CSCI-344
Programming Language Concepts (Section 3)

Lecture 23

Prolog: Cuts

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November 2, 2016

Where we are

Done:

- Logical Programming in Prolog
- Lists

This session:

- Puzzle Example
- Cuts in Prolog

Puzzle Example

Baker, Cooper, Fletcher, Miller and Smith live in a five-story building. Baker doesn't live on the 5^{th} floor and Cooper doesn't live on the 1st floor. Fletcher doesn't live on the top or bottom floors, and he is not on a floor adjacent to Smith or Cooper. Miller lives on the some floor above Cooper.

Who lives on what floors?

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Who lives on what floors?

- We set up the solution as a list of five entries:

```
[floor(_,5),floor(_,4),floor(_,3),floor(_,2),floor(_,1)]
```

- Don't care variables are placeholders for the five names:
  `baker, cooper, fletcher, miller, smith`

Puzzle Example

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[floor(_,5),floor(_,4),floor(_,3),floor(_,2),floor(_,1)]
```

- Don't care variables are placeholders for the five names:
  `baker, cooper, fletcher, miller, smith`
- We associate variables `B,C,F,M,S` $\in \{1,2,3,4,5\}$ with five persons

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floors([floor(_,5),floor(_,4),
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building(Floors) :- floors(Floors),
```

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Who lives on what floors?

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floors([floor(_,5),floor(_,4),
        floor(_,3),floor(_,2),floor(_,1)]).
building(Floors) :- floors(Floors),
  member(floor(baker, B), Floors), not(B is 5),
  member(floor(cooper, C), Floors), not(C is 1),
```

Puzzle Example

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  member(floor(cooper, C), Floors), not(C is 1),
  member(floor(fletcher, F), Floors),
                        not(F is 1), not(F is 5),
  not(S is (F + 1)),  not(F is (S + 1)),
  not(F is (C + 1)),  not(C is (F + 1)),
```

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  member(floor(cooper, C), Floors), not(C is 1),
  member(floor(fletcher, F), Floors),
                        not(F is 1), not(F is 5),
  not(S is (F + 1)),  not(F is (S + 1)),
  not(F is (C + 1)),  not(C is (F + 1)),
  member(floor(miller, M), Floors), (M > C),
```

Puzzle Example

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                        not(F is 1), not(F is 5),
  not(S is (F + 1)),  not(F is (S + 1)),
  not(F is (C + 1)),  not(C is (F + 1)),
  member(floor(miller, M), Floors), (M > C),
  member(floor(smith, S), Floors).
```

Puzzle Example

Baker, Cooper, Fletcher, Miller and Smith live in a five-story building.
Baker doesn't live on the 5^{th} floor and Cooper doesn't live on the 1st floor.
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Who lives on what floors?

```
?- building(X).
X = [floor(miller, 5),
     floor(fletcher, 4),
     floor(baker, 3),
     floor(cooper, 2),
     floor(smith, 1)].
```

Impure Features

- Declarative programming: no side-effects
- Sometimes declarative programming languages offer **"impure"** expressions
- μScheme supports global variable definitions
- Prolog supports cut `!` predicate to have side effect on backtracking behavior
- Forces Prolog to stop searching for alternatives when an answer is found
- Cut prunes the search space: it can remove unwanted answers

Cut Example

```
f(1).
member(X, [X|_]).
member(X, [_|T]) :- member(X,T).
```

- The following query succeeds three times

```
?- member(2,[2,3,2,4]),f(Y).
Y = 1;
Y = 1.
```

- What if we are only interested in a single answer?
- We don't want to consider the alternative solutions after first answer

```
f(1).
member(X, [X|_]) :- !.
member(X, [_|T]) :- member(X,T).
```

Cut Example

```
f(1).
member(X, [X|_]).
member(X, [_|T]) :- member(X,T).
```

```
?- member(2,[2,3,2,4]),f(Y).
```

member(2,[2,3,2,4]),f(Y)

Cut Example

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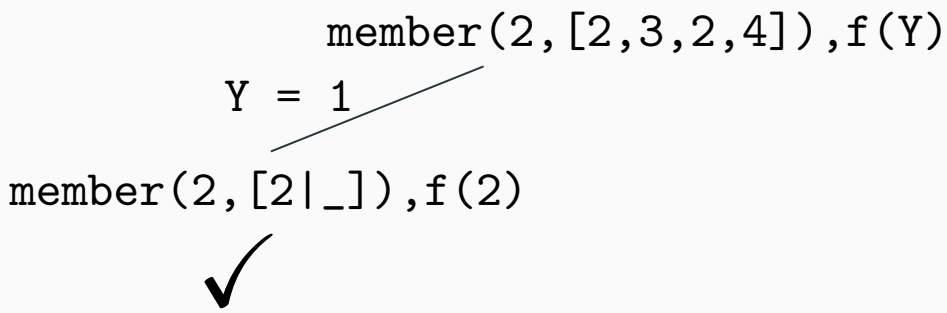

Cut Example

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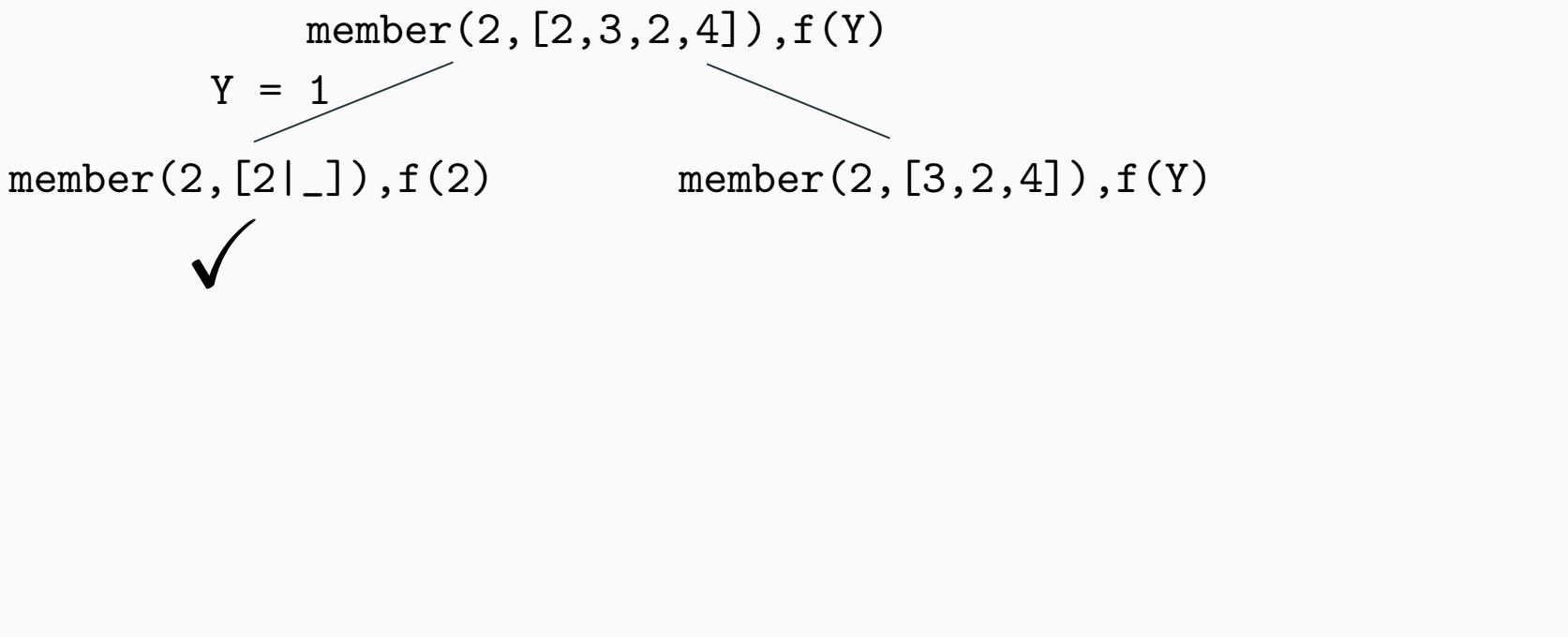

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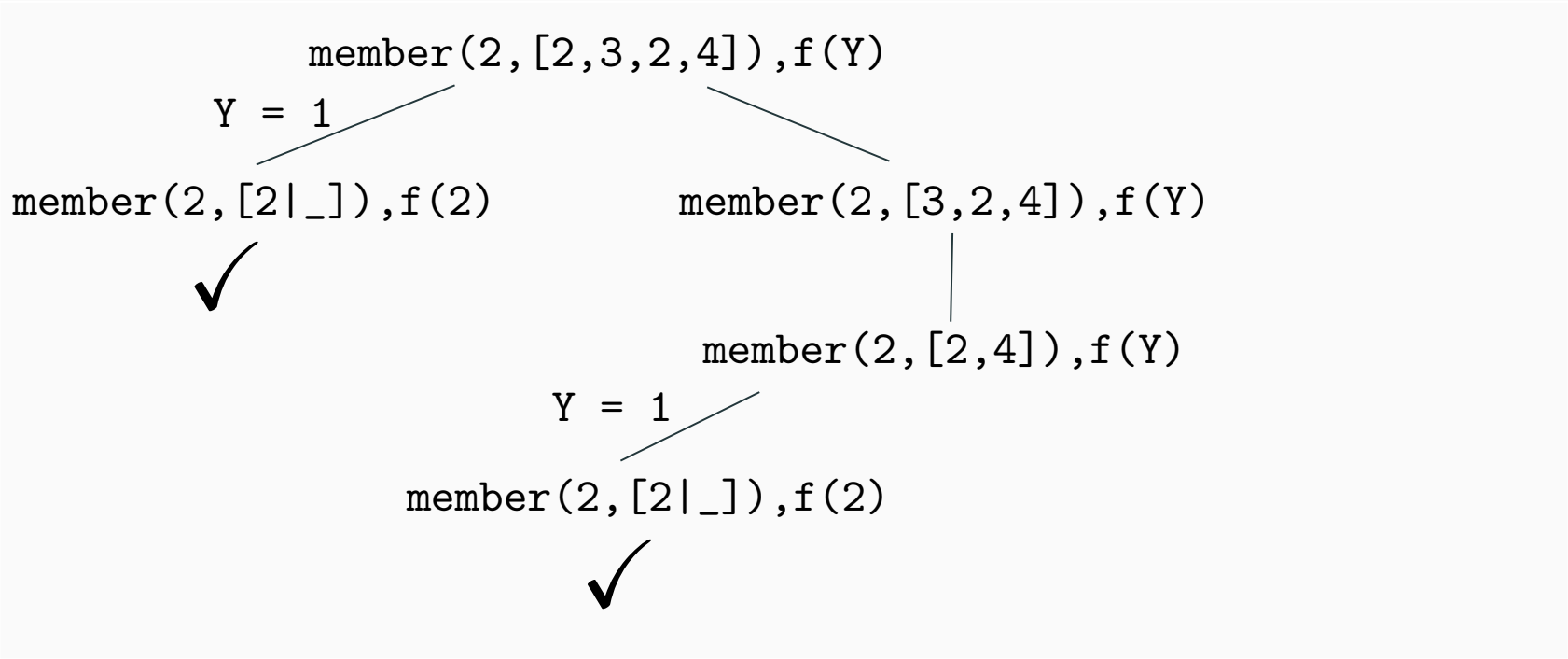

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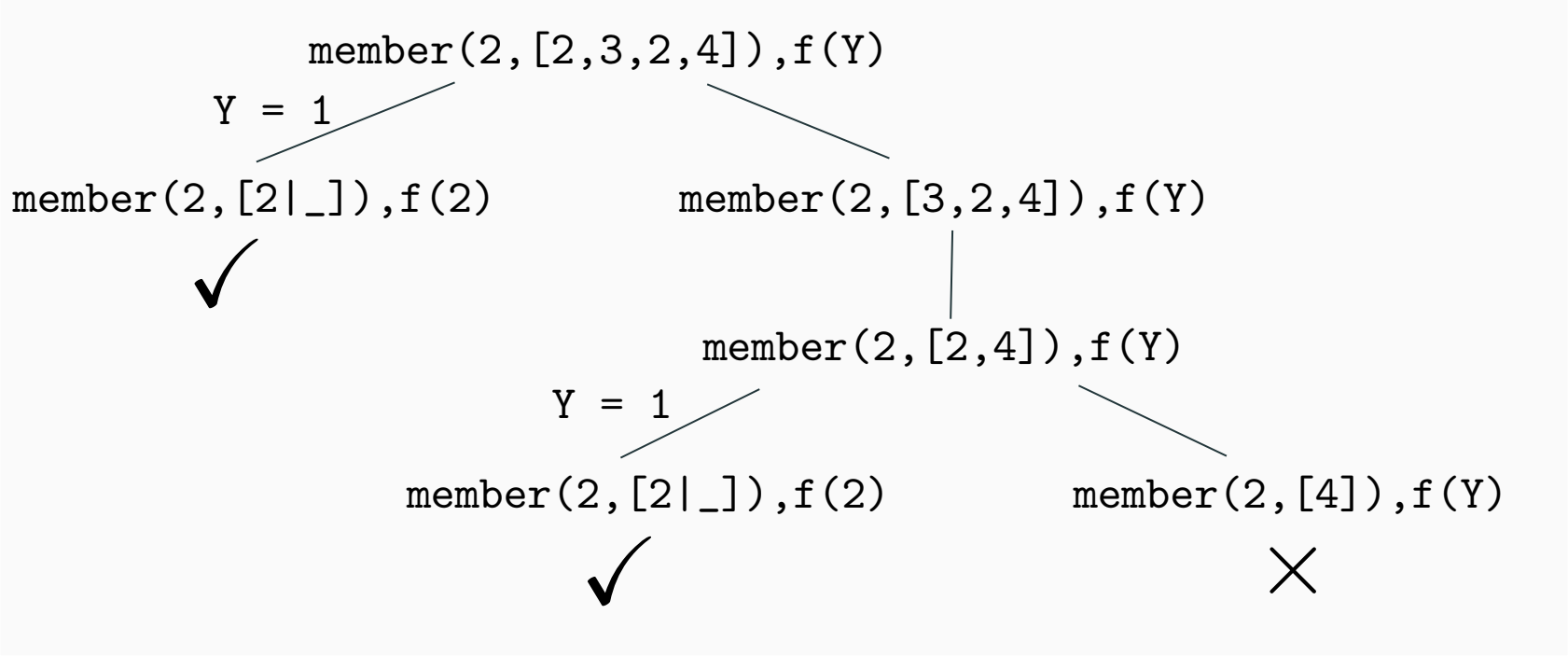

Cut Example

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f(1).
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?- member(2,[2,3,2,4]),f(Y).
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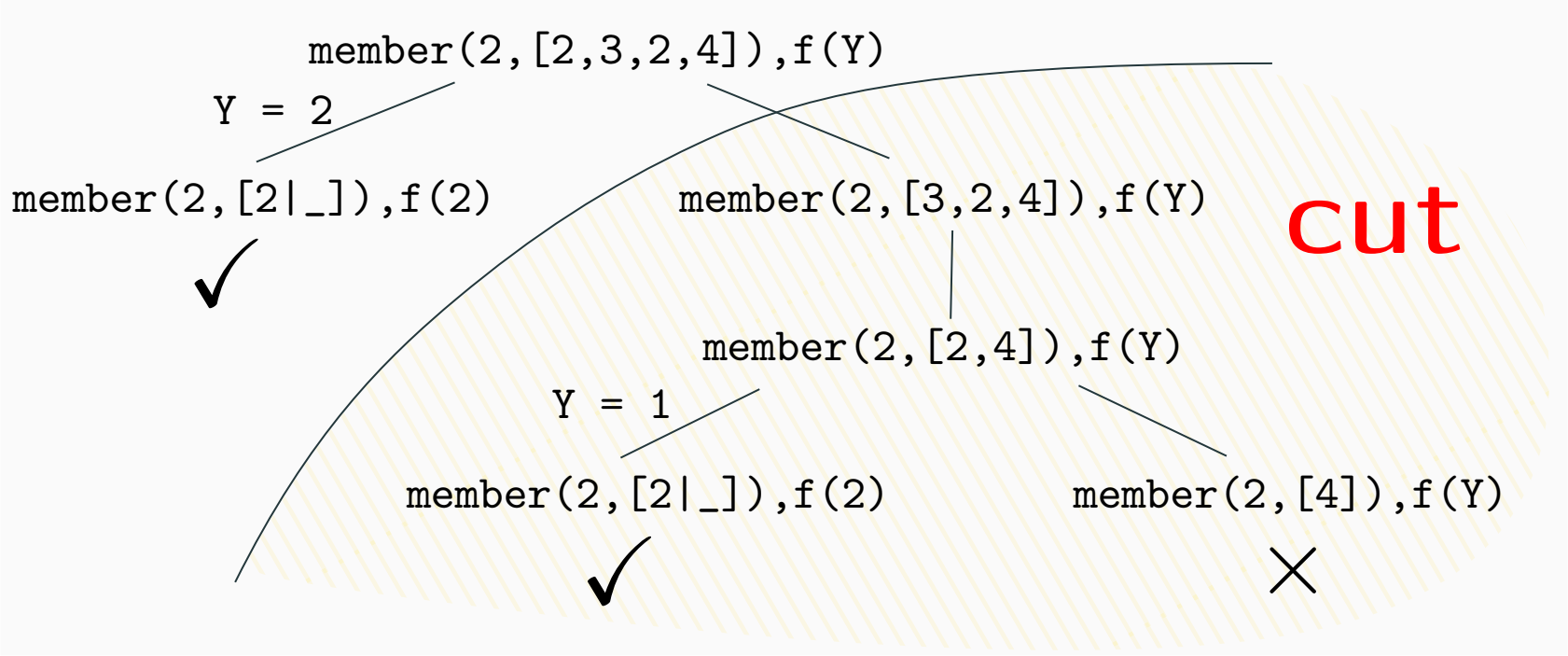


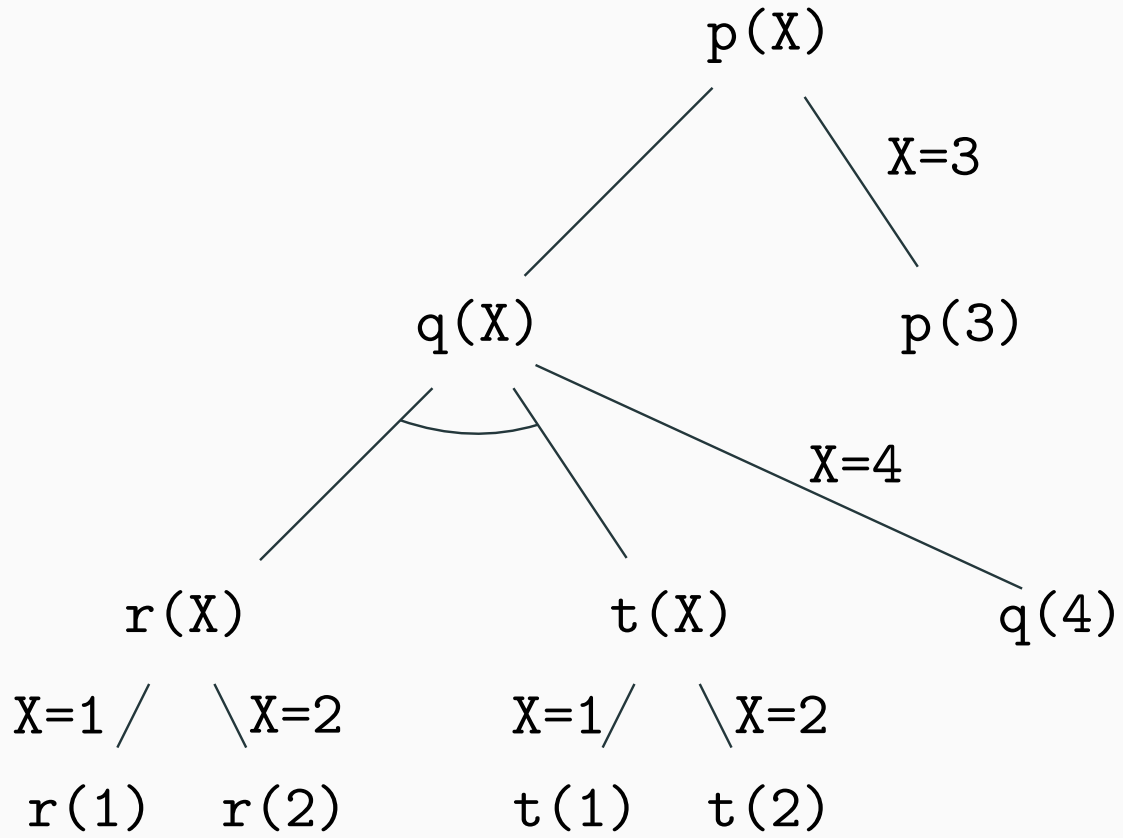
Cut

- Cut `!` is a predicate that always succeeds
- Prolog commits to all the choices that have been made from the point where the rule was applied up through the cut
- In a rule of the form:

  `q :- p1,...,pn, ! , r1,...,rm`
- when we reach the cut it commits us to:
  - Using this particular clause for `q`
  - Choices of variables made when evaluating `p1` ,..., `pn`

Cut-Example

```
-> p(X) :- q(X).
q(X) :- r(X), t(X).
p(3).
q(4).
r(1).
r(2).
t(1).
t(2).
?- p(X).
```



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p(3).
q(4).
r(1).
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t(1).
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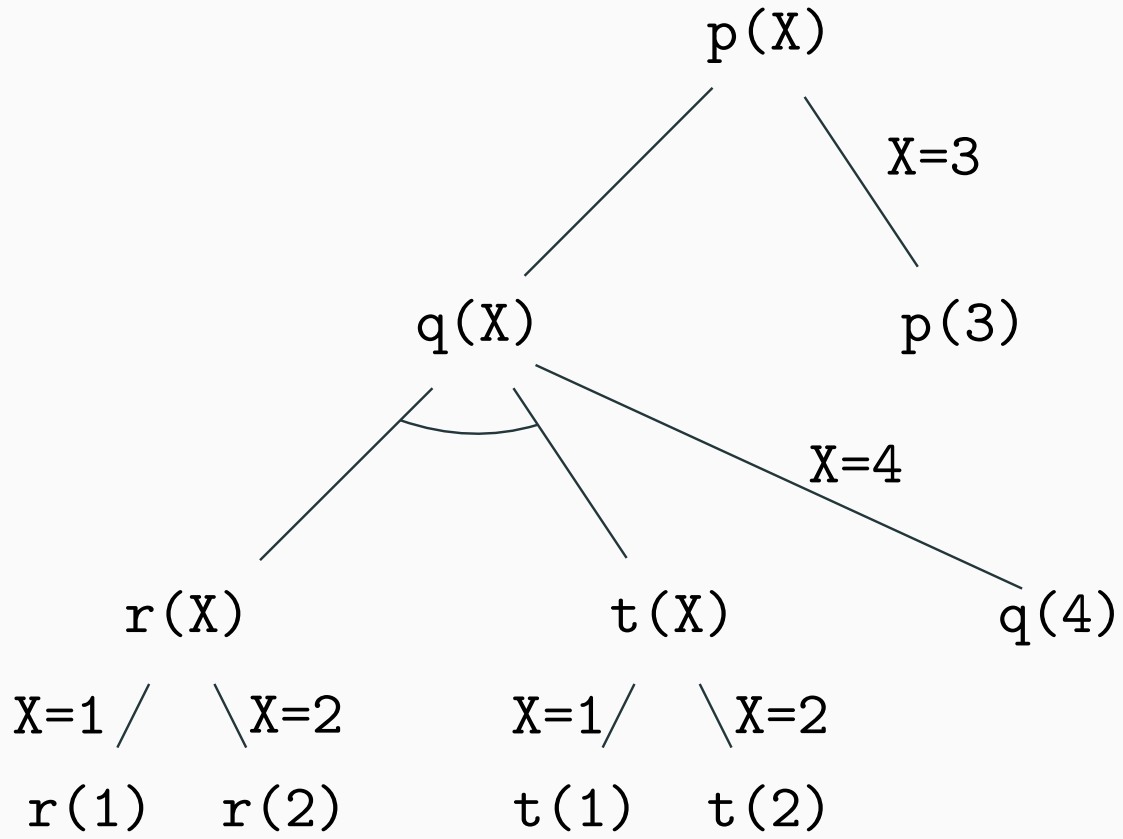
?- p(X).

X = 1;
X = 2;
X = 4;
X = 3;
```



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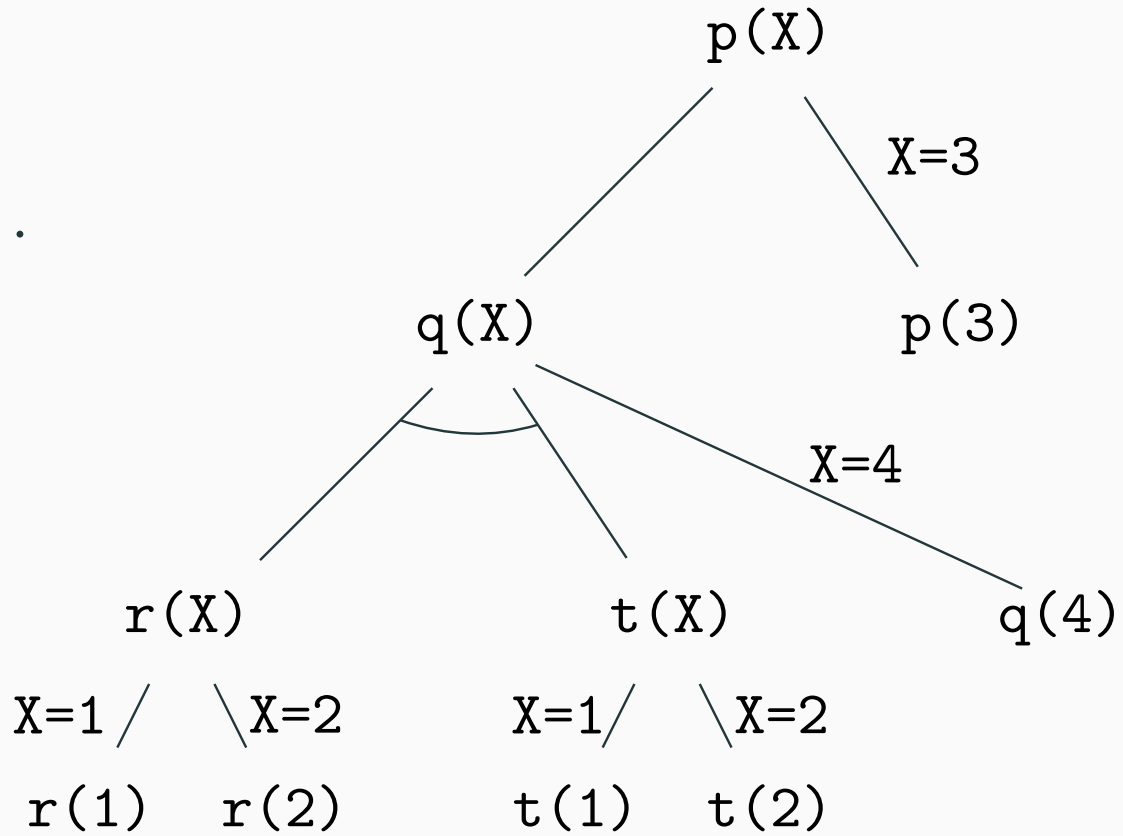

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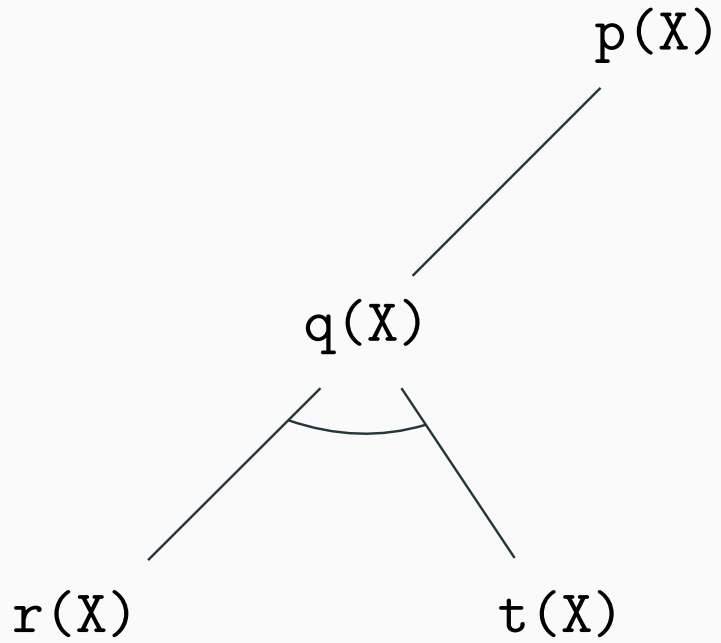

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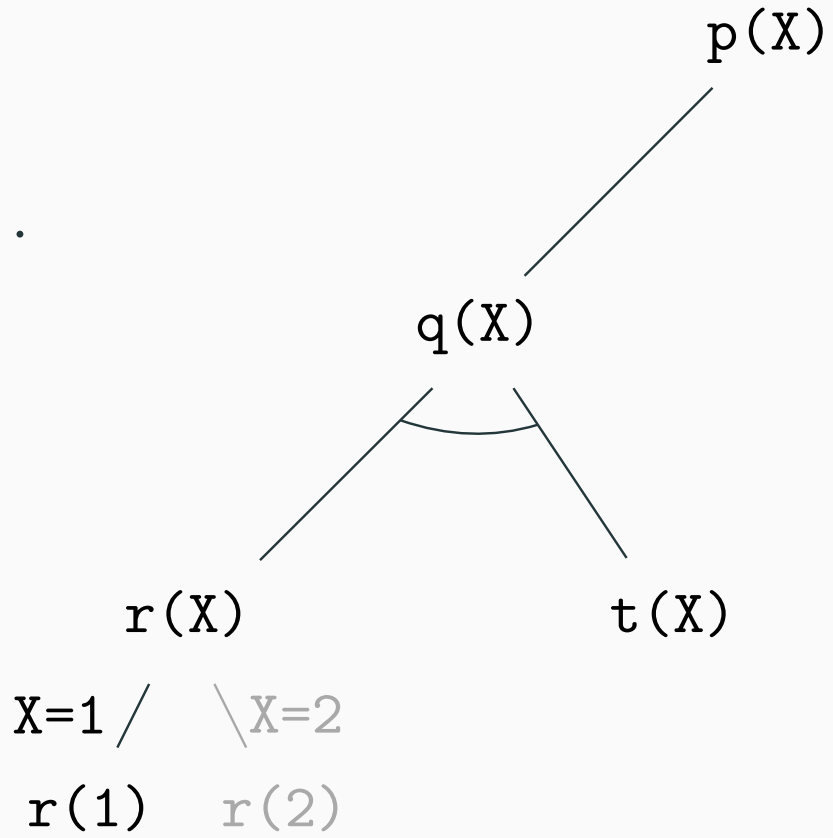

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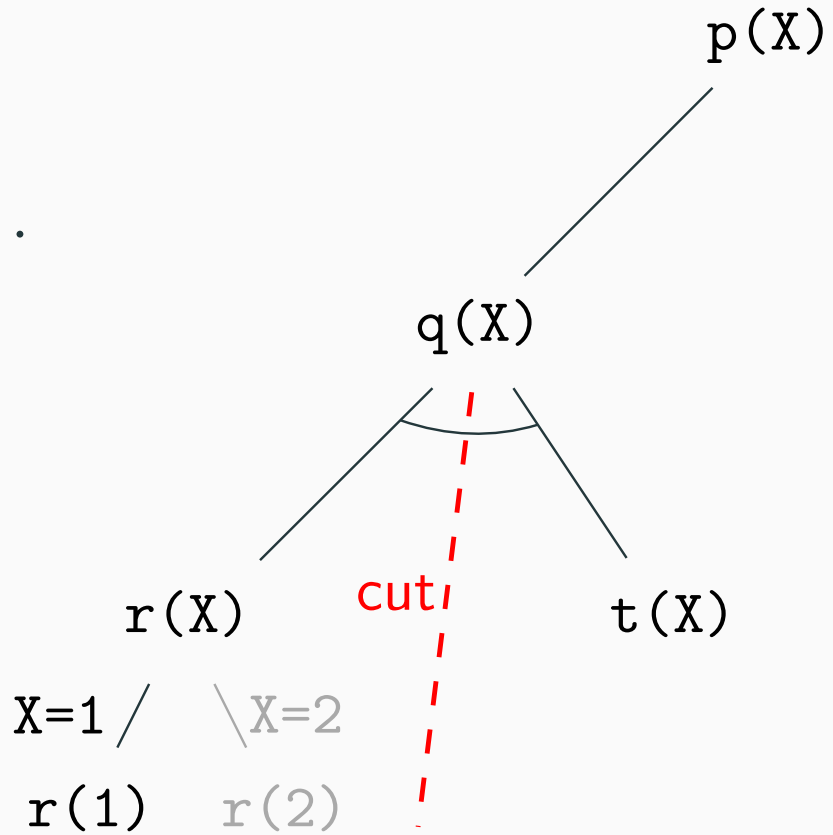

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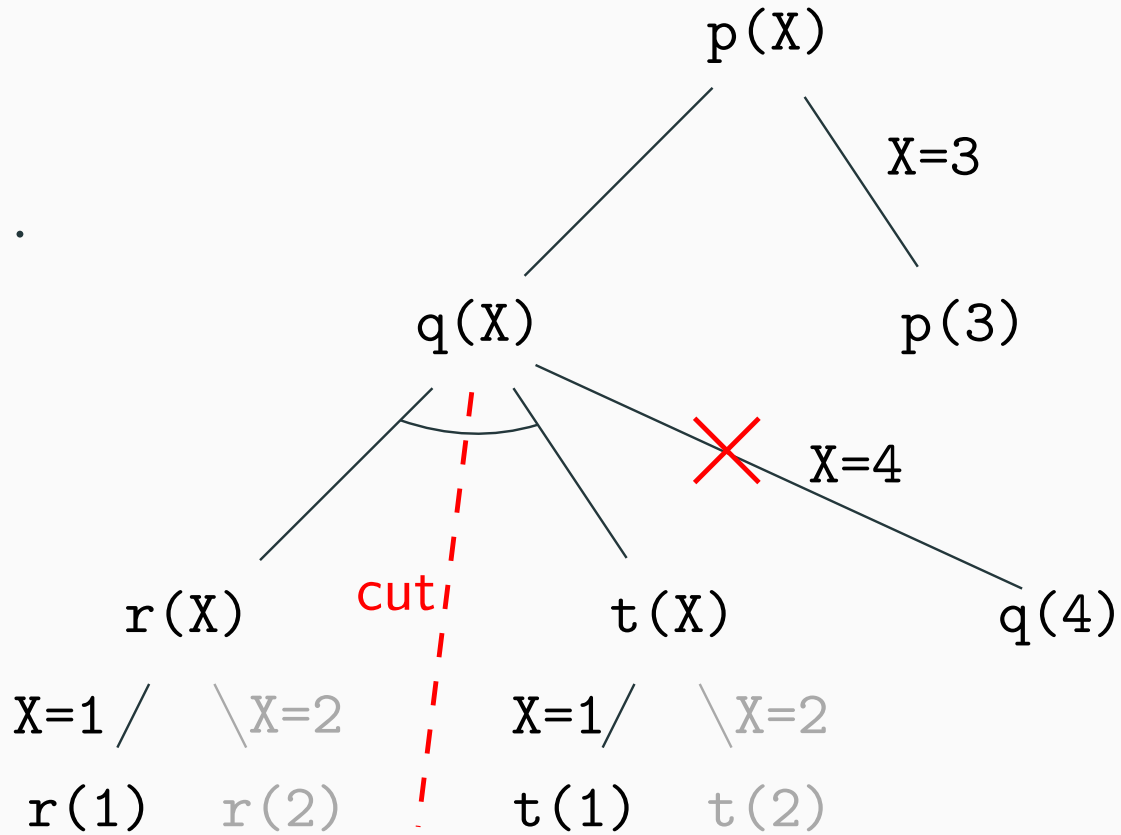

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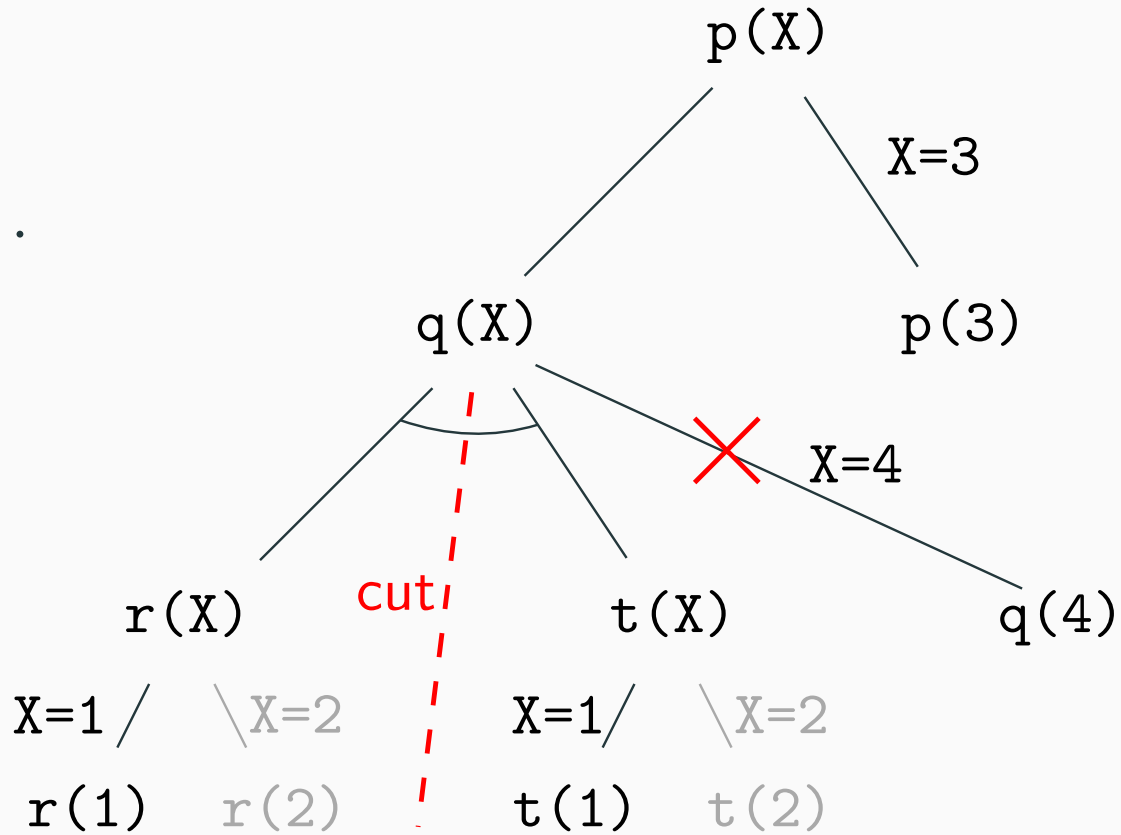

Using Cuts

- Predicate `max` succeeds if third argument is the maximum of first two arguments

```
max(X,Y,Y):- X =< Y.
max(X,Y,X):- X>Y.
```

```
?- max(5,10,Y).
Y = 10;
```

- Inefficiency: if you ask for more answers after `Y=10`, it tries to match the next clause

max with cut

```
max(X,Y,Y):- X =< Y, !.
max(X,Y,X):- X>Y.
```

- If `X =< Y` succeeds, the cut commits us to this choice, and the second clause is never considered
- If `X =< Y` fails, Prolog goes on to the second clause

Cut Classification

Good/Green Cuts

- Introduced to make program more efficient by eliminating "known" useless computations
- Without the cuts, the program produces the same solutions (perhaps requiring more time or space)
- Logical meaning of the program remains the same

Bad/Red Cuts

- Introduced to make program more efficient by eliminating some meaningful solutions
- Without the cuts, the program might produce different solutions
- Changes the logical meaning of the program

Summary

This Lecture

- Prolog: Cuts

Next Lecture

- Type Inference