), member(c,L).
L = [a,b,c|_A]
```

Implementation of member

```
member(X, [X | _] ).

member(X, [_|L]):- member(X,L).
```

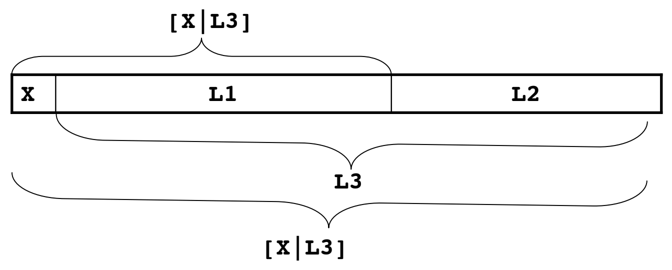
"**append**": List concat'n & decomp'n

Examples:

```
?- append([a,b],[c,d], L).

L = [a,b,c,d]


?- append(X,Y,[a,b,c]).

X = [], Y = [a,b,c] ? ;
X = [a], Y = [b,c] ? ;
X = [a,b], Y = [c] ? ;
X = [a,b,c], Y = [] ? ;
```

A definition of "**append**"

```
append([], L, L).

append([X|L1], L2, [X|L3]):- append(L1, L2, L3).
```



Arithmetic, a stepchild in Prolog

```
?- X is 2 + 2 * 3.

X = 8 ?

?- X is 2 + Y * 3.

! Instantiation error in argument 2 of is/2
! goal:  _79 is 2+_73*3
```

Remember points about
• range-restrictedness
• left-to-right execution

Exercises

- 5.1, p. 46
- 5.2, p. 46–47.
  - Only triangles, **`identical_triangles`**, **`segment_length`** and possibly **`area(`**<triangle>**`,`** <length>**`)`**
- 5.3, p.47.
- Extra: Define, using append, a predicate **`find_abc(L)`**, which is satisfied iff **`[a,b,c]`** is a “sublist” of **`L`**, e.g.

```
?- find_abc([k,l,m,n,a,b,c,d,e])
yes
?- find_abc([k,l,m,n,a,b,z,z,c,d,e])
no
```

(can be done with just *one* call to **`append`**)

Useful built-ins (use with care)

... optimization for special cases

`var(`*arg***`)`**	— argument *currently* uninstantiated?
`nonvar(`*arg***`)`**	— the opposite
`ground(`*arg***`)`**	— is *current* value of arg ground, i.e., variable-free?
`atom(`*arg***`)`**	— *current* value constant that is not a number?
`integer(`*arg***`)`**	— *current* value an integer number?
`atomic(`*arg***`)`**	— *current* value a constant?

Splitting terms by "=.."

Useful for translating one program into another...

```
?- f(a,b) =.. [F|Args].
F = f, Args = [a,b]
?- f(a,b) =.. [F|Args], NewTerm =.. [F,new|Args].
..., NewTerm = f(new,a,b)
```

Control of backtracking by "**!**" (cut)

```
salary(S, 0):- student(S), !.
salary(S, 1000000).
student(peter).

?- salary(peter,S).
S = 0 ;
no
?- salary(jane, S).
S = 1000000 ;
no
```

But trying to generate all solution :(

```
?- salary(X,S).
X = peter, S = 0 ;
no
```

Be careful:
- Destroys logic
- Introduces assumptions about how predicates are called

Conditionals

```
salary(X,S):-
  student(X) -> S=0
  ;
  director(X) -> S=1000000
  ;
  professor(X) -> S=500000
  ;
  S = 10.
```

Like a "soft-cut", successful-test-and-choice not backtracked,
but subsequent clause may be used.

Operators: Extensible syntax

```
:- op(700, xfx, sparker).
manden sparker hunden.
:- op(700, xfx, bider).
X bider Y :-  Y sparker X.
```

Important: Only syntactic sugar, no new semantics

```
?- current_op(X, Y, Z).
X = 1200, Y = xfx, Z = :- ? ;
X = 1200, Y = xfx, Z = --> ? ;
...
X = 1000, Y = xfy, Z = ',' ? ;
...
X = 500, Y = yfx, Z = + ? ;
...
X = 400, Y = yfx, Z = * ? ;
```

Example of program with operators

```
:- op(700, xfx, er).
:- op(100, fx, [en,et]).
en mand er et menneske.
en kvinde er et menneske.
et menneske er et dyr.
en ko er et dyr.
peter er en mand.
X er Z :- X er Y, Y er Z.
```

Other facilities

Generating all solutions:

`setof`, **`bagof`**, **`findall`**

— read about them when you need them

Input-output:

`write('Hello')` useful for test prints...

Inspecting and modifying the program

`clause`, **`asserta`**, **`assertz`**, **`retract`**

We may see those guys later in the course

This is really all of Prolog!