Concepts of programming languages

Prolog

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Proof Search

- The manner in which a query is handled
- Knowledge Database is read from top to bottom
- Tries to unify with facts and heads of rules
- At first valid encounter, unification is carried out
- Variables are replaced by internal variables (e.g. _G2145)
- A search is done in a depth first fashion in a tree-shaped structure

Backtracking

- When a search path is not valid, **backtracking** occurs: Traversing the tree in opposite direction until a variable binding (choise point) is reached
- If a result is found, one can choose to continue the search by using backtracking, using the **;** command

A simple example (1)

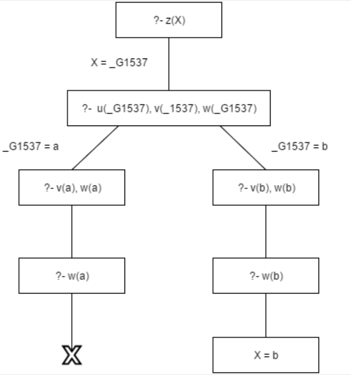
Knowledge database:

```
u(a).
u(b).
v(a).
v(b).
w(b).
z(X):-u(X),v(X),w(X).
```

Figure 1: Knowledge database

A simple example (2)

```
[trace] 6 ?- z(X).
   Call: (7) z(_G1537) ? creep
   Call: (8) u(_G1537) ? creep
   Exit: (8) u(a) ? creep
   Call: (8) v(a) ? creep
   Exit: (8) v(a) ? creep
   Call: (8) w(a) ? creep
   Fail: (8) w(a) ? creep
   Redo: (8) u(_G1537) ? creep
   Exit: (8) u(b) ? creep
   Call: (8) v(b) ? creep
   Exit: (8) v(b) ? creep
   Call: (8) w(b) ? creep
   Exit: (8) w(b) ? creep
   Exit: (7) z(b) ? creep
X = b.
```



A more complicated example (1)

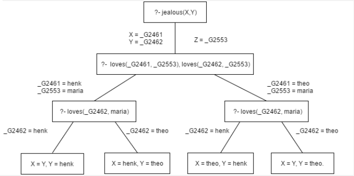
Knowledge database:

```
loves(henk, maria).
loves(theo, maria).
jealous(X,Y):-loves(X,Z),loves(Y,Z).
```

Figure 2: Knowledge database

A more complicated example (2)

```
[trace] 13 ?- jealous(X,Y).
   Call: (7) jealous(_G2461, _G2462) ? creep
   Call: (8) loves(_G2461, _G2553) ? creep
   Exit: (8) loves(henk, maria) ? creep
   Call: (8) loves(_G2462, maria) ? creep
   Exit: (8) loves(henk, maria) ? creep
   Exit: (7) jealous(henk, henk) ? creep
X = Y, Y = henk ;
   Redo: (8) loves(_G2462, maria) ? creep
   Exit: (8) loves(theo, maria) ? creep
   Exit: (7) jealous(henk, theo) ? creep
X = henk,
Y = theo ;
   Redo: (8) loves(_G2461, _G2553) ? creep
   Exit: (8) loves(theo, maria) ? creep
   Call: (8) loves(_G2462, maria) ? creep
   Exit: (8) loves(henk, maria) ? creep
   Exit: (7) jealous(theo, henk) ? creep
X = theo,
Y = henk ;
   Redo: (8) loves(_G2462, maria) ? creep
   Exit: (8) loves(theo, maria) ? creep
   Exit: (7) jealous(theo, theo) ? creep
X = Y, Y = theo.
```



A more complicated example (3)

- Results are not always as expected
- jealous(X,Y):

```
3 ?- jealous(X,Y)
X = Y, Y = henk ;
X = henk,
Y = theo ;
X = theo,
Y = henk ;
X = Y, Y = theo.
```

Figure 3: jealous(X,Y)

- jealous(X,X)

```
1 ?- jealous(X,X)
|    .
X = henk ;
X = theo.
```

Figure 4: jealous(X,X)

Powerful basis for logical inference

- Combining unification and backtracking into search trees results in a fast tool for logical inference
- Understanding of underlying concepts is important to understand results produced
- Various implementations might grant diffrent results, when cosidering a query like:

```
?- father(X) = X
```