Recursion in Prolog. Compound terms

Alex Muscar

Software Engineering Department
Faculty of Automation, Computers and Electronics
University of Craiova

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Compound terms

Definition

Compound terms are composed of an atom called *functor* and a sequence of one or more terms called *arguments*.

The functor acts as the name of the compound term.
Note: The arguments can be themselves compound terms.

Examples of compound terms

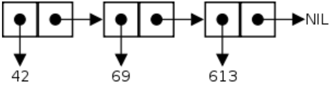
Example of a structure defining a person and of the predicates to extract the information.

Example

```
% A compound term defining a person with a name and
% a location
person('Alex', location(craiova, romania)).
% Name extractor
name(person(Name, _), Name).
% Location extractor
location(person(_, Location), Location).
% City extractor
city(person(_, location(City, _)), City).
```

Examples of compound terms (cont'd)

Compound terms can be used to define complex data structures such as linked lists.

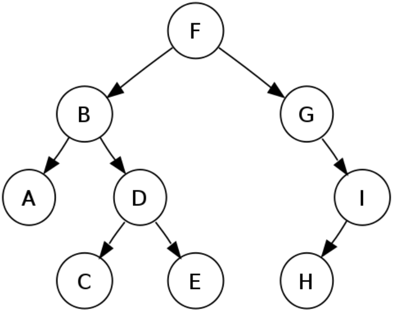


Example

```
cons(42, cons(69, cons(613, nil))).
```

Examples of compound terms (cont'd)

Compound terms can be used to define complex data structures such as trees.



Examples of compound terms (cont'd)

Example

```
node(f,
    node(b,
        node(a, leaf, leaf),
        node(d,
            node(c, leaf, leaf),
            node(e, leaf, leaf))),
    node(g,
        leaf,
        node(i,
            node(h, leaf, leaf),
            leaf)))
```

Recursion

While defining some rules it is sometimes necessary to refer to the rule we are defining.
Such rules are called *recursive* predicates.
Where you would use a loop (e.g. *for*, *while*) in an imperative language, in Prolog you use a recursive predicate.

Recursion scheme

A recursive predicate usually has:

base case acts as a termination condition

Recursion scheme

A recursive predicate usually has:

- base case acts as a termination condition
- recursive case the main part of the predicate

Note: in some cases the base case is not mandatory since the termination condition can be checked in other ways.

Recursion scheme

The basic shape of a recursive predicate in Prolog:

Example

```
predicate($t_1$, ..., $t_n$).
predicate($t_1$, ..., $t_n$) :-
    $g_1$, ..., $g_n$.
```

Recursion example

Assuming we have a knowledge base with the appropriate predicates and we wanted to find the ancestor of a person X we could (naively) go about it like this:

Example

```
ancestor(X, Y) :-  parent(X, Y).
ancestor(X, Y) :-
    parent(X, A1), parent(A1, Y).
ancestor(X, Y) :-
    parent(X, A1), parent(A1, A2), parent(A2, Y).
...
ancestor(X, Y) :-
    parent(X, A1), ..., parent(AN, Y).
```

Recursion example (cont'd)

We could define the ancestor relation as:

Definition

1. X is the ancestor of Y if X is a direct parent of Y

Recursion example (cont'd)

We could define the ancestor relation as:

Definition

1. X is the ancestor of Y if X is a direct parent of Y
2. X is the ancestor of Y if X is a direct parent of Z and Z is the ancestor of Y

Recursion example (cont'd)

Example

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

Tail recursion

Often recursive implementations are not as efficient as iterative ones.

This happens because recursion wastes stack space.

The solution is to use *tail recursion* implemented by *tail calls*.

Tail calls

Definition

A tail call is a call in the tail position of the recursive rule.

Tail calls allow for efficient implementations of recursive predicates.
Note: the *ancestor* predicate we defined earlier is tail recursive.
Note: sometimes in order to make a predicate tail recursive we can use accumulators.

Tail calls

The basic shape of a tail recursive predicate in Prolog:

Example

```
predicate($t_1$, ..., $t_n$).
predicate($t_1$, ..., $t_n$) :-
    $g_1$, ..., $g_n$, predicate($u_1$, ..., $u_n$).
```

Resources

- http://www.doc.gold.ac.uk/~mas02gw/prolog_tutorial/prologpages/recursion.html
- http://www.cse.unsw.edu.au/~billw/cs9414/notes/write-recursive-proc.html