Programming Paradigms

Unit 7 — Debugging and the Box Model

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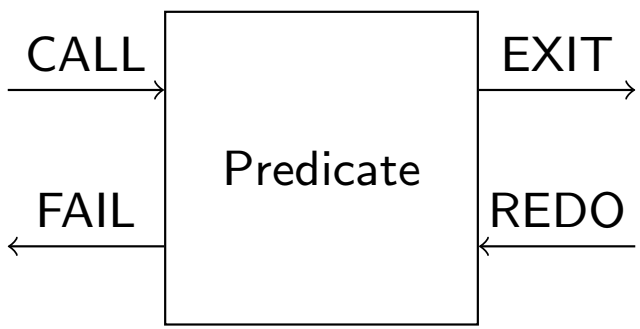
The Box Model

- The box model of Prolog execution provides a simple way to show the control flow
- A box represents the invocation of a single predicate
- The box has four ports (with associated events)
  - CALL: The first call of a predicate; control enters into the box
  - EXIT: The goal has been proven
  - REDO: The system comes back to a goal, trying ot re-satisfy it, i.e., backtracking
  - FAIL: The goal/predicate fails



Debugging

- The box model is used to debug the execution of Prolog programs
- Predicate `trace/0` starts the exhaustive tracing mode
  - `notrace/0` stops the tracing mode
- The debugger then displays a line for every port and waits for a command
  - With `Return` or `c` ("creep") one steps to the next port
  - The command `a` (abort) stops the execution of the query
- Other debugger commands are available
  - Usually displayed when entering `?` or `h`

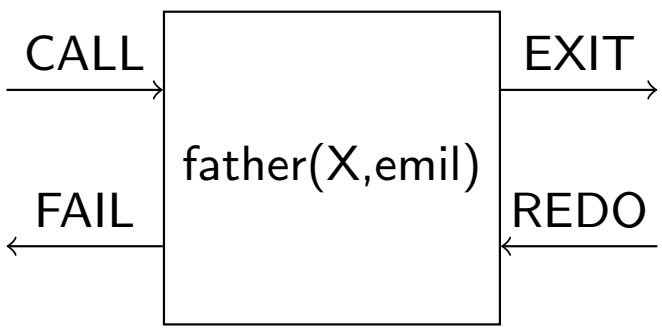
The Box Model Example/1

- Consider the following facts (e.g., `emil` is the father of `jan`)

```
father(jan,emil).
father(julia,emil).
father(emil,arno).
```

- The goal `trace/0` activates "tracing"

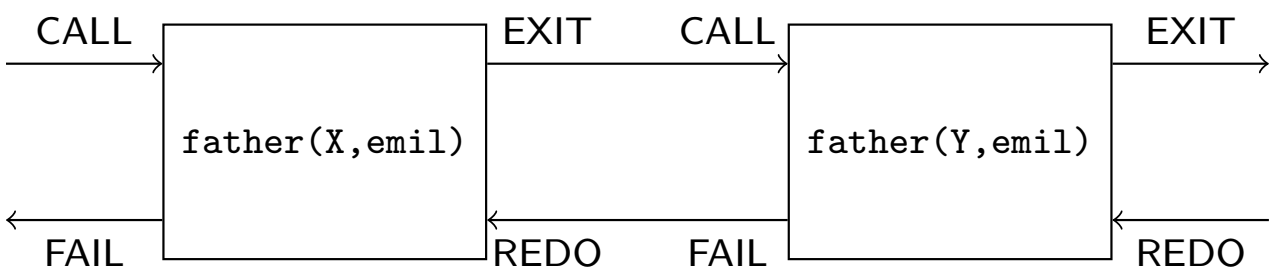
```
?- trace, father(X,emil).
Call:  father(_16,emil) ?
Exit:  father(jan,emil) ?
X = jan ?  ;

Redo:  father(jan,emil) ?
Exit:  father(julia,emil) ?
X = julia.
```



Concatenation of Boxes

- A conjunction of two predicates is represented by two connected boxes
  - The EXIT port of the first box is connected to the CALL port of the second port
  - The FAIL port of the second box is connected to the REDO port of the first port
- Consider the following goal consisting of two predicates

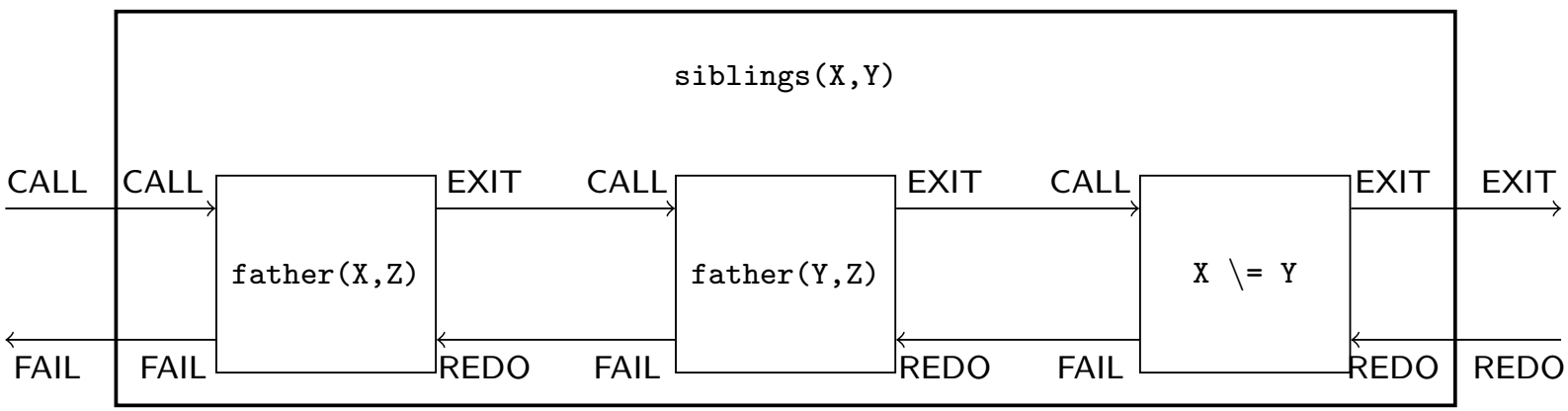
```
?- father(X,emil), father(Y,emil).
```



Nesting Boxes

- Rules are represented by nexted boxes
  - The head of the rule is represented by an outer box
  - The body of the rule is represented by one or more inner boxes
  - Each port of the outer box is connected to the corresponding port of the inner box
- Consider the following rule

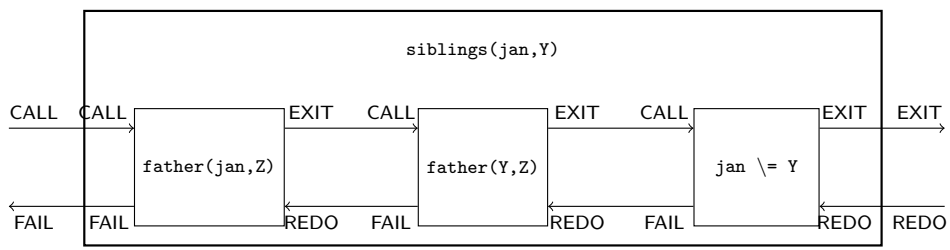
```
siblings(X,Y) :- father(X,Z),
                 father(Y,Z),
                 X \= Y.
```



The Box Model Example/2

```
?- trace, siblings(jan, Y).
(1) 0 CALL siblings(jan, Y) ?
(2) 1 CALL father(jan, Z) ?
(2) 1 EXIT father(jan, emil) ?
(3) 1 CALL father(Y, emil) ?
(3) 1 *EXIT father(jan, emil) ?
(4) 1 CALL jan \= jan ?
(4) 1 FAIL jan \= jan?
(3) 1 REDO father(Y, emil) ?
(3) 1 EXIT father(julia, emil) ?
(5) 1 CALL julia \= jan ?
(5) 1 EXIT julia \= jan ?
(1) 0 EXIT siblings(jan, julia) ?
X = julia ?  ;
(1) 1 REDO: siblings(jan, julia) ?
(3) 2 REDO: father(julia, emil) ?
(3) 2 FAIL: father(Y, emil) ?  c
(1) 1 FAIL: siblings(jan, Y) ? c
no
```

```
father(jan,emil).
father(julia,emil).
father(emil,arno).

siblings(X,Y) :- father(X,Z),
                 father(Y,Z),
                 X \= Y.
```



Remarks about the Box Model

- The exact form of the output depends on the Prolog system
- The above output contains a box number in the first column and a nesting depth (call stack depth) in the second column
- The asterisc "*" before EXIT marks that there are possibly further solutions (nondeterministic exit)
  - Otherwise, the box is already removed, and not visited during backtracking (i.e., no REDO-FAIL will be shown)
  - Because of such optimizations, the debugger output might violate the pure four-port model.
- Tracing is switched on by the predicate `trace/0` and switched off by the predicate `notrace/0`.
- Another useful debugging predicate is `spy/1`, which allows to specify specific subgoals, for which the user wants to obtain detailed information of the box model

Spy Points/1

- Tracing is doing exhaustive debugging of all subgoals
- Another useful debugging predicate is `spy/1`
  - Allows to inspect the execution for selected subgoals only
- The following predicate sets a "syp point" on the predicate `father/2`

```
?- spy(father/2).
```

- If the `debug` predicate is now used, Prolog executes the program without interruption until the first spypoint is reached
- Then one can continue debugging as with `trace` or "leap" to the next spy point (usually with the command `l`)
- `nodebug` stops the debugger, `nospy` removes the spy points

Spy Points/2

- The debugger output for the query `debug, siblings(jan,Y)` after setting a spy point for `father/2`

```
?- debug, siblings(jan,Y).
* Call:  (8) father(jan, _G3270) ?  creep
* Exit:  (8) father(jan, emil) ?  creep
* Call:  (8) father(_G3159, emil) ?  creep
* Exit:  (8) father(jan, emil) ?  creep
Call:  (8) jan\=jan ?  creep
Fail:  (8) jan\=jan ?  creep
* Redo:  (8) father(_G3159, emil) ?  creep
* Exit:  (8) father(julia, emil) ?  creep
Call:  (8) jan\=julia ?  creep
Exit:  (8) jan\=julia ?  creep
Exit:  (7) siblings(jan, julia) ?  creep
Y = julia.
```

- Notice that the CALL port of `sibling` is not shown!

Spy Points/3

- The comand `leap` jumps to the next spy point

```
?- debug, siblings(jan,Y).
* Call:  (8) father(jan, _G1003) ?  leap
* Exit:  (8) father(jan, emil) ?  leap
* Call:  (8) father(_G889, emil) ?  leap
* Exit:  (8) father(jan, emil) ?  leap
* Exit:  (8) father(julia, emil) ?  leap
Y = julia.
```