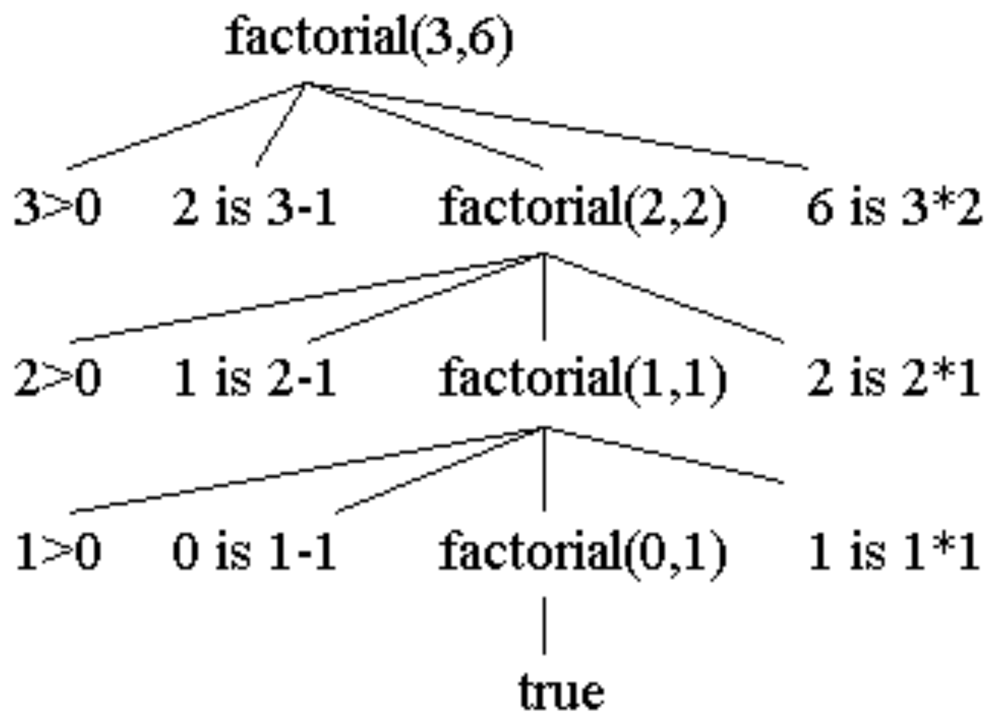
Clause Tree

- Clause tree
  - Shows (recursive) evaluation of all clauses
  - Shows value (instance) of variable for each clause
  - Clause tree is true if all leaves are true
- Factorial example

```
factorial(0,1).
factorial(N,F) :-
        N > 0,
        N1 is N-1,
        factorial(N1,F1),
        F is N*F1.
```



Tracing

- trace lets you step through a goal's execution
  - notrace turns it off

```
① my_last(X, [X]).

② my_last(X, [_|T]) :-
        my_last(X, T).
```

```
?- trace.
true.

[trace]  ?- my_last(X, [1,2,3]).
② Call: (6) my_last(_G2148, [1, 2, 3]) ? creep
② Call: (7) my_last(_G2148, [2, 3]) ? creep
① Call: (8) my_last(_G2148, [3]) ? creep
   Exit: (8) my_last(3, [3]) ? creep
   Exit: (7) my_last(3, [2, 3]) ? creep
   Exit: (6) my_last(3, [1, 2, 3]) ? creep
X = 3
```

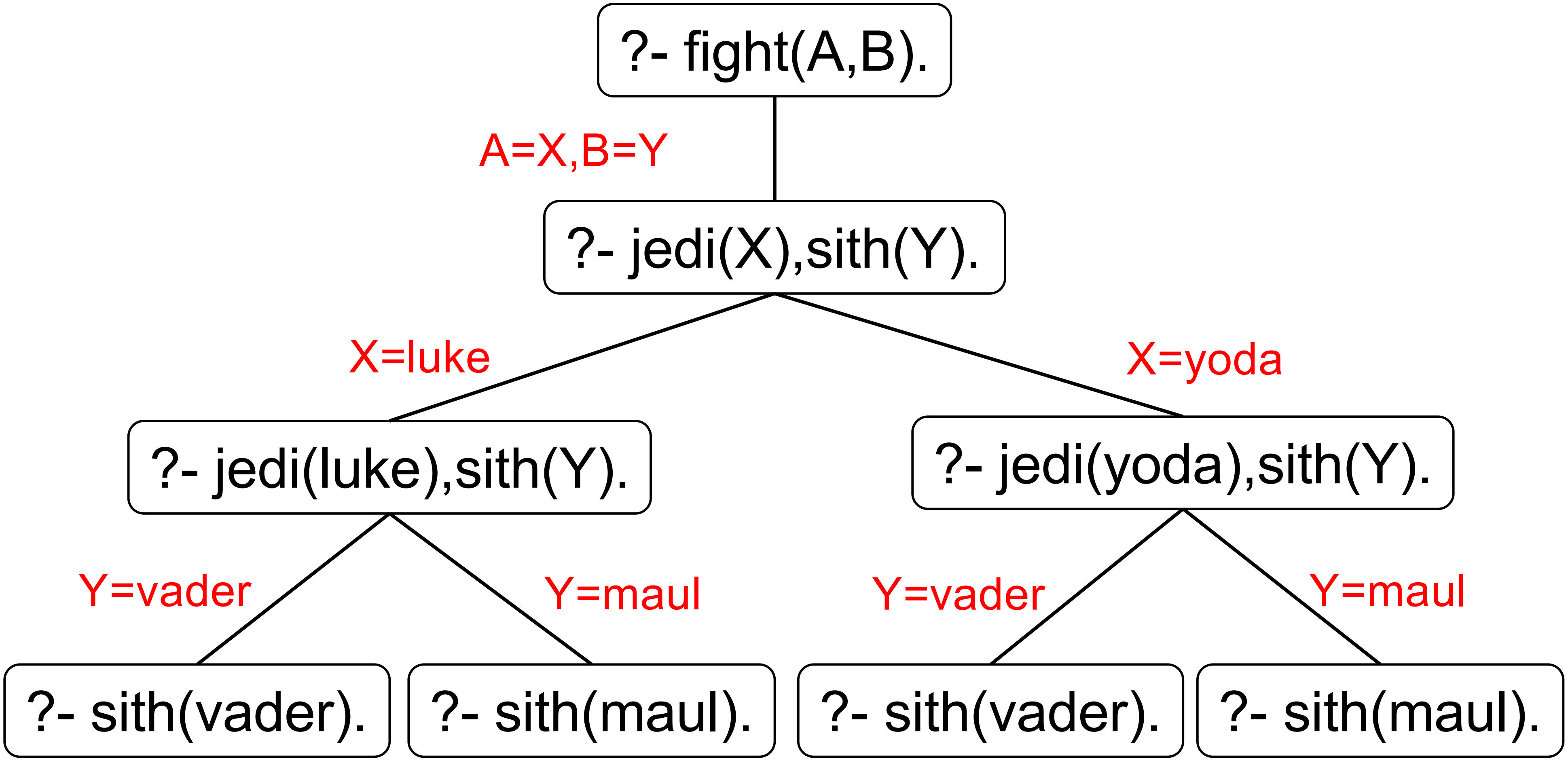
Goal Execution – Backtracking

- Clauses are tried in order
- If clause fails, try next clause, if available
- Example

```
jedi(luke).
jedi(yoda).
sith(vader).
sith(maul).
fight(X,Y) :- jedi(X), sith(Y).
```

```
?- fight(A,B).
A=luke,
B=vader;
A=luke,
B=maul;
A=yoda,
B=vader;
A=yoda,
B=maul.
```

Prolog (Search / Proof / Execution) Tree



Lists In Prolog

- [a, b, 1, ‘hi’, [X, 2]]
- But really represented as compound terms
  - [ ] is an atom
  - [a, b, c] is represented as .(a, .(b, .(c, [])))
- Matching over lists

```
?- [X, 1, Z] = [a, _, 17]
X = a,
Z = 17.
```

List Deconstruction

- Syntactically similar to Ocaml: [H|T] like h::t

```
?- [Head | Tail] = [a,b,c].
Head = a,
Tail = [b, c].

?- [1,2,3,4] = [ _, X | _].
X = 2
```

- This is sufficient for defining complex predicates
- Let's define concat(L1, L2, C)

```
?- concat([a,b,c], [d,e,f], X).
X = [a,b,c,d,e,f].
```

Example: Concatenating Lists

- To program this, we define the "rules" of concatenation
  - If L1 is empty, then C = L2

    ```
    concat( [ ], L2, L2 ).
    ```

  - Prepending a new element to L1 prepends it to C, so long as C is the concatenation of L1 with some L2

    ```
    concat( [E | L1], L2, [E | C] ) :-
       concat(L1, L2, C).
    ```

- … and we're done

Why Is The Return Value An Argument?

- Now we can ask what inputs lead to an output

```
?- concat(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 = [ ] ;
```

User types ; to request additional answers

More Syntax: Built-in Predicates

- Equality (a.k.a. unification)

  X = Y   f(1,X,2) = f(Y,3,_)
- fail and true
- "Consulting" (loading) programs

  ?- consult('file.pl')   ?- ['file.pl']
- Output/Input

  ?- write('Hello world'), nl   ?- read(X).
- (Dynamic) type checking

  ?- atom(elephant)   ?- atom(Elephant)
- help