A (very) basic introduction to Prolog

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2. Steps of Programming

- 1. step: create a database
  - facts ~ object properties and relations to other objects
    - girl(jane). beer(heineken). likes(jane,heineken).
    - likes(jane,beer(heineken).
    - HIERARCHICAL STRUCTURES
  - rules ~ relations between facts
    - head :- body.
    - IF body – THEN head
    - Will talk on it later … hope today ;-)

- DB contains the true information, i.e. information not in DB are false... closed world assumption

2. Steps of Programming

- 2. step: dialogue with the system
  - We are asking questions, Prolog answers
  - e.g.

```
?- 3>2.
yes
?- likes(jane,heineken).
yes
?- likes(jane,beer).
no
?- girl(jane), beer(heineken)     // compound question, “,” == ” &”
yes
```

Variables

- who is a girl? what is a beer?

  ?- girl(X).

  X = jane

- enter after the answer ~ thanks
- “;” after the answer ~ thanks and want more

  ?- girl(X).

  X = jane → enter

  yes

  ?- girl(X).

  X = jane → ;

  no

More sophisticated asking

- asking have 2 uses:
  - is something true?
    - yes or no
  - give me some values.
    - need variables

Variables

- bounded … input
- free … output
- special, 'don't care' variable: “_”

- how to write a proposition “peter loves women who like beer.” ?
  - be careful to use just the facts in the table!

more sophisticated questions

- “peter loves women who like beer”
- “if there is a women and this woman likes beer then peter loves this woman”
- “if X is a woman and X likes beer then peter loves X”

  ?- loves(peter,X) :- woman(X), likes(X,beer).

  X = jane → enter

  yes

Unification

- when searching for answers Prolog tries to unify two objects (variables or constants)
  - unifying a variable and constant is basically a bounding of a variable to a concrete object.
  - strict rules for unification!
    - constants ~ if are the same
    - variable can be unified with an arbitrary object (two variables became associated after unification
    - structures ~ same functor and number of arguments and all arguments are unifiable
    - **goals** are unifiable with facts if are represented with unifiable structures
    - goals are unifiable with rules if the goal and the head of the rule are unifiable

Unification

- “=” is an operator for syntactical unification

  ?- 5 = 2+3

  no

- “is” is an operator for semantical unification

  ?- X is 2+3

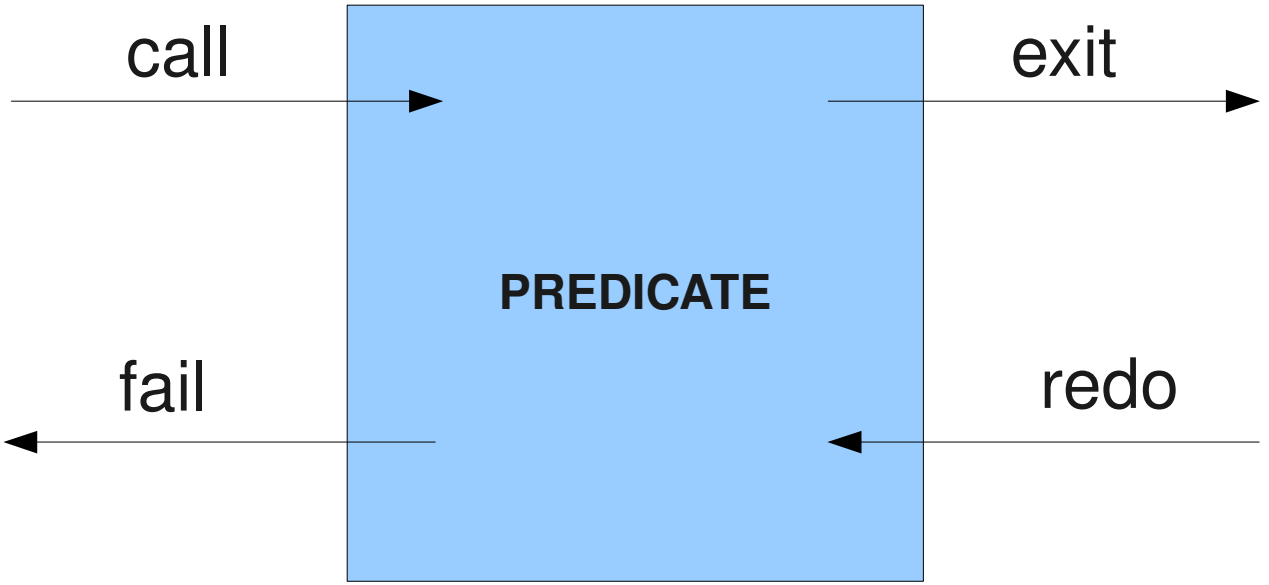
  X = 5 → enter

  yes

- arithmetical comparison “=:=”, “=\=”

How does Prolog answering?

- 4 actions
  - Call, Exit, Redo, Fail



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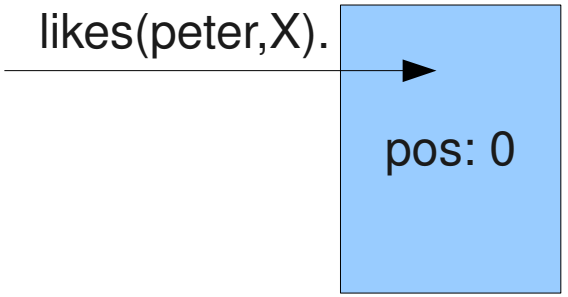

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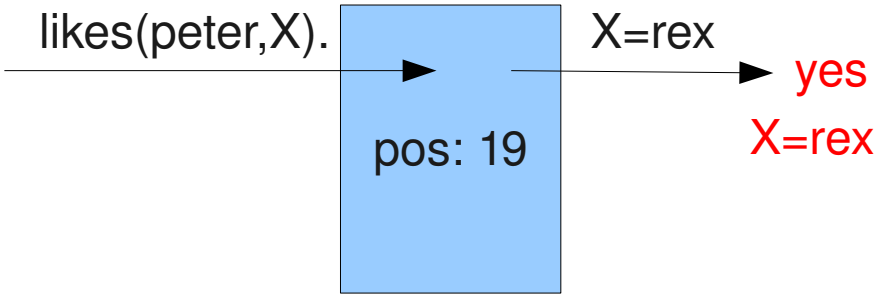

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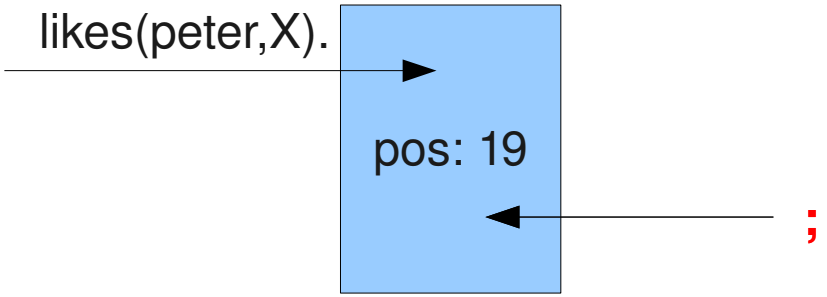

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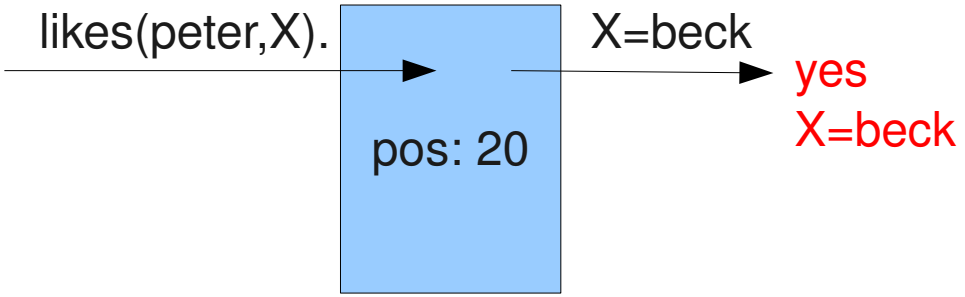

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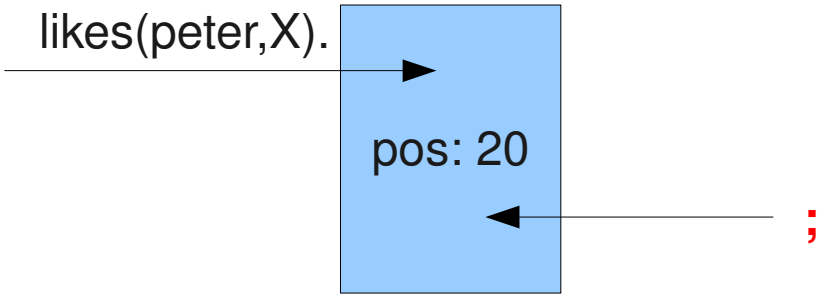

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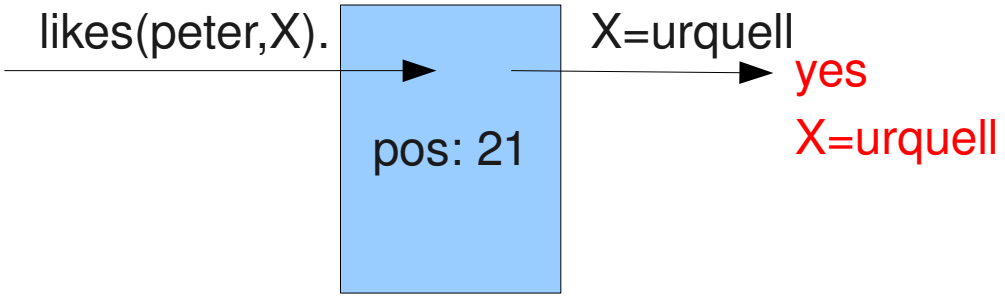

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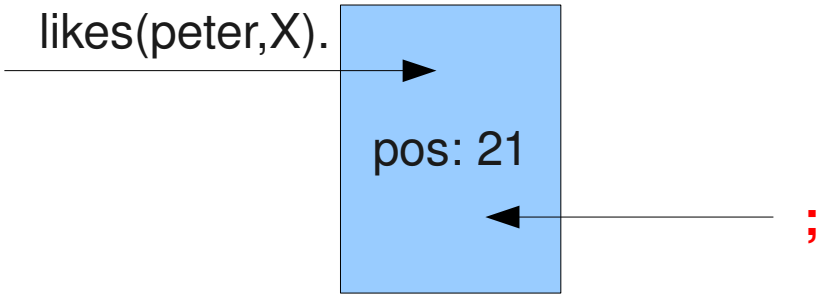

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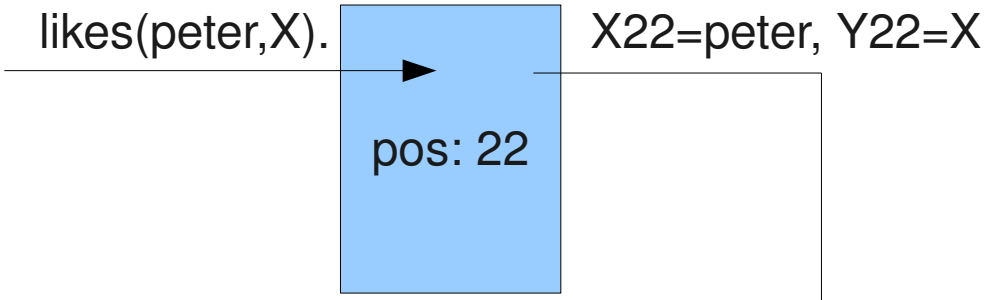

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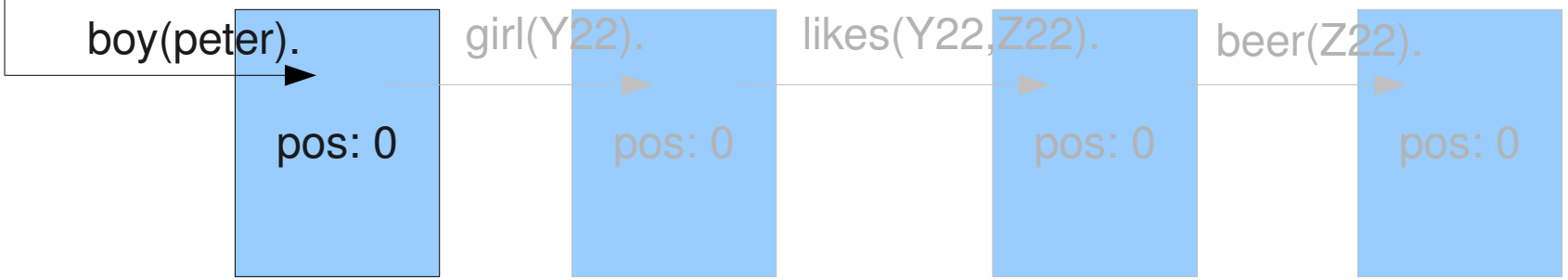

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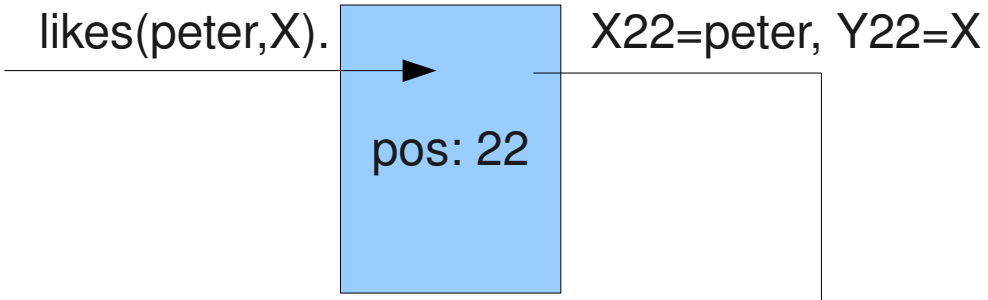

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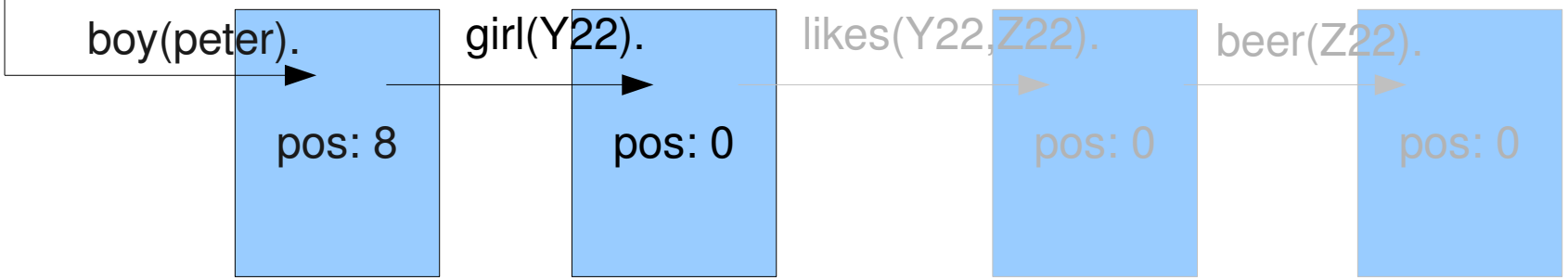

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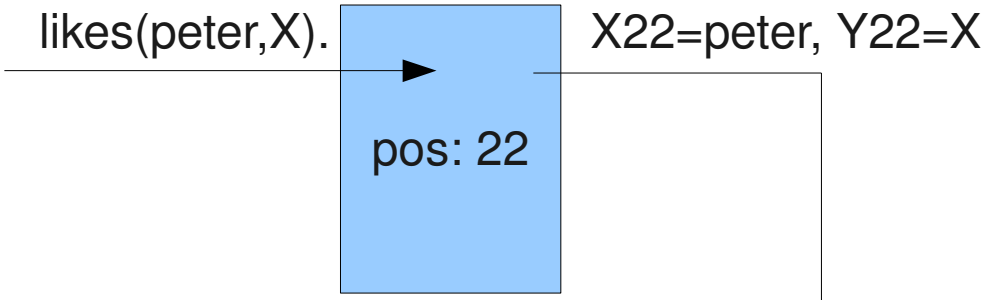

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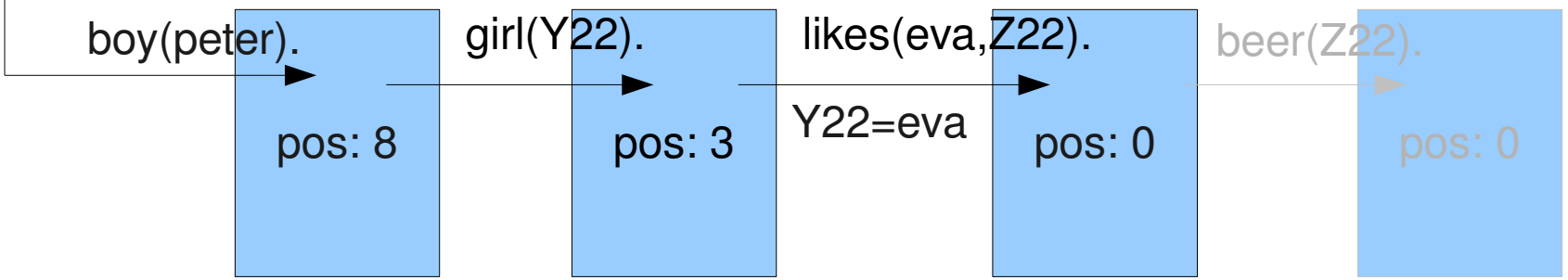

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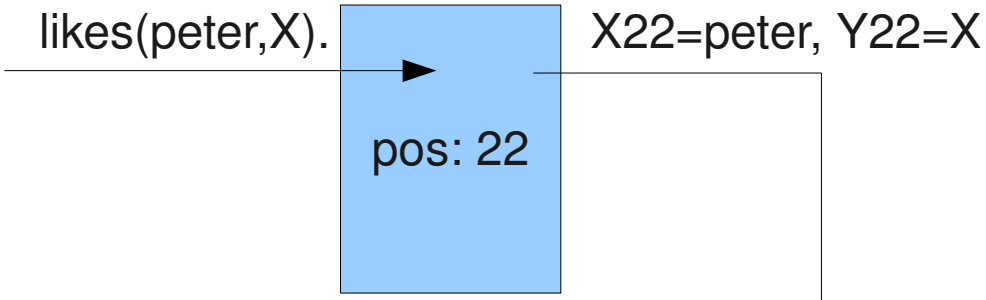

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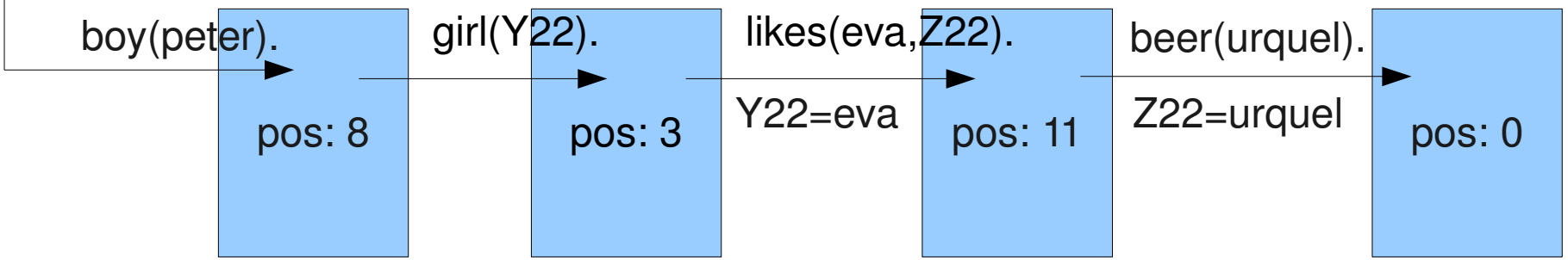

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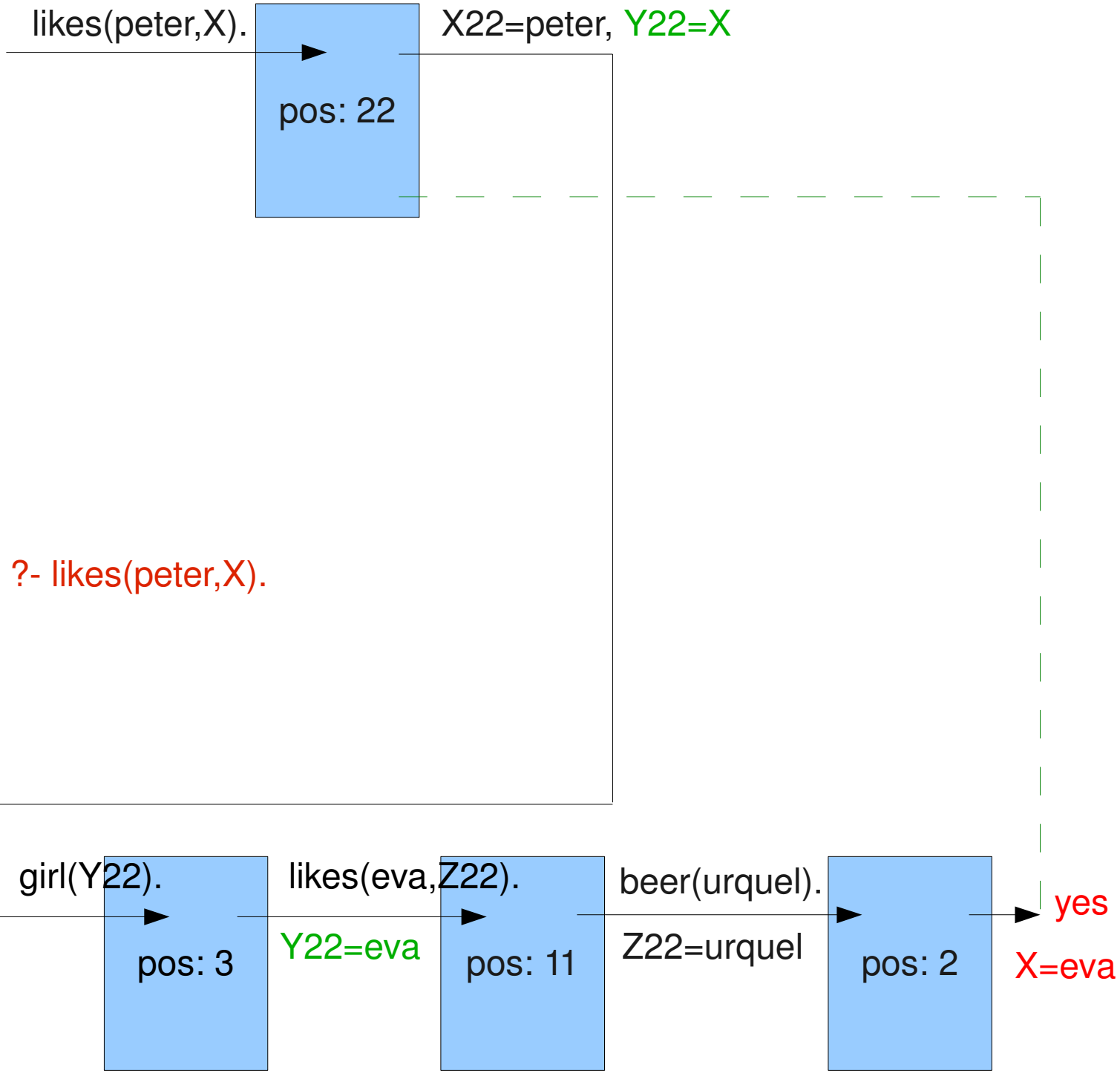

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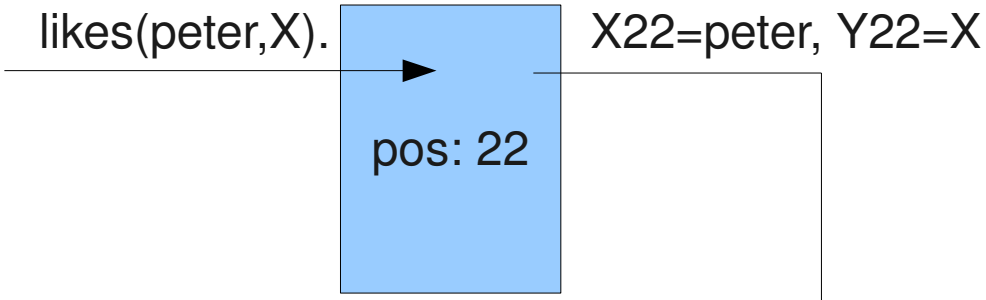

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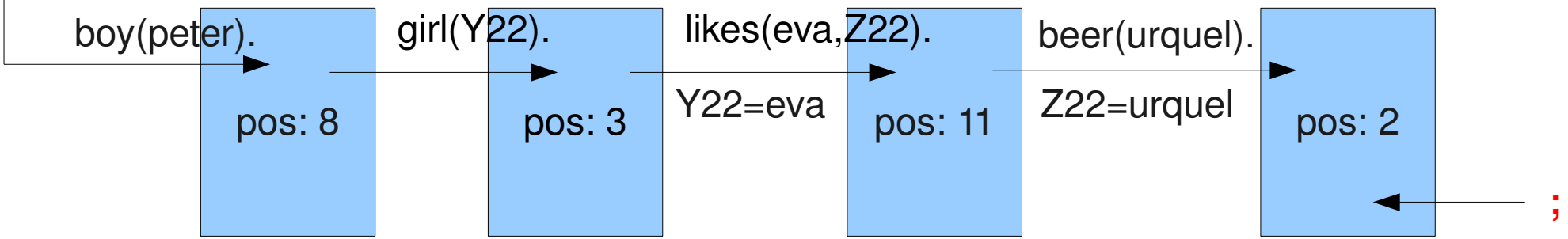

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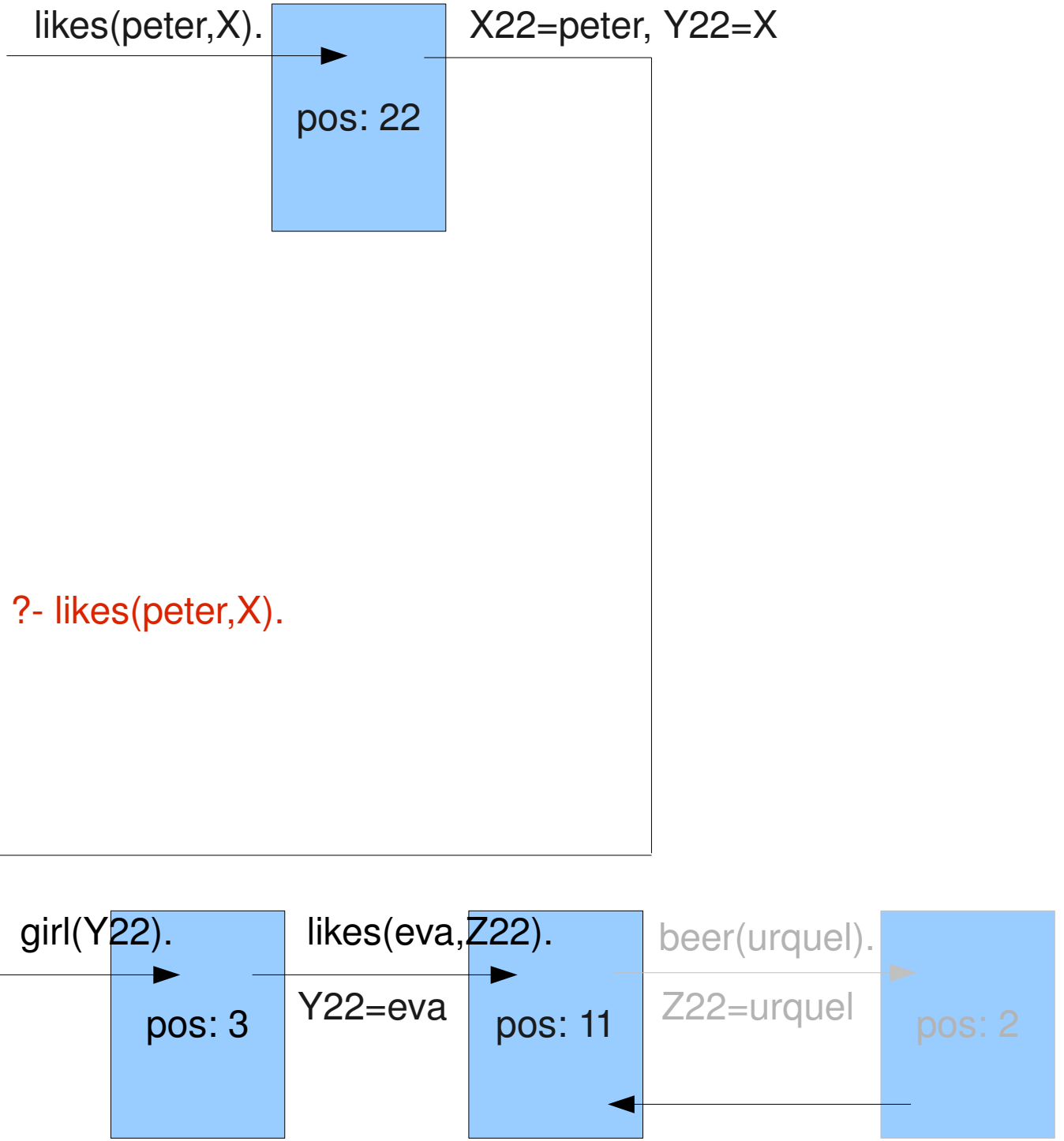

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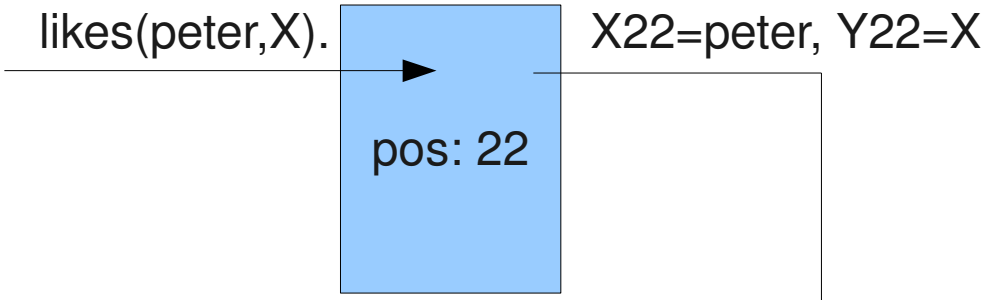

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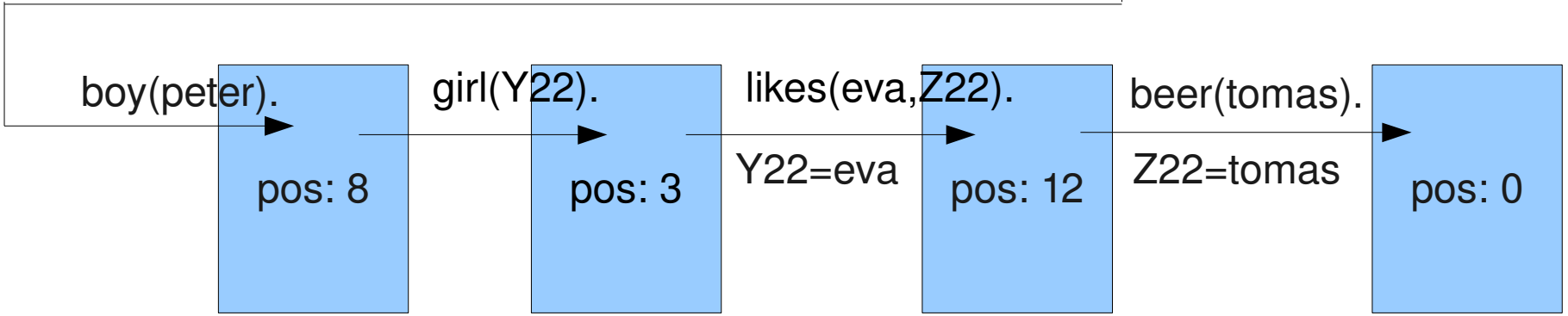

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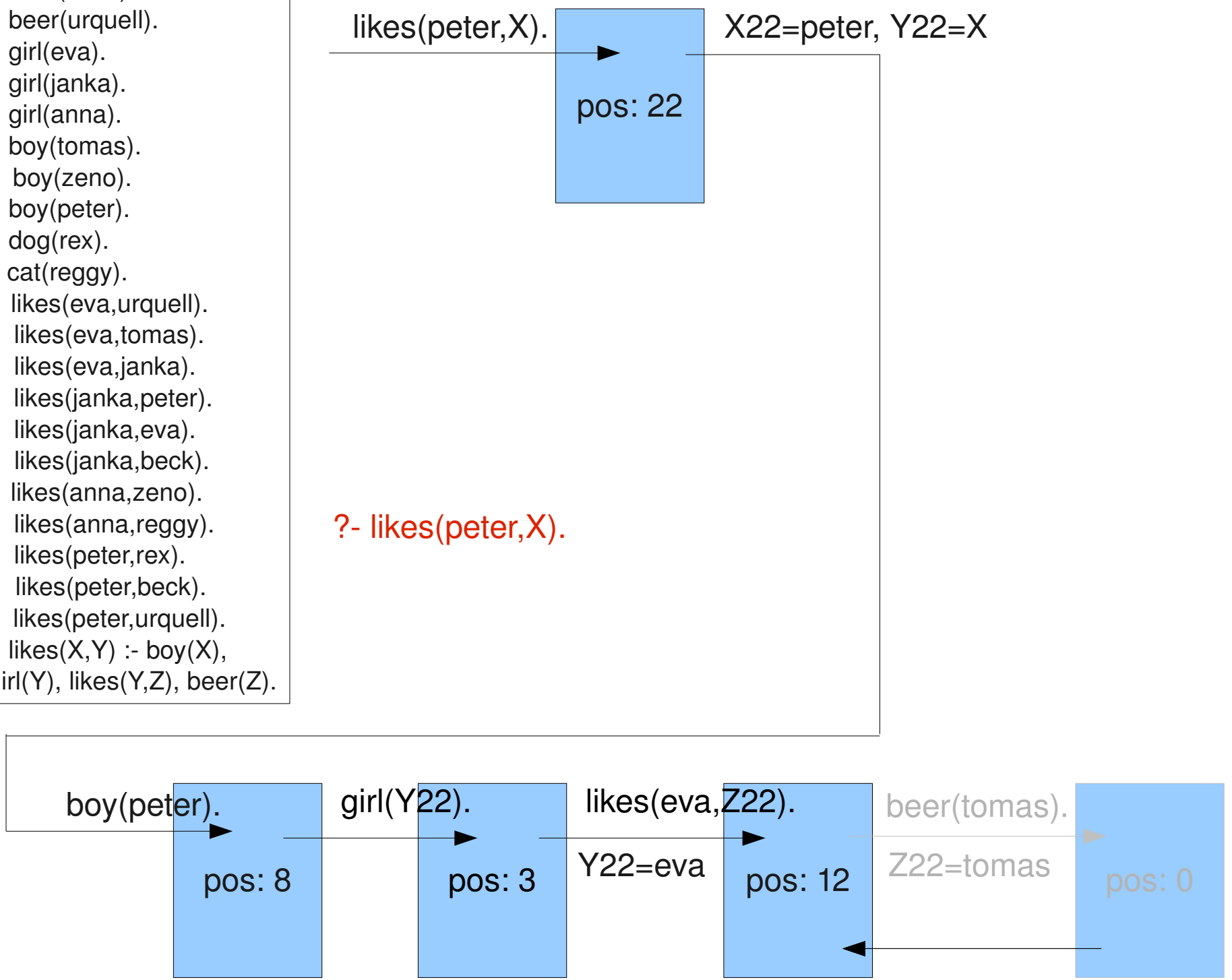

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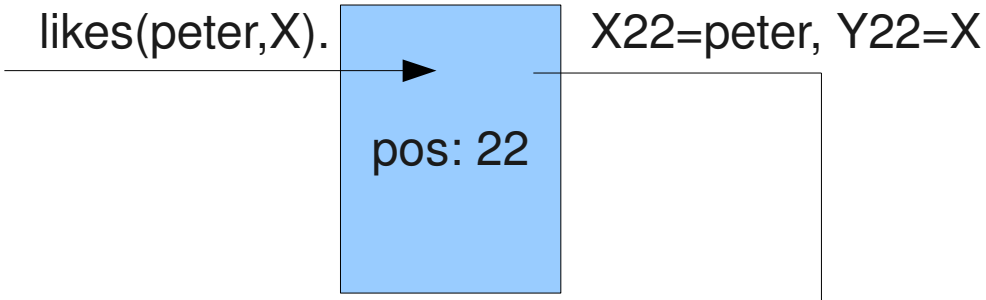
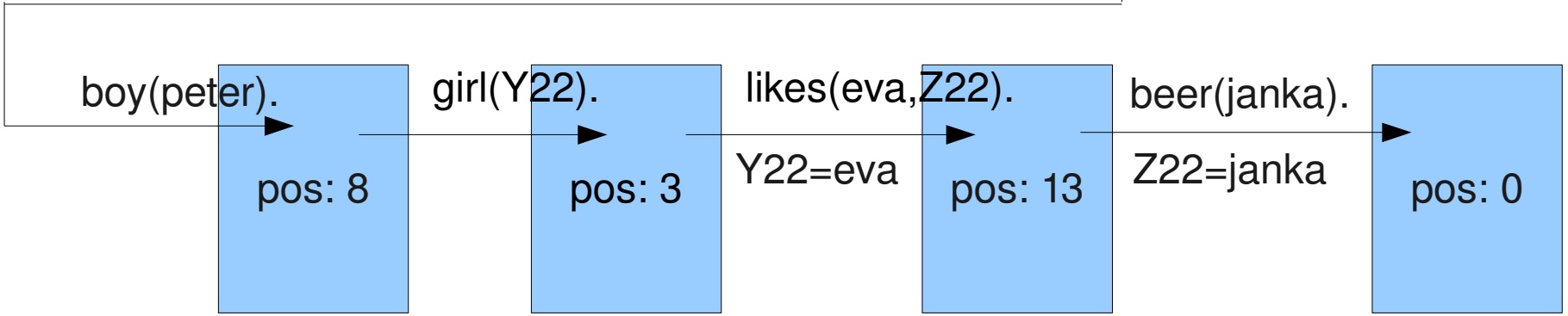


?- likes(peter,X).



1. beer(beck).
2. beer(urquell).
3. girl(eva).
4. girl(janka).
5. girl(anna).
6. boy(tomas).
7. boy(zeno).
8. boy(peter).
9. dog(rex).
10. cat(reggy).
11. likes(eva,urquell).
12. likes(eva,tomas).
13. likes(eva,janka).
14. likes(janka,peter).
15. likes(janka,eva).
16. likes(janka,beck).
17. likes(anna,zeno).
18. likes(anna,reggy).
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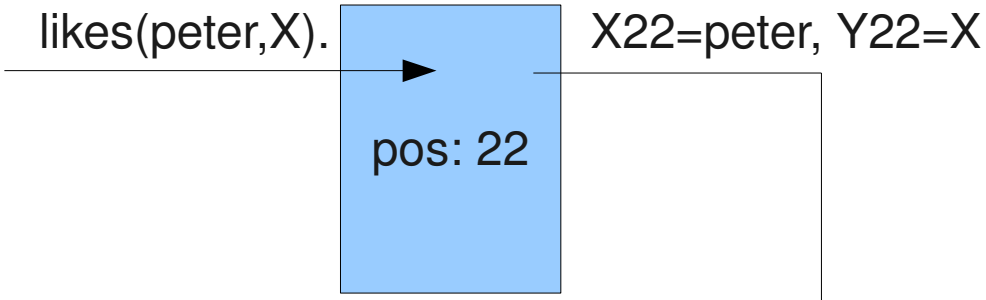

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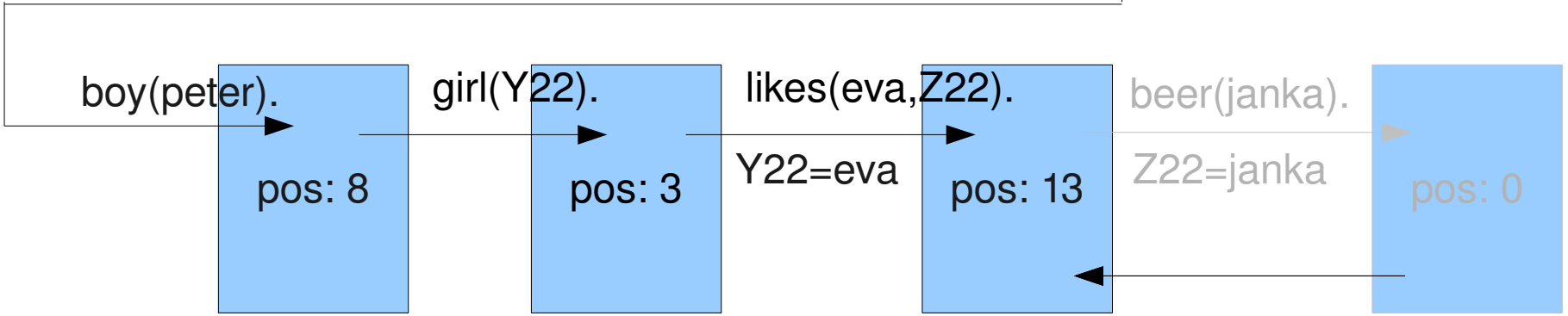

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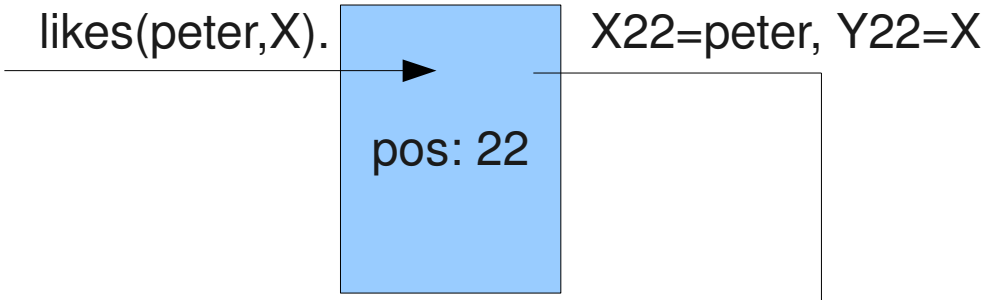

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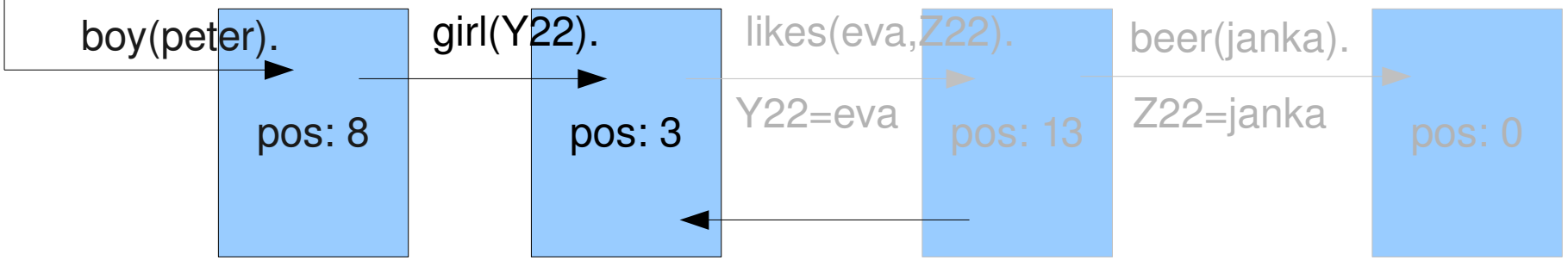

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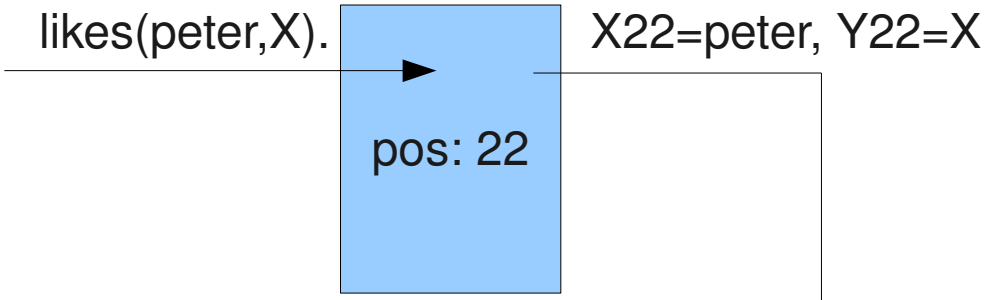

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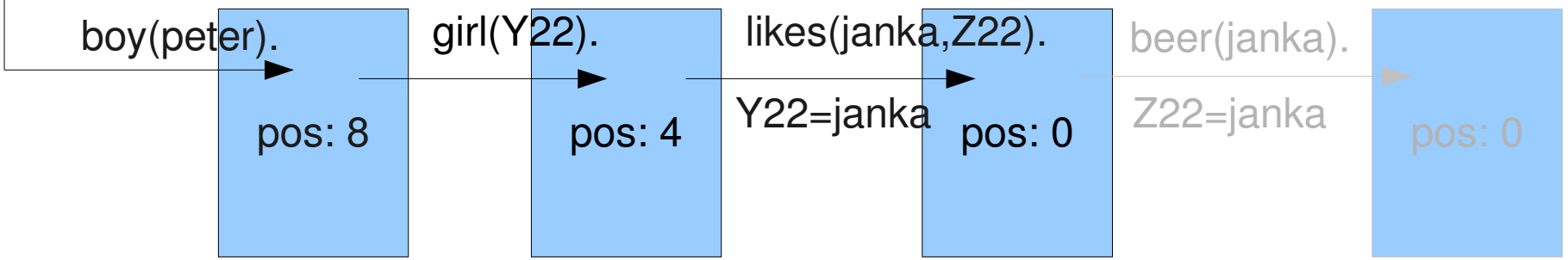

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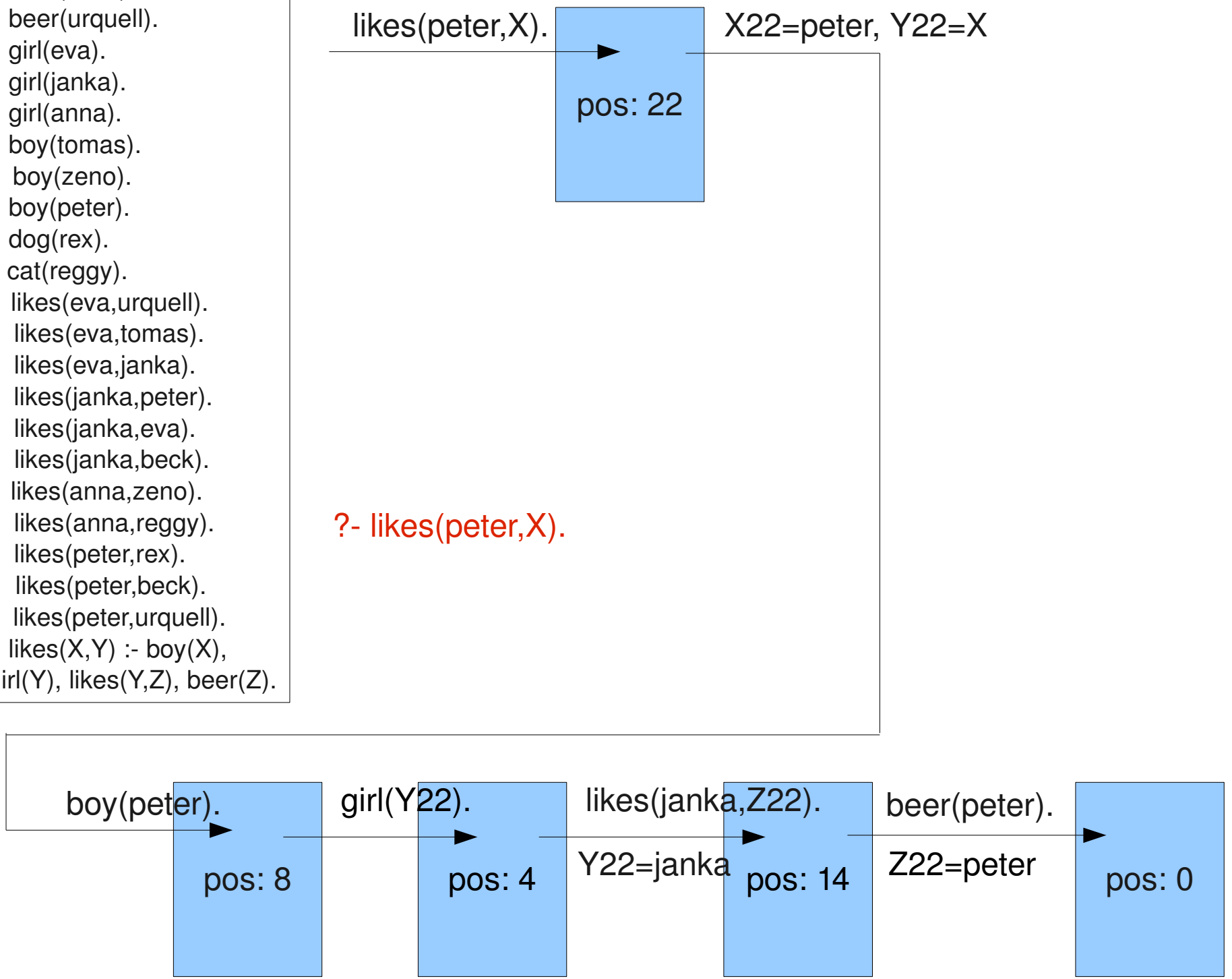

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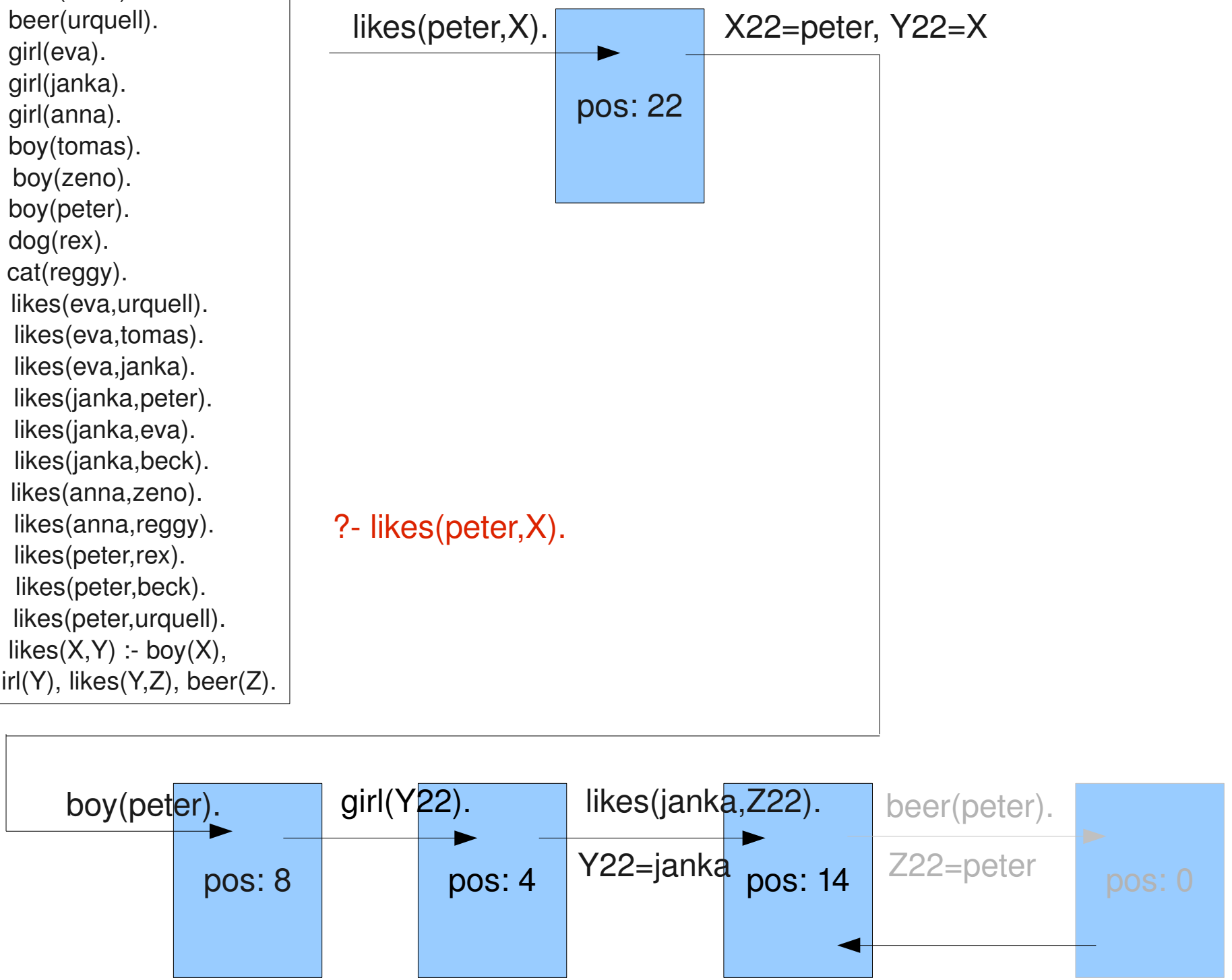

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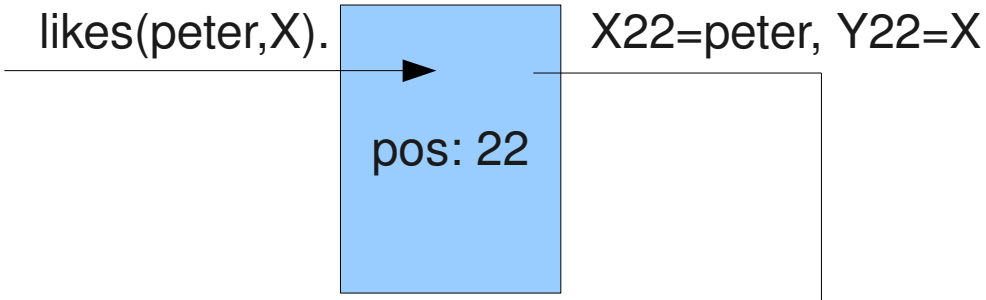

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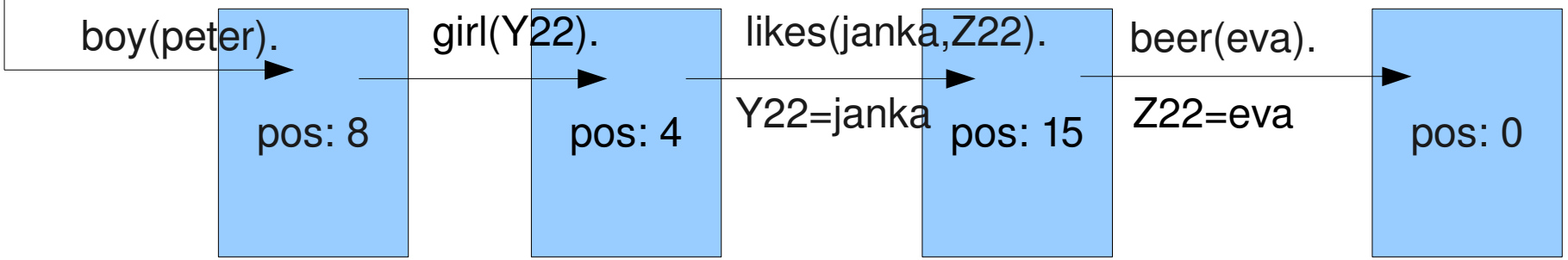

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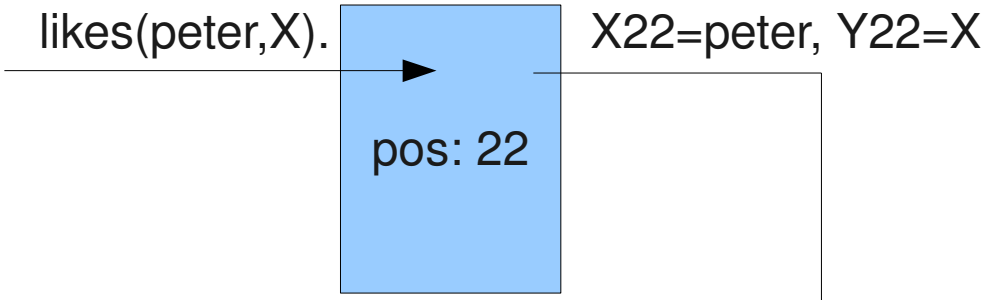

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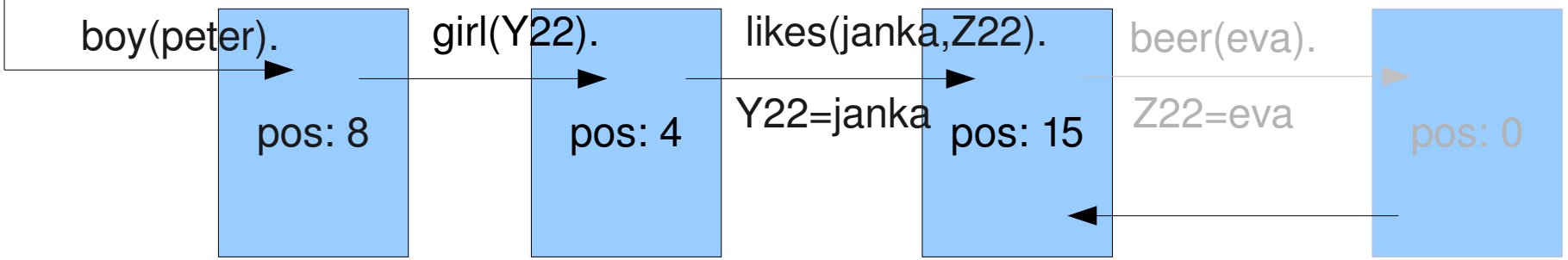

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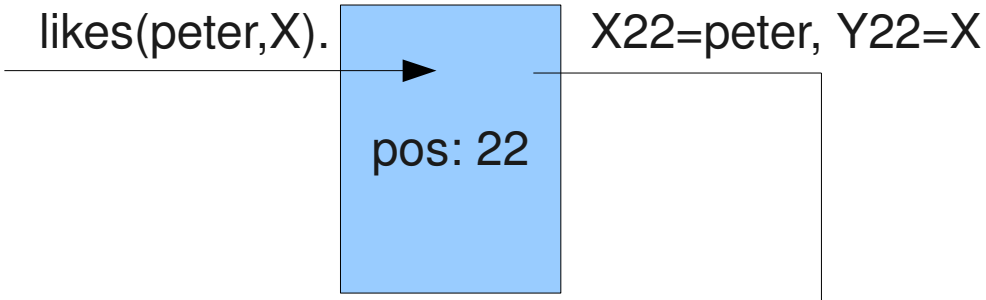

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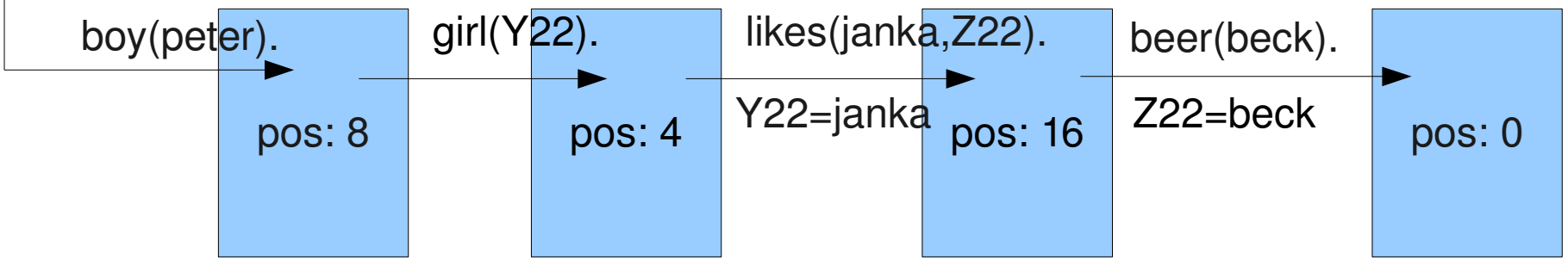

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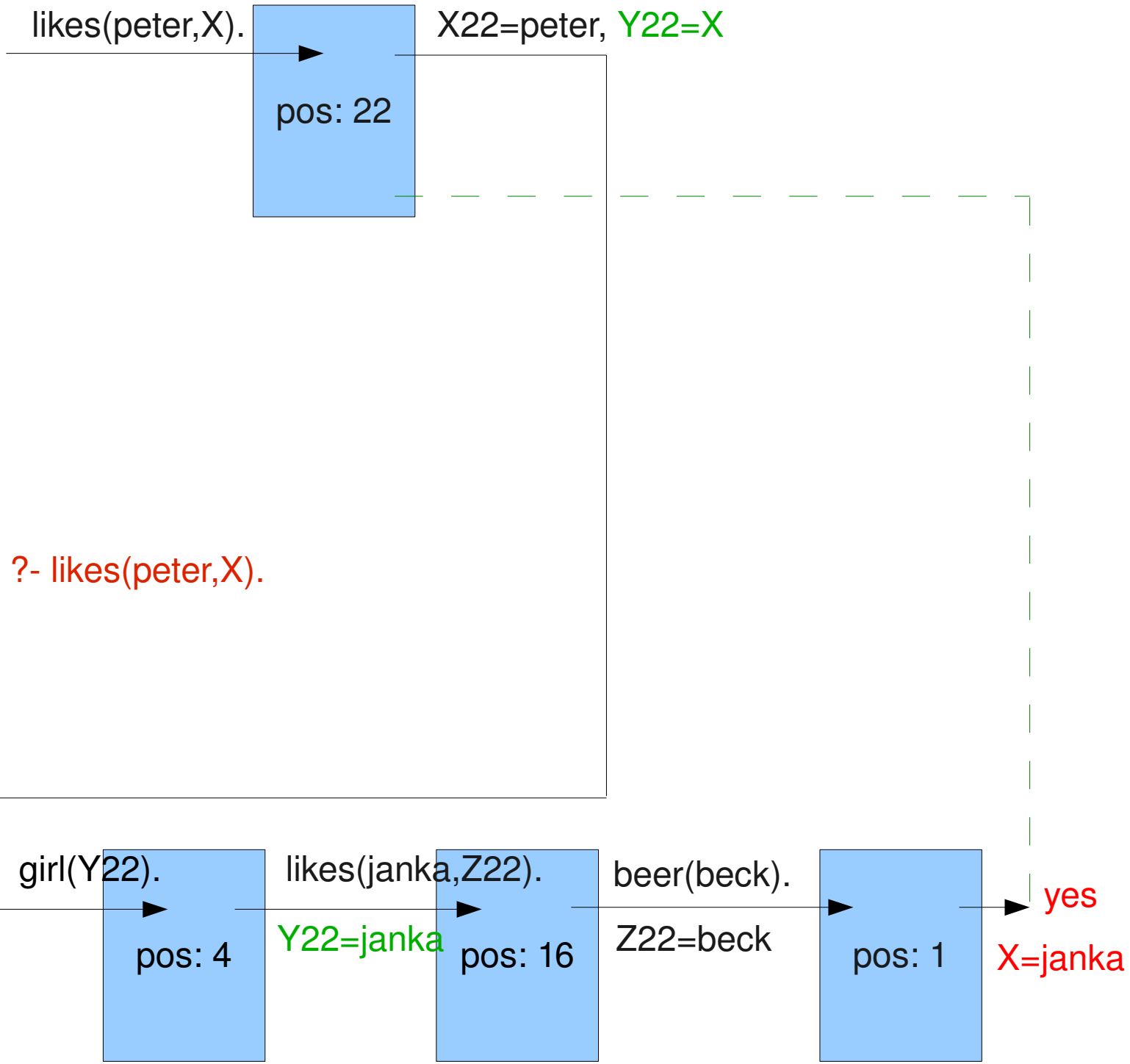

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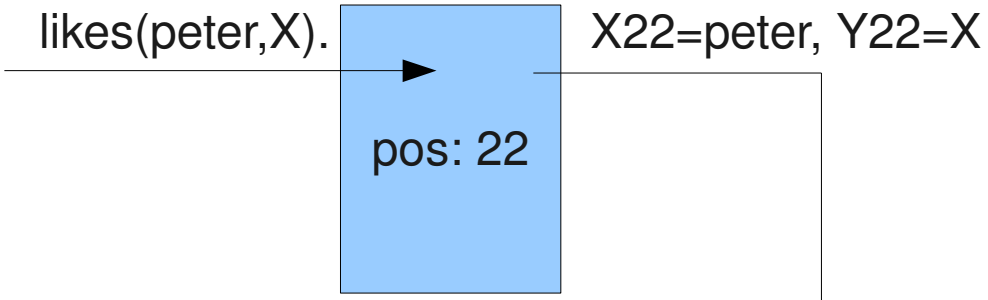

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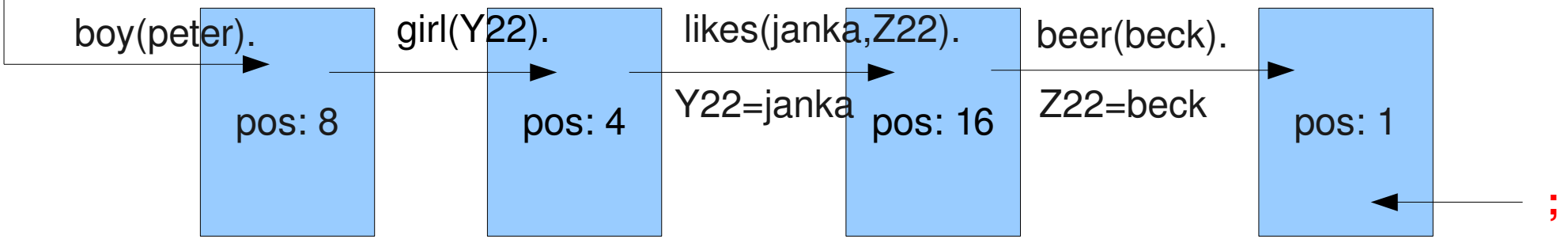

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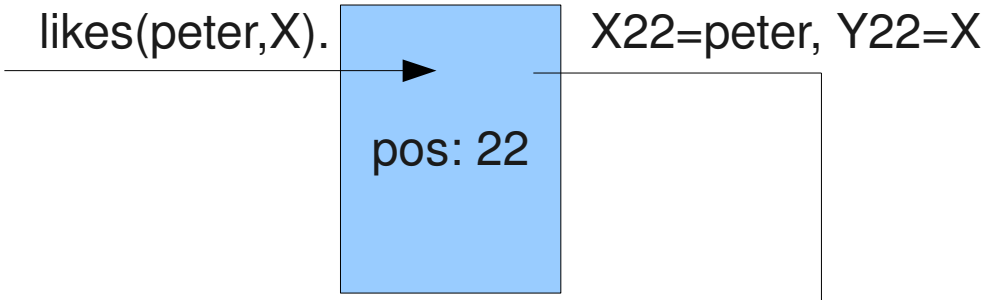

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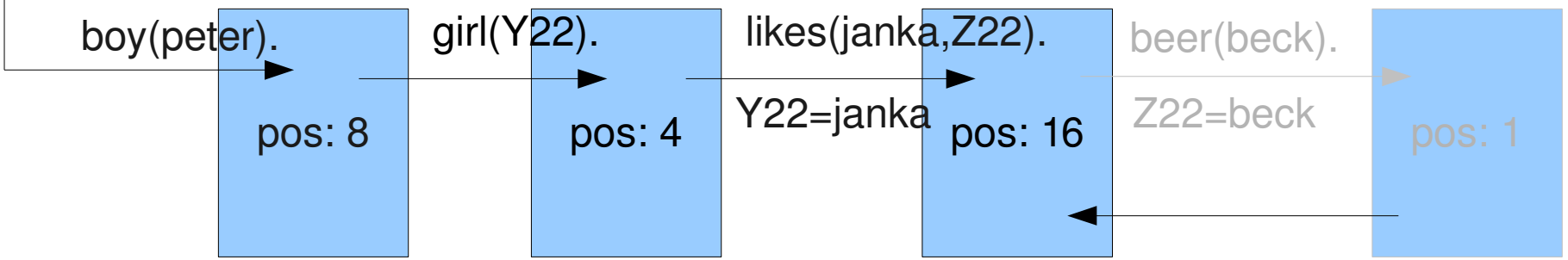

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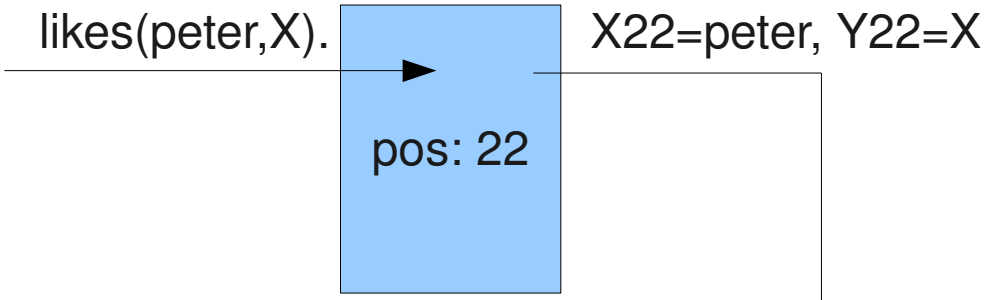

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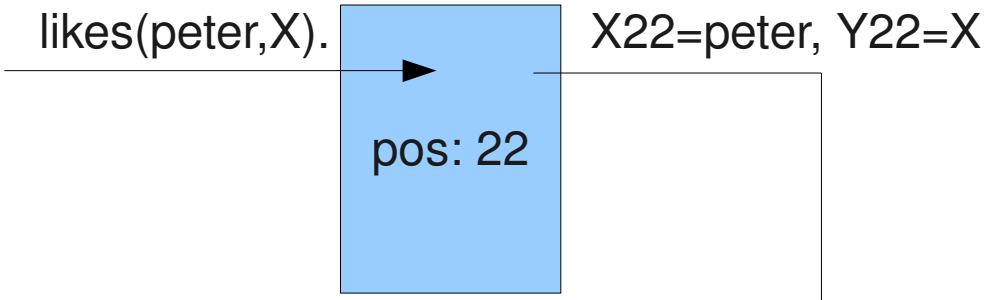

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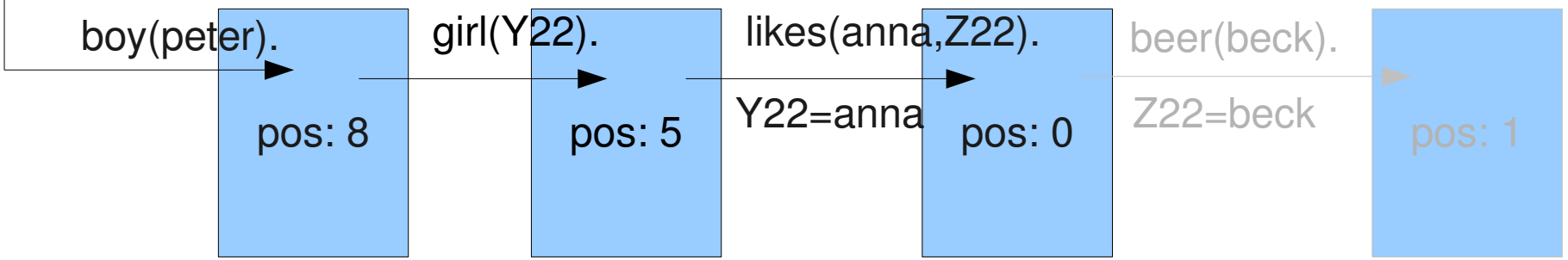

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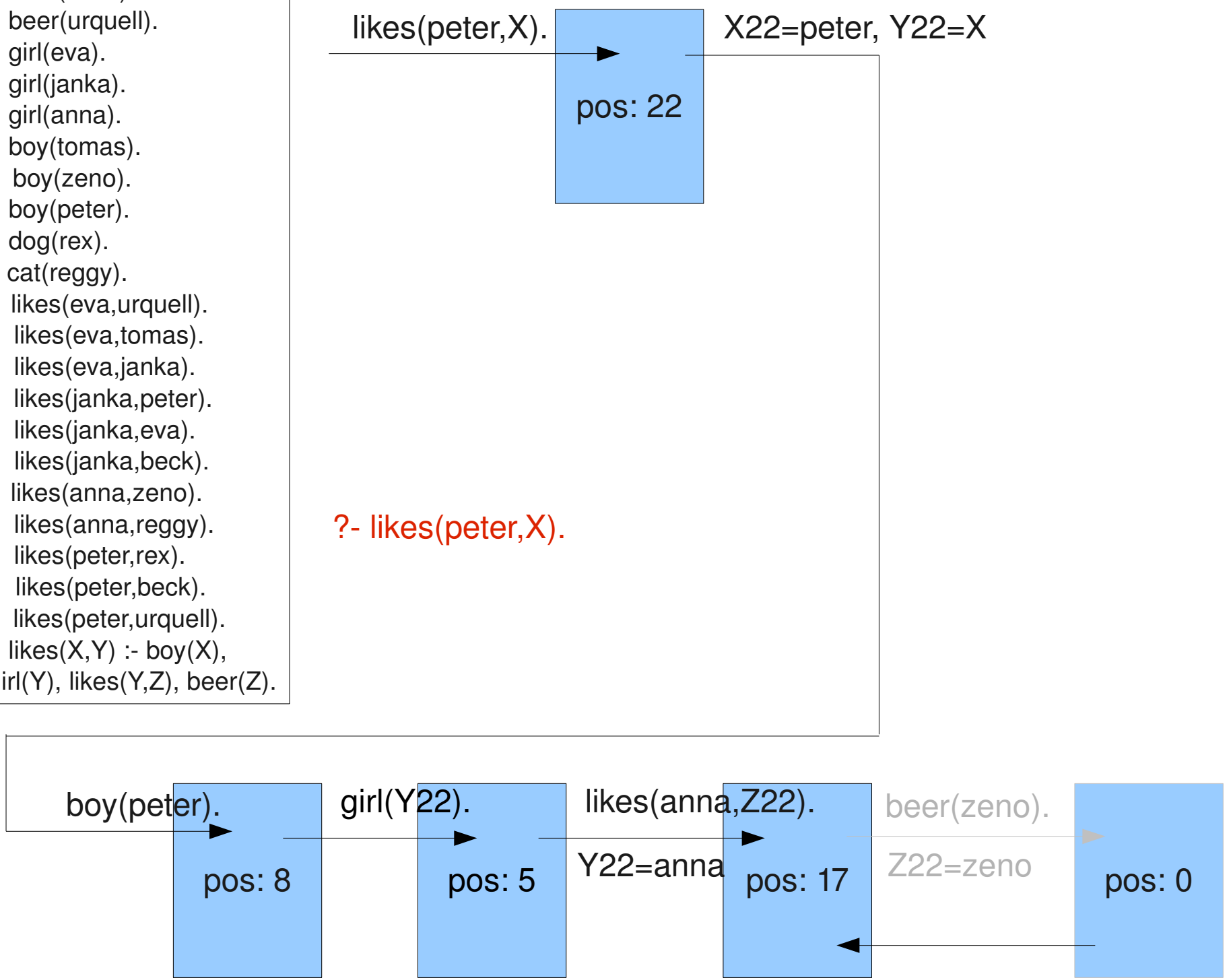

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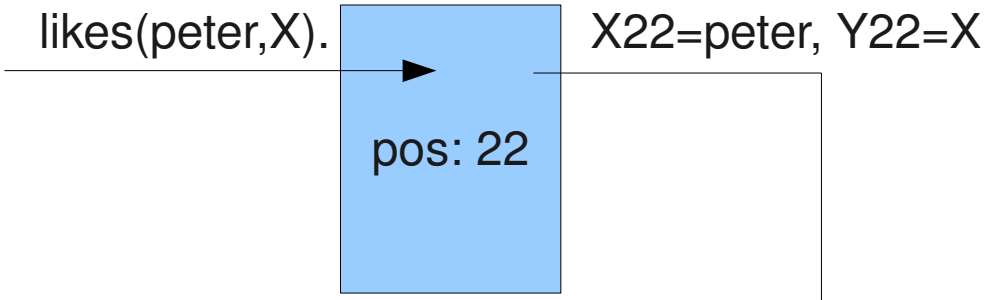

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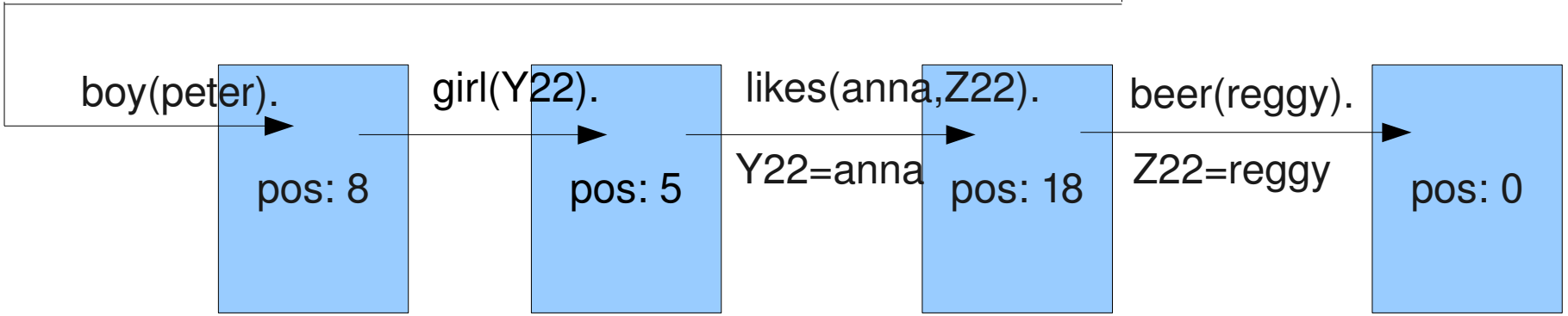

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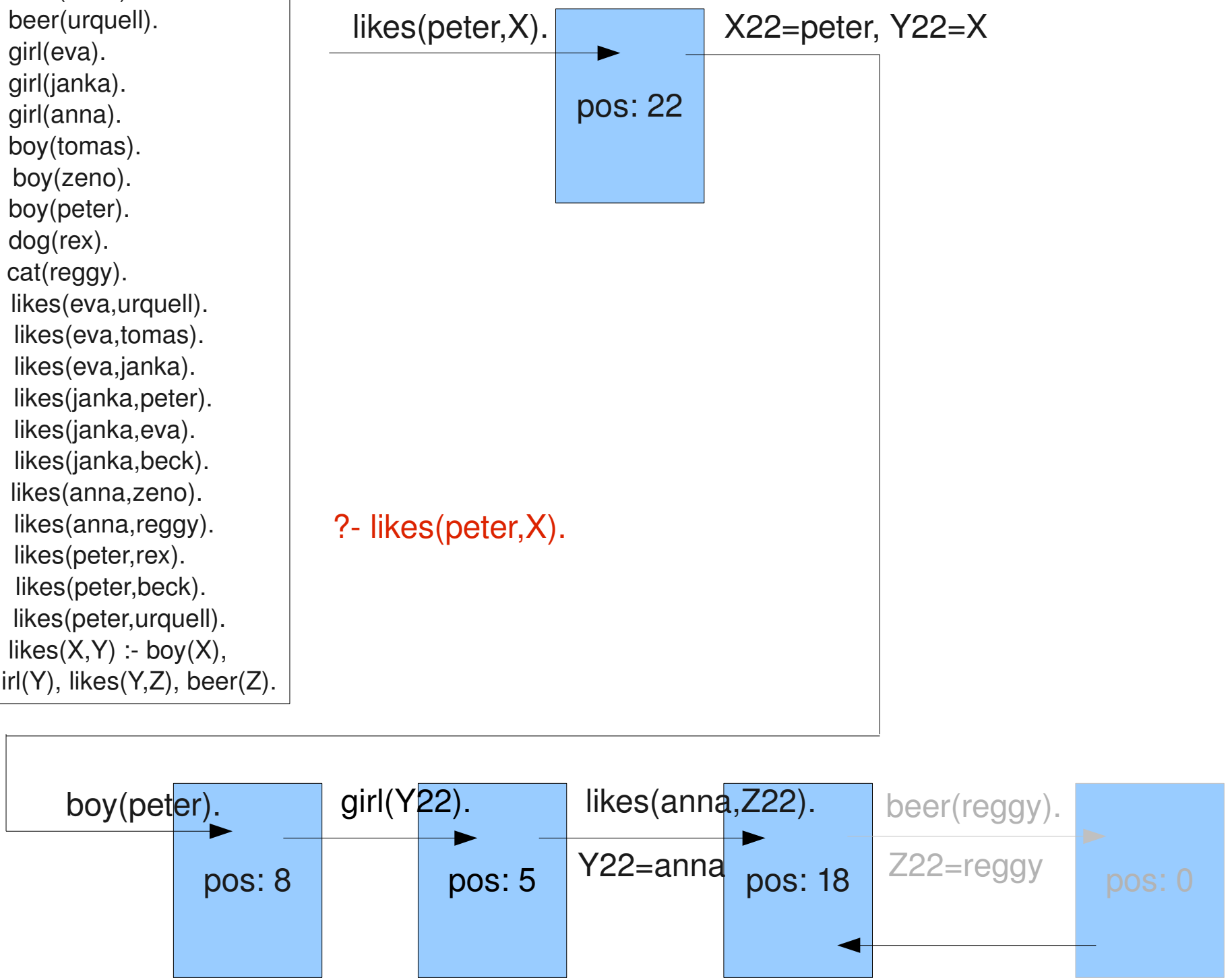

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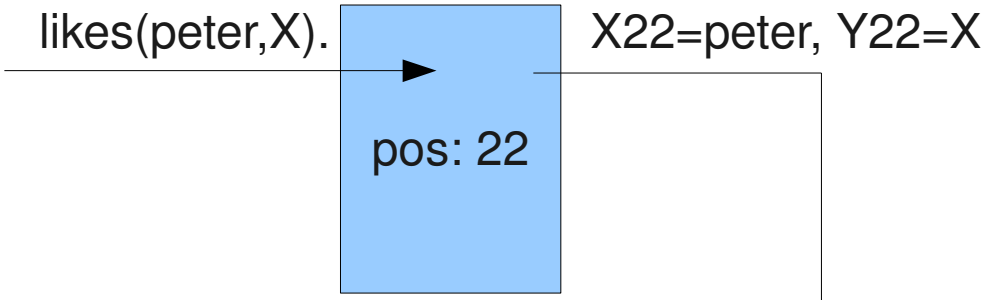
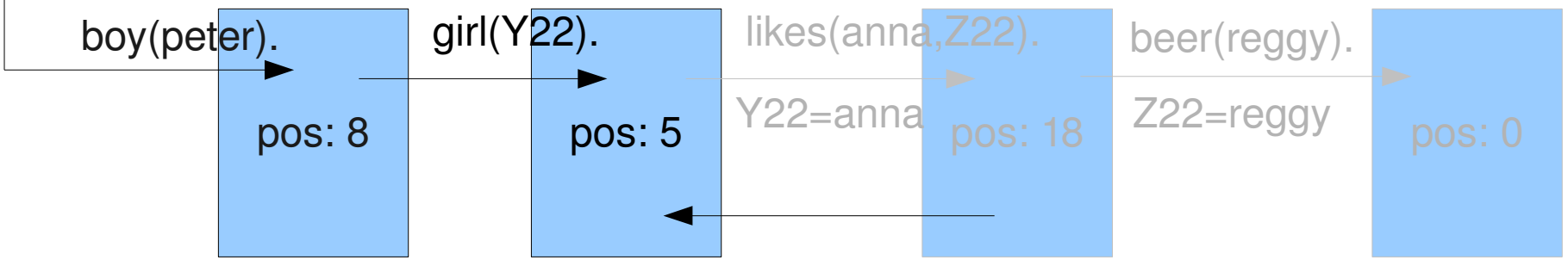


?- likes(peter,X).



1. beer(beck).
2. beer(urquell).
3. girl(eva).
4. girl(janka).
5. girl(anna).
6. boy(tomas).
7. boy(zeno).
8. boy(peter).
9. dog(rex).
10. cat(reggy).
11. likes(eva,urquell).
12. likes(eva,tomas).
13. likes(eva,janka).
14. likes(janka,peter).
15. likes(janka,eva).
16. likes(janka,beck).
17. likes(anna,zeno).
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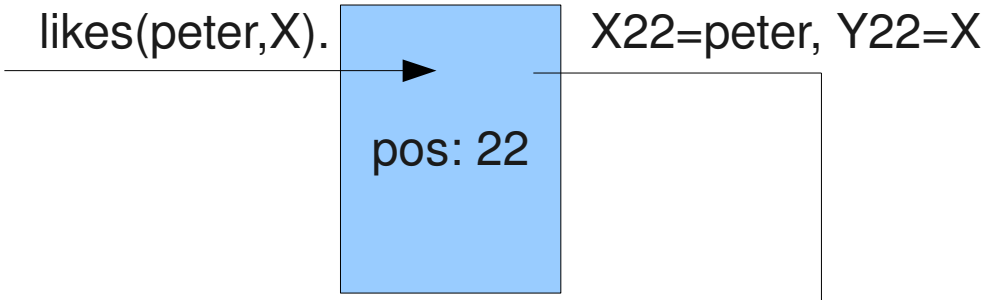

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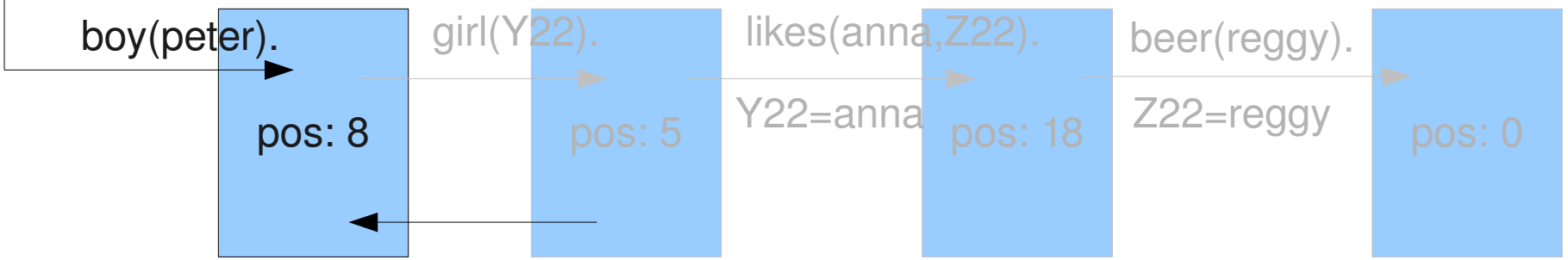

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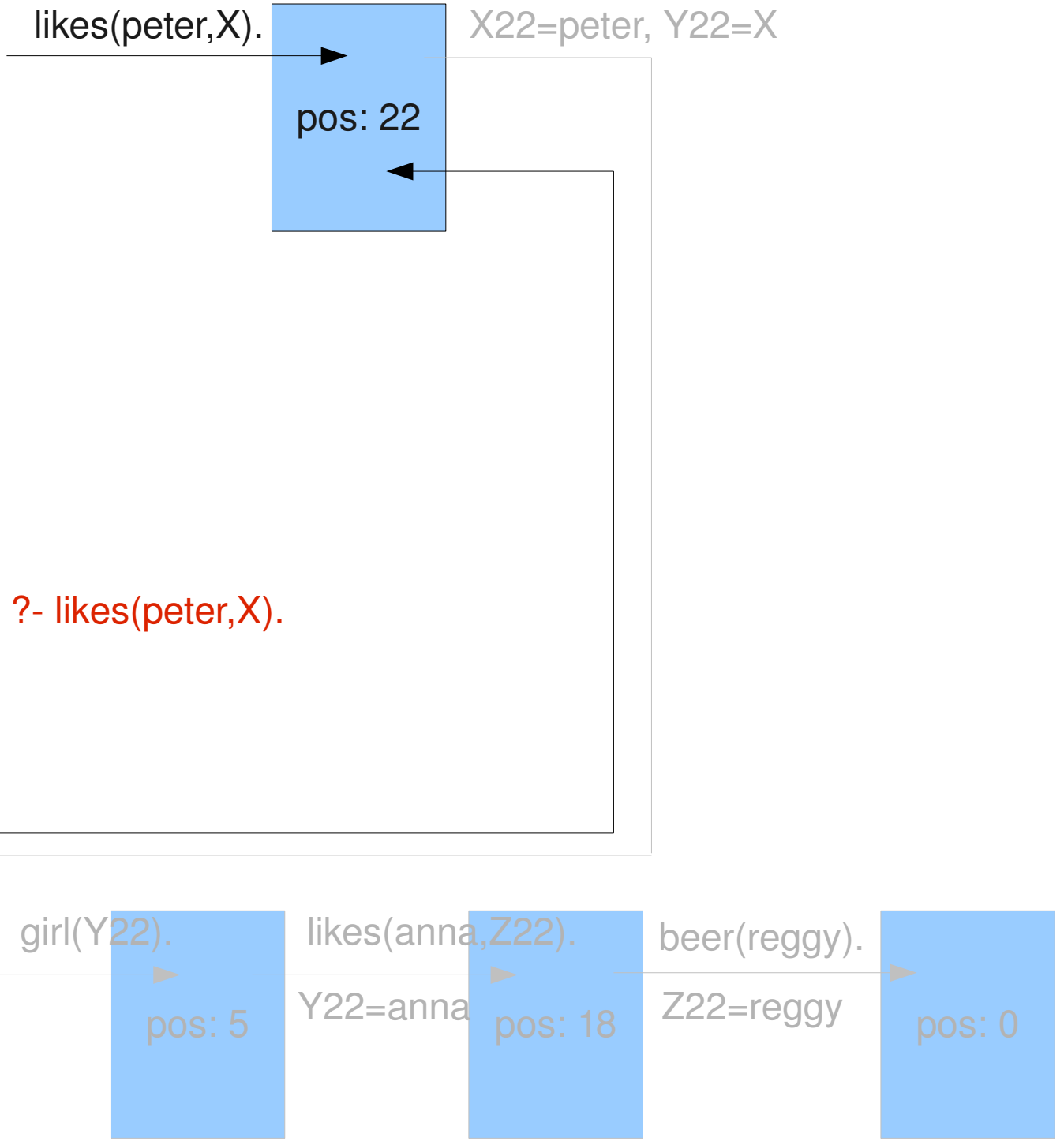

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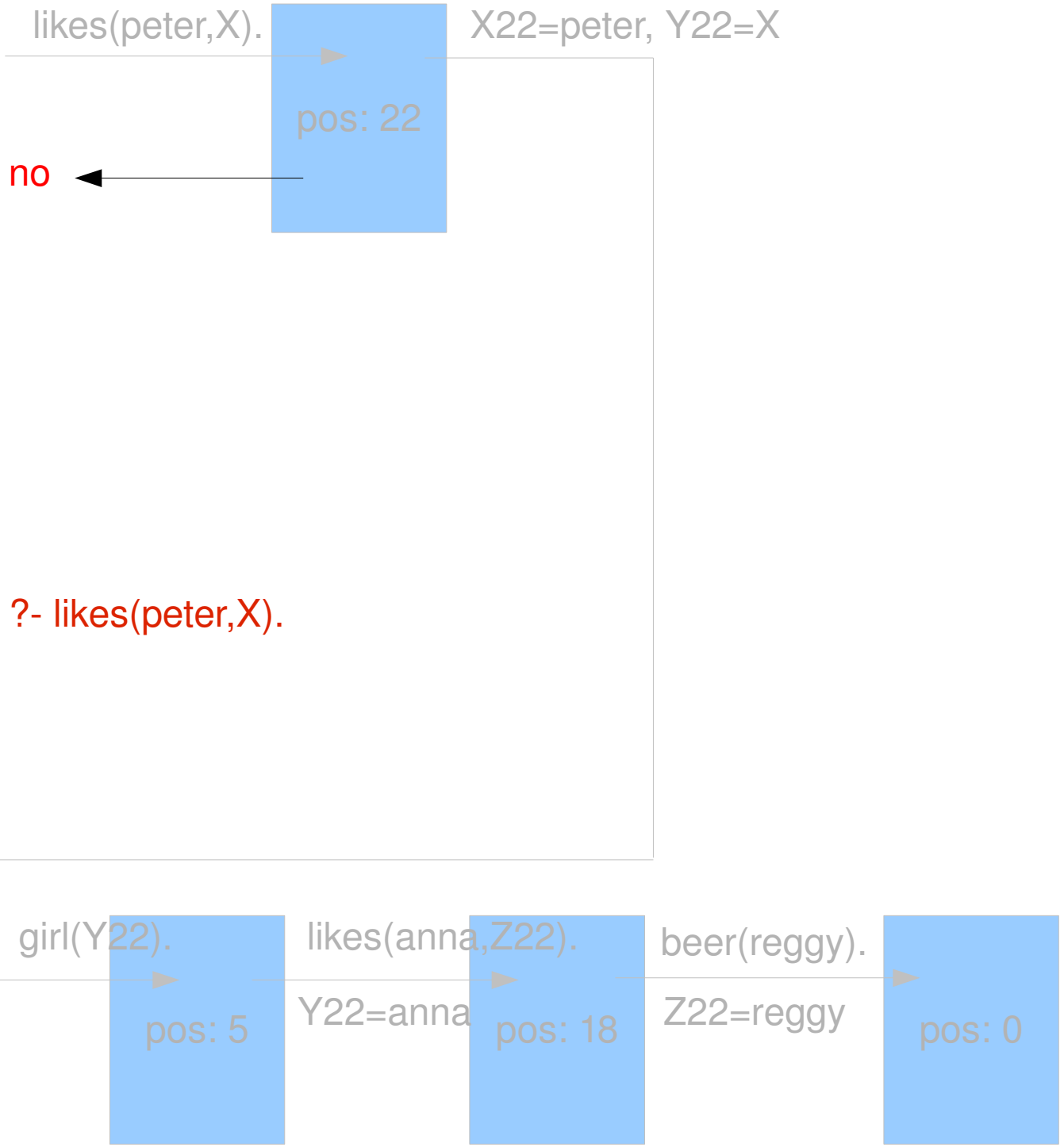

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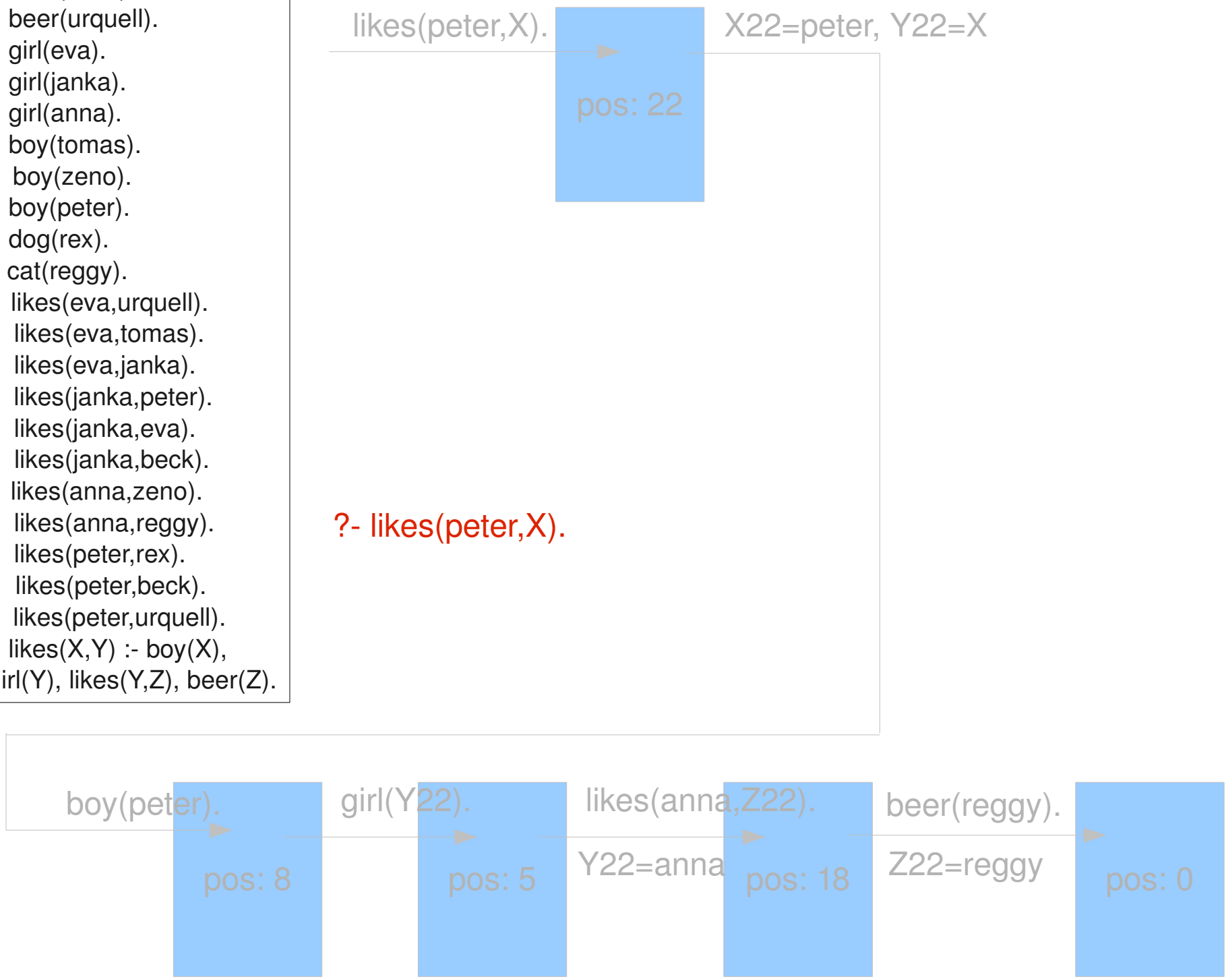


Negation vs. closed world

- “not”
  - not (Goal) is true if Goal is not true (i.e. not **derivable** from DB)

  likes(peter, jana). likes(fred,jana). likes(joe,jana). likes(peter,mary). likes(fred,mary). likes(joe,mary). likes(peter,paula). liikes(joe,paula). likes(peter,beer). likes(fred,beer). girl(jana). girl(paula). girl(mary). boy(peter). boy(fred). boy(joe).

- who is not liked by fred? who doesn't likes beer? who doesn't likes any girl? who likes all the girls?

Negation vs. closed world

?- not likes(fred,**W**ho).

?- no

?- not likes(Who, beer).

no

?-boy(B), girl(G), not likes(B,G).

no

4. question needs Universal quantifier but Prolog knows just Existential...

- why are such answers? how to solve it?

Trick is in smart asking ;-)

?- girl(G), not likes(fred,G).

G = paula → enter

no

?- (boy(Who); girl(Who)), not likes(Who, beer).

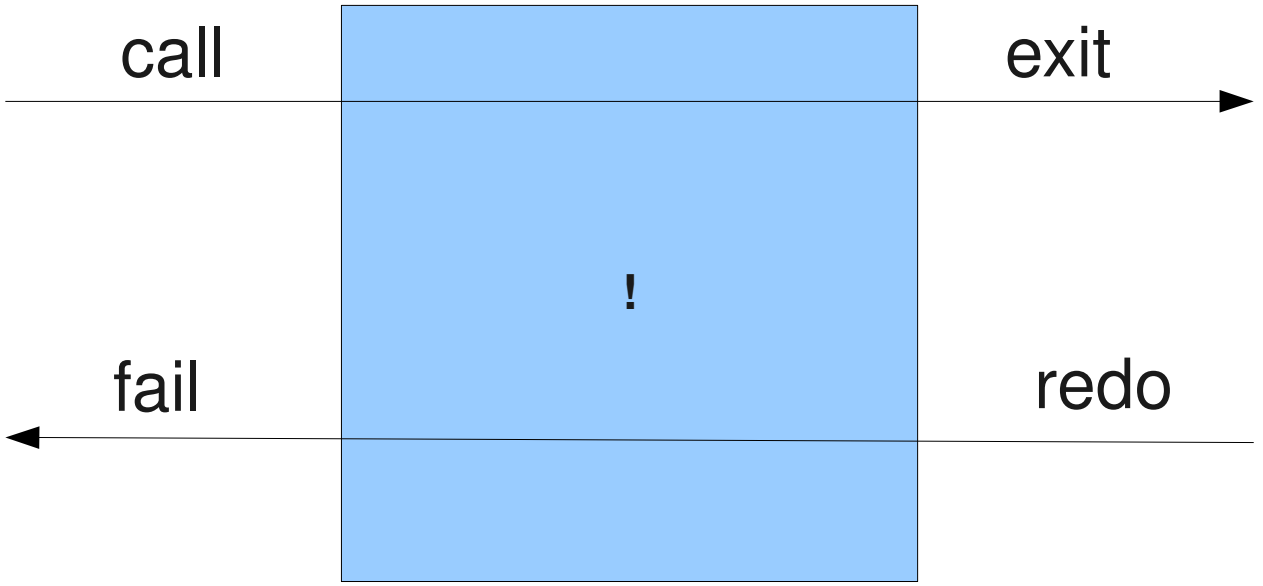
?- boy(B), not ((girl(G), likes(B,G))).

- (( )) for right interpretation of “,” as a conjunction and not as a parameter separator

?- boy(B), not((girl(G), not likes(B,G))).

The Cut !

- sounds like a title for a new thriller...
- predicate which exits immediately when call and fails immediately when redo



```
x(t).
x(tt).
a(t).
b(t).
b(ttt).
c(w).
c(ww).
d(v).
e(t).
f(t).

hc(X) :- x(X), nc(X), y(X).

nc(X) :- a(X), b(X), !, c(Y), d(Y).
nc(X) :- e(X), f(X).
```

The Cut !

```
[trace]  ?- hc(X).
   Call: (7) hc(_G335) ? creep
   Call: (8) x(_G335) ? creep
   Exit: (8) x(t) ? creep
   Call: (8) nc(t) ? creep
   Call: (9) a(t) ? creep
   Exit: (9) a(t) ? creep
   Call: (9) b(t) ? creep
   Exit: (9) b(t) ? creep
   Call: (9) c(_L212) ? creep
   Exit: (9) c(w) ? creep
   Call: (9) d(w) ? creep
   Fail: (9) d(w) ? creep
   Redo: (9) c(_L212) ? creep
   Exit: (9) c(ww) ? creep
   Call: (9) d(ww) ? creep
   Fail: (9) d(ww) ? creep
   Fail: (8) nc(t) ? creep
   Redo: (8) x(_G335) ? creep
   Exit: (8) x(tt) ? creep
   Call: (8) nc(tt) ? creep
   Call: (9) a(tt) ? creep
   Fail: (9) a(tt) ? creep
   Redo: (8) nc(tt) ? creep
   Call: (9) e(tt) ? creep
   Fail: (9) e(tt) ? creep
   Fail: (7) hc(_G335) ? creep
false.
```

- moreover, when fails all the predicates on her left are unable to redo
  - the parent goal (or the head of the rule) fails immediately, too

The Cut !

```
bigger(X,Y,Z) :- X < Y, Z is Y.
bigger(X,Y,Z) :- X > Y, Z is X.
```

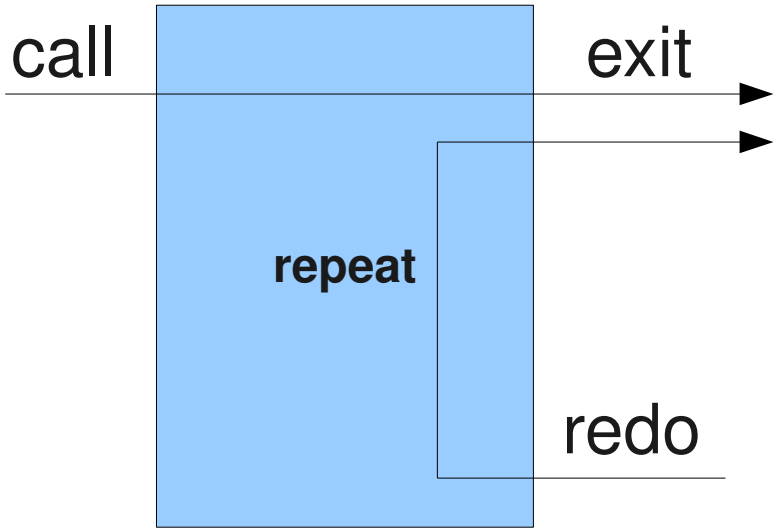
- Green cut (no impact on semantics)

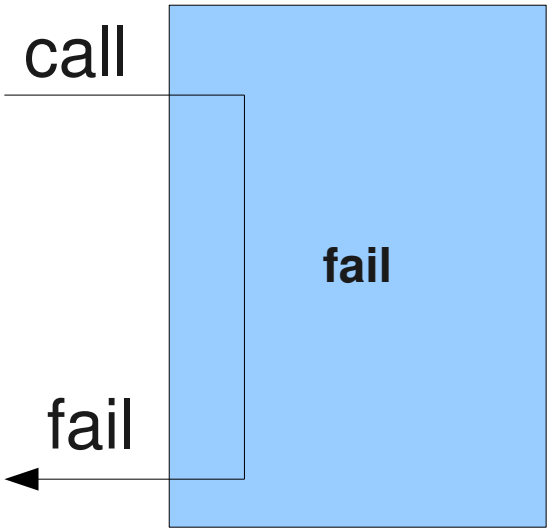
```
bigger1(X,Y,Y) :- X < Y, !.
bigger1(X,Y,X).
```

- Red cut (influences the semantics)
  - the real horror for computer scientists

```
bigger2(X,Y,Y) :- !, X < Y.
bigger2(X,Y,X).
```

Other interesting built-in predicates



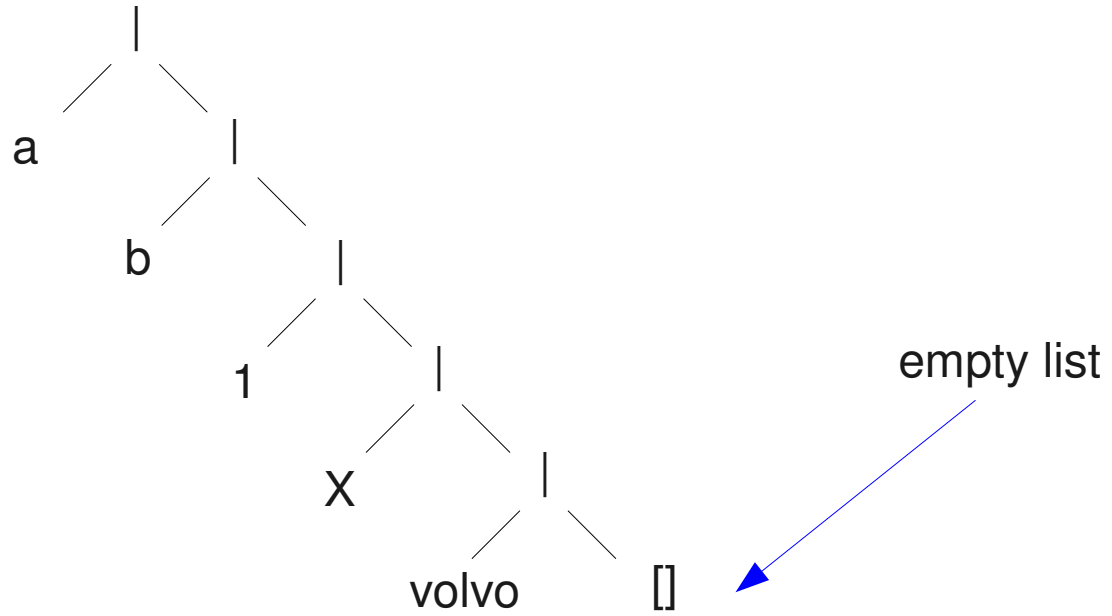



```
:- dynamic(man/1).

man(tomas). man(zeno).

write_men :- man(M), write(M), nl, fail.
write_men :- write('No other man in the database').
read_men :- repeat, write('Name: '), read(M), man(M), !.
add_man_first(M) :- asserta(man(M)).
add_man_last(M) :- assertz(man(M)).
delete_man(M) :- retract(man(M)).
```

changes the DB just implicitly

Lists

- [a,b,1,X,volvo]
  - in fact, it is a binary structure [Head | Body]
  - [a | [b | [1 | [X | [volvo | []]]]]]
    - direct access ONLY from the Head
    - can be represented as a tree



Lists

```
results(p1,[1,1,3,2,5,3]).
results(p2,[2,2,3,1,1,4]).

member(X,[X|_]).
member(X,[H|B]) :- member(X,B).

append([],L,L).
append([H|B1],L2,[H|B]) :- append(B1,L2,B).

reverse([],[]).
reverse([H|B],L) :- reverse(B,X), append(X,[H],L).

sum([],0).
sum([H|B],S) :- sum(B,S1), S is S1 + H.

compute_res1(Prog,Res) :- results(Prog,Results), sum(Results,Res).
```

References

- Lloyd, J. W. 1984 Foundations of Logic Programming. Springer-Verlag New York, Inc.
- this presentation was inspired by the following study materials:
  - Július Csontó: Umelá inteligencia v príkladoch. Elfa s.r.o, Košice, Slovakia, 1995.