Prolog: Bits and Pieces

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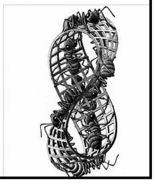
Backtracking (again)

- Backtracking = systematic search for alternatives
- Backtracking + recursion replace:
  - iteration (for/while/repeat structure)
  - recursion

in imperative languages



Example: Simple Bubble Sort

```
proc Bubsort(var L : intarray);
   interchanged := true;
   while interchanged do
      interchanged := false;
      i := 1;
      while (i < n) and not interchanged do
         if L[i] > L[i+1] then
             temp := L[i];
             L[i] := L[i+1];
             L[i+1] := temp;
             interchanged := true
         else i := i + 1
      end
   end
end;
```

Bubble Sort in Prolog

```
bubsort(L, S) :-                    conc([], L, L).
   conc(X, [A, B|Y], L),            conc([X|U],V,[X|W]) :-
   B < A,                              conc(U, V, W).
   conc(X, [B, A|Y], M), !,
   bubsort(M, S).
bubsort(L, L).
```

```
        ?- bubsort([2, 3, 1], S).
①      bubsort([2, 3, 1], S) :-
           conc([], [2, 3|[1]], [2, 3, 1]),
back-      3 < 2,
track      conc([], [3, 2|[1]], [3, 2, 1]), !,
           bubsort([3, 2, 1], S).
        bubsort(L, L).
```

Bubble Sort: Next Pair

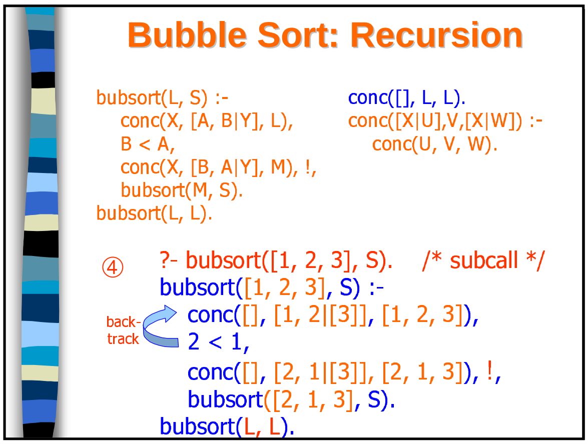
```
bubsort(L, S) :-                    conc([], L, L).
   conc(X, [A, B|Y], L),            conc([X|U],V,[X|W]) :-
   B < A,                              conc(U, V, W).
   conc(X, [B, A|Y], M), !,
   bubsort(M, S).
bubsort(L, L).
```

```
     ?- bubsort([2, 3, 1], S).
     bubsort([2, 3, 1], S) :-
②      conc([2], [3, 1|[]], [2, 3, 1]),
        1 < 3,
        conc([2], [1, 3|[]], [2, 1, 3]), !,
        bubsort([2, 1, 3], S).
     bubsort(L, L).
```

Bubble Sort: Recursion

```
bubsort(L, S) :-                    conc([], L, L).
   conc(X, [A, B|Y], L),            conc([X|U],V,[X|W]) :-
   B < A,                              conc(U, V, W).
   conc(X, [B, A|Y], M), !,
   bubsort(M, S).
bubsort(L, L).
```

```
③   ?- bubsort([2, 1, 3], S).   /* subcall */
     bubsort([2, 1, 3], S) :-
        conc([], [2, 1|[3]], [2, 1, 3]),
        1 < 2,
        conc([], [1, 2|[3]], [1, 2, 3]), !,
        bubsort([1, 2, 3], S).
     bubsort(L, L).
```

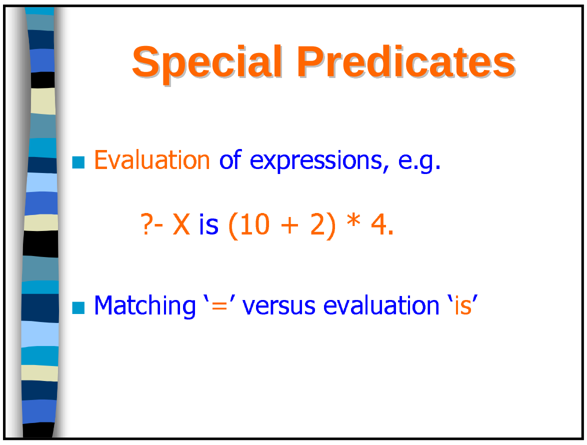


Bubble Sort: Recursion

```
bubsort(L, S) :-
    conc(X, [A, B|Y], L),
    B < A,
    conc(X, [B, A|Y], M), !,
    bubsort(M, S).
bubsort(L, L).
```

```
conc([], L, L).
conc([X|U],V,[X|W]) :-
    conc(U, V, W).
```

```
④      ?- bubsort([1, 2, 3], S).    /* subcall */
       bubsort([1, 2, 3], S) :-
back-      conc([], [1, 2|[3]], [1, 2, 3]),
track      2 < 1,
           conc([], [2, 1|[3]], [2, 1, 3]), !,
           bubsort([2, 1, 3], S).
       bubsort(L, L).
```

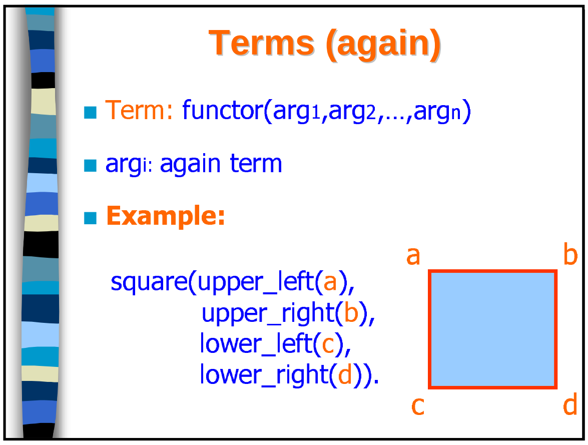


Special Predicates

- Evaluation of expressions, e.g.

  ?- X is (10 + 2) * 4.

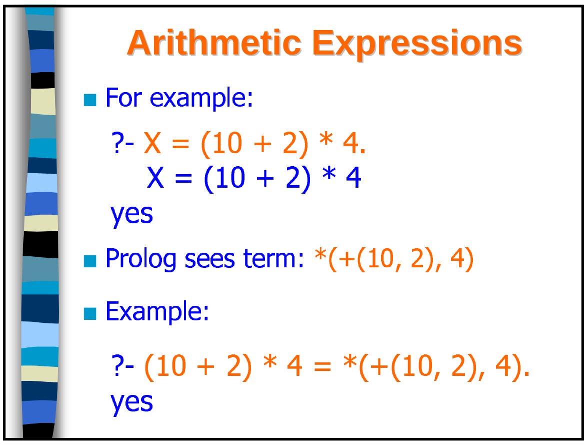
- Matching '=' versus evaluation 'is'



Terms (again)

- Term: functor(arg1,arg2,…,argn)
- argi: again term
- **Example:**

```
square(upper_left(a),
       upper_right(b),
       lower_left(c),
       lower_right(d)).
```



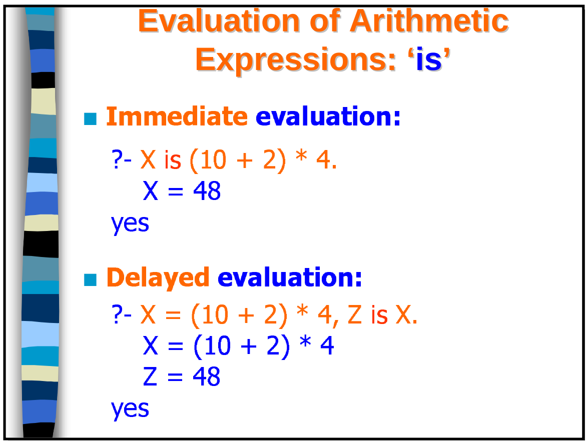
Arithmetic Expressions

- For example:

```
?- X = (10 + 2) * 4.
   X = (10 + 2) * 4
yes
```

- Prolog sees term: *(+(10, 2), 4)
- Example:

```
?- (10 + 2) * 4 = *(+(10, 2), 4).
yes
```



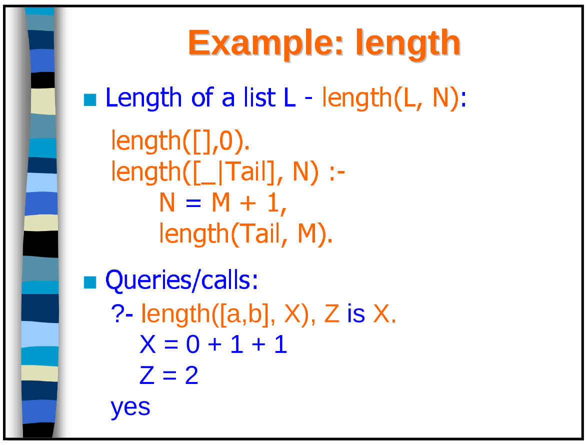
Evaluation of Arithmetic Expressions: 'is'

- **Immediate evaluation:**

```
?- X is (10 + 2) * 4.
   X = 48
yes
```

- **Delayed evaluation:**

```
?- X = (10 + 2) * 4, Z is X.
   X = (10 + 2) * 4
   Z = 48
yes
```



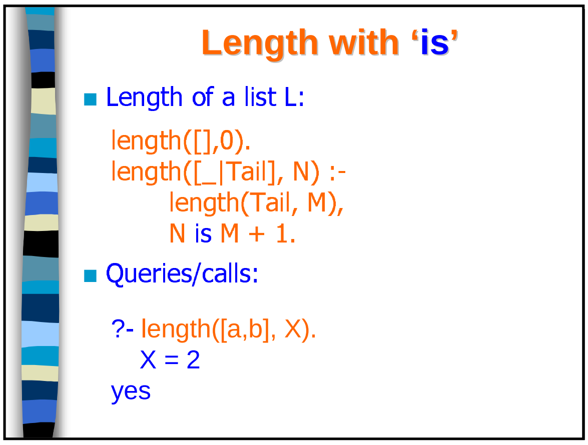
Example: length

- Length of a list L - length(L, N):

```
length([],0).
length([_|Tail], N) :-
    N = M + 1,
    length(Tail, M).
```

- Queries/calls:

```
?- length([a,b], X), Z is X.
   X = 0 + 1 + 1
   Z = 2
yes
```



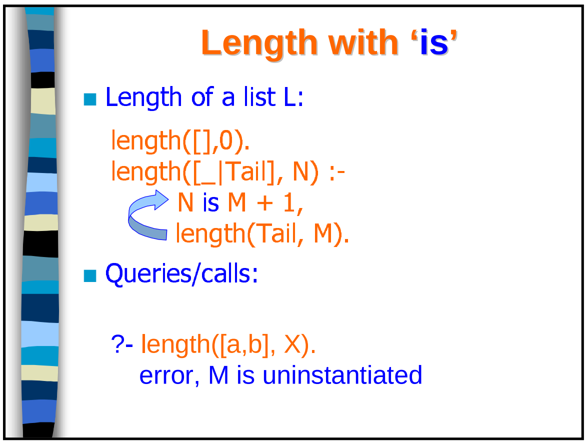
Length with ‘is’

- Length of a list L:

```
length([],0).
length([_|Tail], N) :-
        length(Tail, M),
        N is M + 1.
```

- Queries/calls:

```
?- length([a,b], X).
    X = 2
yes
```



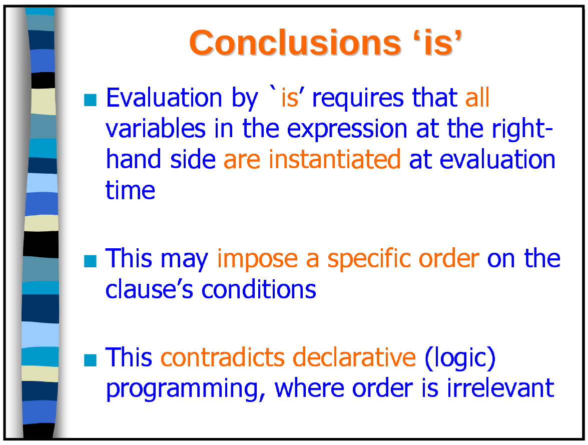
Length with ‘is’

- Length of a list L:

```
length([],0).
length([_|Tail], N) :-
         N is M + 1,
         length(Tail, M).
```

- Queries/calls:

```
?- length([a,b], X).
    error, M is uninstantiated
```



Conclusions ‘is’

- Evaluation by `is’ requires that all variables in the expression at the right-hand side are instantiated at evaluation time
- This may impose a specific order on the clause’s conditions
- This contradicts declarative (logic) programming, where order is irrelevant