CSE 259 - Logic in Computer Science
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Recitation-3

Recursion and Cut

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Recursion - Definition

Definition: Recursion is a technique in which one predicate uses itself to find the truth value.

Example:

```
predecessor(X, Z) :- parent(X, Z).
```

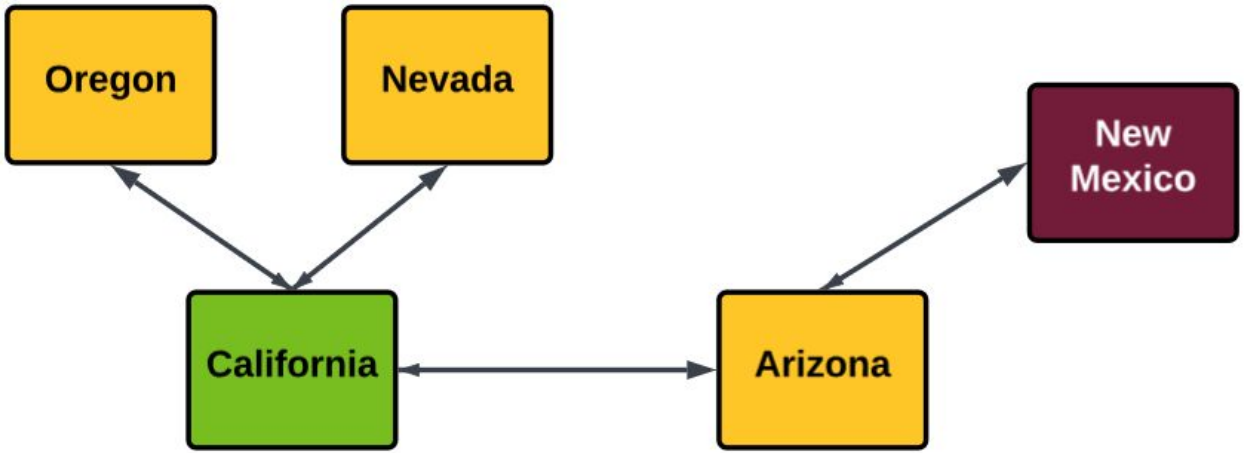
Base case

```
predecessor(X, Z) :- parent(X, Y),predecessor(Y, Z).
```

Recursion - Applying recursion

Last time we solved this problem had a **limitation**: Travelling from Oregon to New Mexico was not possible :(

Solution: Using recursion



Recursion - Applying recursion

```
1  % facts
2  next_to(california, arizona).
3  next_to(california, oregon).
4  next_to(california, nevada).
5  next_to(arizona, new_mexico).
6
7  % a rule where we write the logic of when two states are connected
8  connected(A, B) :- next_to(A, B) ; next_to(B, A).
9
10 /*
11  * recusrive rule
12  */
13 path(A, B) :- connected(A, B).
14 path(A, B) :- connected(A, C), C \== B, path(C, B).
15
16 travel(A, B) :- path(A, B).
```

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

```
path(A, B) :- connected(A, B).
path(A, B) :- connected(A, C), C \== B, path(C, B).
```

```
      A        B                  A                B                B
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico)
```

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

```
path(A, B) :- connected(A, B).
path(A, B) :- connected(A, C), C \== B, path(C, B).
```

```
        A         B                   A                        B                   B
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico)
```

```
        A         B                        A         C         C              B          C          B
path(oregon, new_mexico) :- connected(oregon, california), california \== new_mexico, path(california, new_mexico)
```

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

```
path(A, B) :- connected(A, B).
path(A, B) :- connected(A, C), C \== B, path(C, B).
```

```
        A       B                 A                       B                   B
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico).
```

```
        A       B                         A       C       C           B           C       B
path(oregon, new_mexico) :- connected(oregon, california), california \== new_mexico, path(california, new_mexico).
```

```
        A         B                     A                   B                   B
path(california, new_mexico) :- connected(california, C), C \== new_mexico, path(C, new_mexico).
```

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

path(A, B) :- connected(A, B).
path(A, B) :- connected(A, C), C \== B, path(C, B).

A B A B B
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico).

A B A C C B C B
path(oregon, new_mexico) :- connected(oregon, california), california \== new_mexico, path(california, new_mexico).

A B A B B
path(california, new_mexico) :- connected(california, C), C \== new_mexico, path(C, new_mexico).

A B A C C B A B
path(california, new_mexico) :- connected(california, arizona), arizona \== new_mexico, path(arizona, new_mexico).
path(california, new_mexico) :- connected(california, oregon), oregon \== new_mexico, path(oregon, new_mexico).
path(california, new_mexico) :- connected(california, nevada), nevada \== new_mexico, path(nevada, new_mexico).

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).

path(A, B) :- connected(A, B).
path(A, B) :- connected(A, C), C \== B, path(C, B).

A B A B B
path(oregon, new_mexico) :- connected(oregon, C), C \== new_mexico, path(C, new_mexico).

A B A C C B C B
path(oregon, new_mexico) :- connected(oregon, california), california \== new_mexico, path(california, new_mexico).

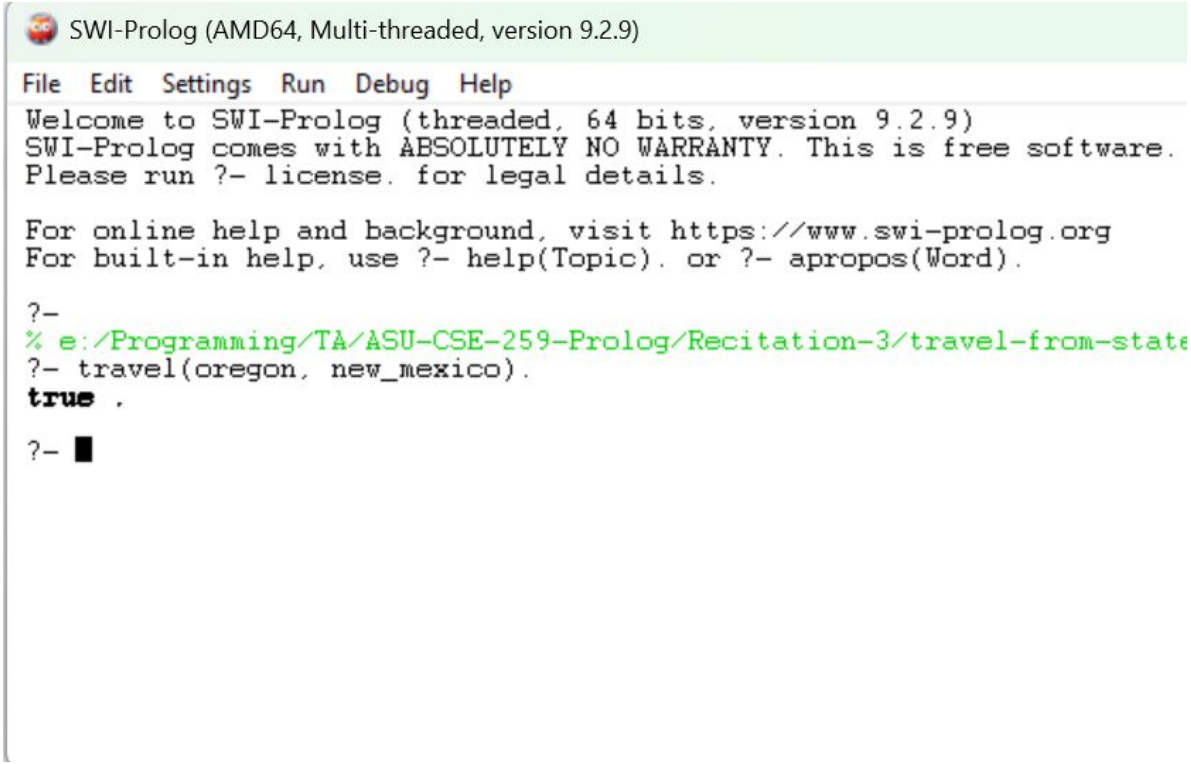
A B A B B
path(california, new_mexico) :- connected(california, C), C \== new_mexico, path(C, new_mexico).

A B A C C B A B
path(california, new_mexico) :- connected(california, arizona), arizona \== new_mexico, path(arizona, new_mexico).
path(california, new_mexico) :- connected(california, oregon), oregon \== new_mexico, path(oregon, new_mexico).
path(california, new_mexico) :- connected(california, nevada), nevada \== new_mexico, path(nevada, new_mexico).

A B A B
path(arizona, new_mexico) :- connected(arizona, new_mexico).

Recursion - Applying recursion

Query: | ?-travel(oregon, new_mexico).



Cut

- Represented by !
- Always succeeds - in the rules it is considered as true
- Prevents Backtracking

Cut - example

```
1  % facts
2  red(apple).
3  red(lexus).
4  red(honda).
5  blue(monkey).
6
7  car(honda).
8  car(lexus).
9  bike(monkey).
10
11 fun(X) :- red(X), car(X).
12 fun(X) :- blue(X), bike(X).
13
```

```
% e:/Programming/TA/ASU-(
?- fun(X).
X = lexus ;

?- fun(X).
X = lexus ;
X = honda ;
X = monkey.

?-
```

Cut - example

```
1   % facts
2   red(apple).
3   red(lexus).
4   red(honda).
5   blue(monkey).
6
7   car(honda).
8   car(lexus).
9   bike(monkey).
10
11  fun(X) :- red(X), car(X), !.
12  fun(X) :- blue(X), bike(X).
13
```

- First, X is bound to apple. apple is red, so red(X) is true. Then car(X) is checked and it is false. So, we get back to red(X).
- Now X is bound to lexus. lexus is red and a car. So we reach the cut operator. And then stop backtracking

```
% e:/Programming/
?- fun(X).
X = lexus.

?-
```

Cut - example - order matters!

```
1   % facts
2   red(apple).
3   red(honda).
4   red(lexus).
5   blue(monkey).
6
7   car(honda).
8   car(lexus).
9   bike(monkey).
10
11  fun(X) :- red(X), car(X), !.
12  fun(X) :- blue(X), bike(X).
13
```

```
% e:/Programming/TA/
?- fun(X).
X = honda.

?-
```

Cut - example - order matters!

```
1   % facts
2   red(apple).
3   red(honda).
4   red(lexus).
5   blue(monkey).
6
7   car(honda).
8   car(lexus).
9   bike(monkey).
10
11  fun(X) :- red(X), !, car(X).
12  fun(X) :- blue(X), bike(X).
13
```

- X is bound to apple: apple is red. Then ! is true. The apple is not a car. Now, we need to get back to red(X) for more solution. But we can't get past the ! operator. So, not backtracking for more solution

```
% e:/Programming
?- fun(X).
false.

?
```

Cut - example - order matters!

```
1   % facts
2   red(apple).
3   red(honda).
4   red(lexus).
5   blue(monkey).
6
7   car(honda).
8   car(lexus).
9   bike(monkey).
10
11  fun(X) :- !, red(X), car(X).
12  fun(X) :- blue(X), bike(X).
13
```

- ! is true
- X is bound to apple, X is red, X is not a car. So, we get back to red(X). The cut was before red(X) so no problem getting back.
- honda and lexus is found.
- Finally we get back to the cut. We stop backtracking which is why fun(X) :- blue(X), bike(X) is not checked.

```
% e:/Programmin
?- fun(X).
X = honda ;
X = lexus.

?-
```