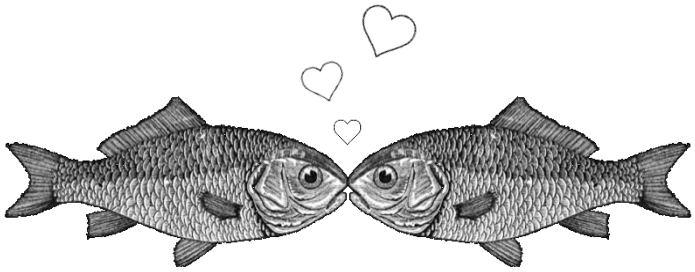
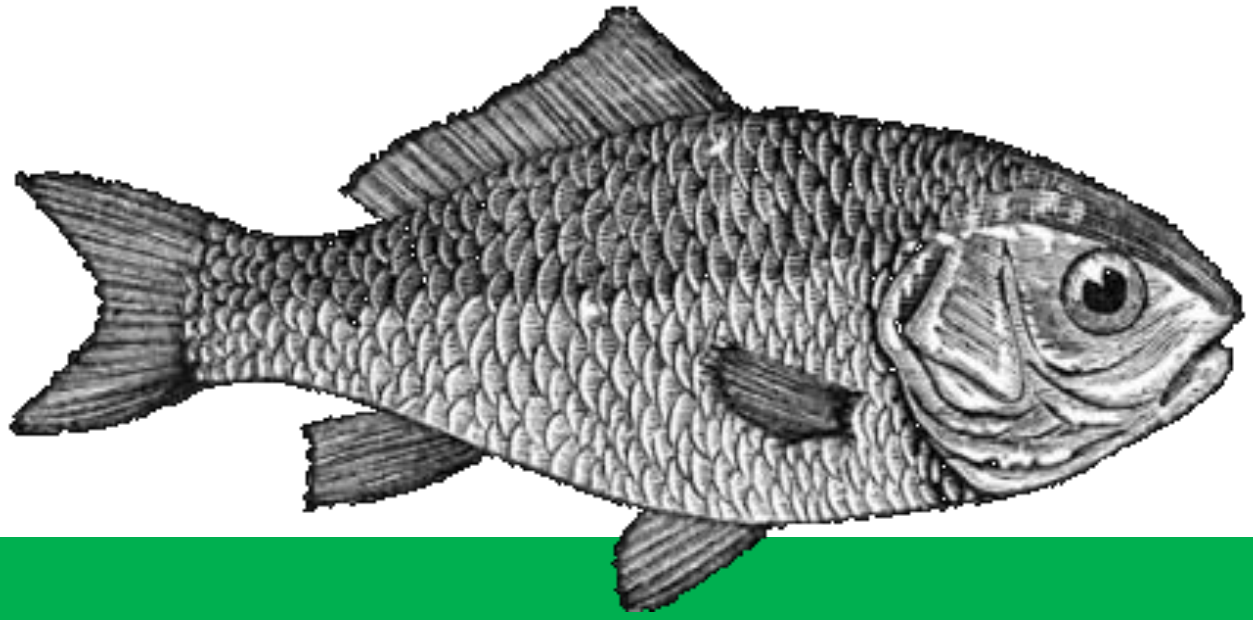
Primitive Guide

Version 1.2
Updated on 22-02-2017





A Fifth-generation Programming Langauge

PROLOG

Very high level langauge for beginner

FREE FOR ALL

Willow Fung

2017.

Basic

Command line> awk -f awkprolog.awk father.pro

Facts and Rules

File: father.pro	Output
father(johnny, thomas). father(samuel, david). father(james, kevin). father(thomas, edward). father(david, leo). father(david, peter). father(david, gordan). father(edward, joe). grandfather(X, Z) :- father(X, Y), father(Y, Z). ?- grandfather(Who, peter), writeln(Who). ?- grandfather(samuel, Who), writeln(Who), printmore.	samuel yes leo yes leo peter gordan fail

File: parent.pro	Output
human(david). human(john). human(suzie). human(eliza). man(david). man(john). woman(suzie). woman(eliza). parent(david, john). parent(john, eliza). parent(suzie, eliza). father(X,Y) :- parent(X,Y), man(X). mother(X,Y) :- parent(X,Y), woman(X). ?- father(Who, eliza), writeln(Who).	john yes suzie eliza yes

Arithmetic

Factorial

File: fac.pro	Output

`fac(1, 1) :- !.`
`fac(N, F) :- N2 is N - 1, fac(N2, F2), F is F2 * N.`
 	
`?- fac(5, R), writeln(R).`
	120
	yes

Fibonacci

File: fib.pro	Output

`fib(0, 0).`
`fib(1, 1).`
`fib(X, Y) :-`
`  X > 1,`
`  X2 is X - 2,`
`  fib(X2, Y2),`
`  X1 is X - 1,`
`  fib(X1, Y1),`
`  Y is Y1 + Y2.`
 	
`?- fib(7, F), writeln(F).`
	13
	yes

List Operations

File: member.pro	Output
member(X, [X|_]). member(X, [_|L]) :- member(X, L). ?- member(b,[a,b,c]). ?- member(X,[a,b,c]), writeln(X), allresult.	yes a b c fail

File: append.pro	Output
append([], L, L). append([H|T], L, [H|L2]) :- append(T, L, L2). ?- append([a, b], [c, d], C), writeln(C). ?- append(A, B, [a, b, c, d]), write(A), write(', '), writeln(B), all.	[a, b, c, d] yes [], [a, b, c, d] [a], [b, c, d] [a, b], [c, d] [a, b, c], [d] [a, b, c, d], [] Fail

File: length.pro	Output
length([], 0). length([_|L], N) :- length(L, N1), N is N1 + 1. ?- length([a, b, c, d, e], LEN), writeln(LEN).	5 yes

File: length.pro	Output
last(X, [X]). last(X, [_|L]) :- last(X, L). ?- last(X, [a, b, c, d, e]), writeln(X).	e yes

File: element_n.pro	Output
at(X, [X|_], 1). at(X, [_|L], N) :- N > 1, N1 is N - 1, at(X,L,N1). ?- at(X, [a, b, c, d, e], 3), writeln(X).	c yes

File: reverse.pro	Output
rev(L1, L2) :- rev2(L1, L2, []). rev2([],L,L). rev2([X|Xs], L2, Acc) :- rev2(Xs, L2, [X|Acc]). ?- rev([a, b, c, d, e], L), writeln(L).	[e, d, c, b, a] yes

File: drop.pro	Output
drop(X,[X|Xs],1,Xs). drop(X,[Y|Xs],K,[Y|Ys]) :- K > 1, K1 is K - 1, drop(X,Xs,K1,Ys). ?- N is 3, drop(X,[a,b,c,d,e],N,R), writeln(X), writeln(R).	c [a, b, d, e] yes

File: compress.pro	Output
compress([],[]). compress([X],[X]). compress([X,X|Xs],Zs) :- compress([X|Xs],Zs). compress([X,Y|Ys],[X|Zs]) :- notequal(X, Y), compress([Y|Ys],Zs). notequal(X, X) :- !, fail. notequal(X, Y). ?- compress([a,a,a,a,b,c,c,a,a,d,d,e,e,e,e], X), writeln(X).	[a, b, c, a, d, e] yes

File: pack.pro	Output
pack([],[]). pack([X|Xs],[Z|Zs]) :- transfer(X,Xs,Ys,Z), pack(Ys,Zs). transfer(X,[],[],[X]). transfer(X,[Y|Ys],[Y|Ys],[X]) :- notequal(X, Y). transfer(X,[X|Xs],Ys,[X|Zs]) :- transfer(X,Xs,Ys,Zs). notequal(X, X) :- !, fail. notequal(X, Y). ?- pack([a,a,a,a,b,c,c,a,a,d,e,e,e,e],X), writeln(X).	[a, b, c, a, d, e] yes

Problem Solving

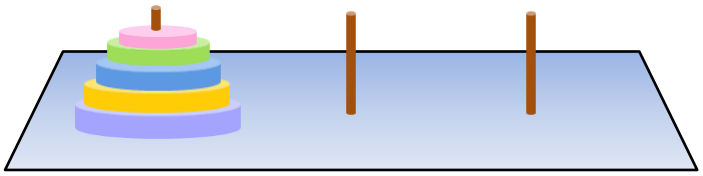
Run-length encoding

File: encoding.pro	Output

`notequal(X, X) :- !, fail.`
`notequal(X, Y).`
 	
`length([], 0).`
`length([_|L], N) :- length(L, N1), N is N1 + 1.`
 	
`pack([],[]).`
`pack([X|Xs],[Z|Zs]) :- transfer(X,Xs,Ys,Z),`
`pack(Ys,Zs).`
 	
`transfer(X,[],[],[X]).`
`transfer(X,[Y|Ys],[Y|Ys],[X]) :- notequal(X, Y).`
`transfer(X,[X|Xs],Ys,[X|Zs]) :-`
`transfer(X,Xs,Ys,Zs).`
 	
`transform([],[]).`
`transform([[X|Xs]|Ys],[[N,X]|Zs]) :-`
`length([X|Xs],N), transform(Ys,Zs).`
 	
`encode(L1,L2) :- pack(L1,L), transform(L,L2).`
 	
`?- encode([a,a,b,c,c,c,a,a,d,e,e,e,e],X),`
`writeln(X).`
	[[2, a], [1, b], [3, c], [2, a], [1, d], [4, e]]
	yes

Hanoi Tower

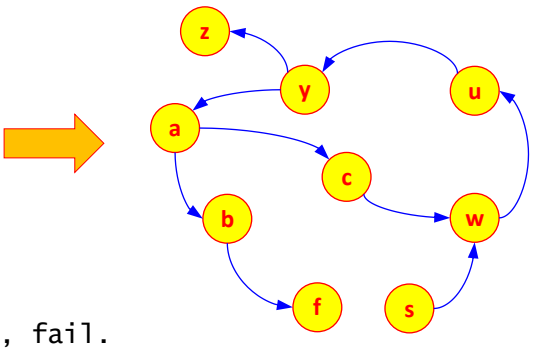
File: hanoi.pro	Output

`hanoi(N) :- move(N, left, middle, right).`
`move(1, A, U, C) :- inform(A, C), !.`
`move(N, A, B, C) :-`
`  N1 is N - 1,`
`  move(N1, A, C, B),`
`  inform(A, C),`
`  move(N1, B, A, C).`
 	
`inform(P1, P2) :- write(P1), write(' -> '),`
`writeln(P2).`
 	
`?- hanoi(5).`
 	
 
	left -> right
	left -> middle
	right -> middle
	left -> right
	middle -> left
	middle -> right
	left -> right
	left -> middle
	right -> middle
	right -> left
	middle -> left
	right -> middle
	left -> right
	left -> middle
	right -> middle
	left -> right
	middle -> left
	middle -> right
	left -> right
	middle -> left
	right -> middle
	right -> left
	middle -> left
	middle -> right
	left -> right
	left -> middle
	right -> middle
	left -> right
	middle -> left
	middle -> right
	left -> right
	yes

Find Path

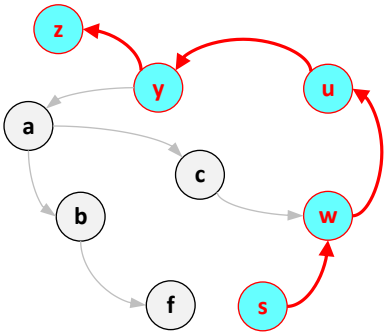
File: path.pro

```
a(a, c).
a(a, b).
a(b, f).
a(s, w).
a(y, a).
a(y, z).
a(w, u).
a(u, y).
a(c, w).

not(G) :- G, !, fail.
not(G).

path(X, X, T, [X]).
path(X, Z, T, [X|T2]) :-
        a(X, Y),
        not(member(Y, T)),
        path(Y, Z, [Y|T], T2).

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

?- path(s, z, [], P),
    write('The path from s to z : '),
    writeln(P).
```



Output

```
The path from s to z : [s, w, u, y, z]
yes
```



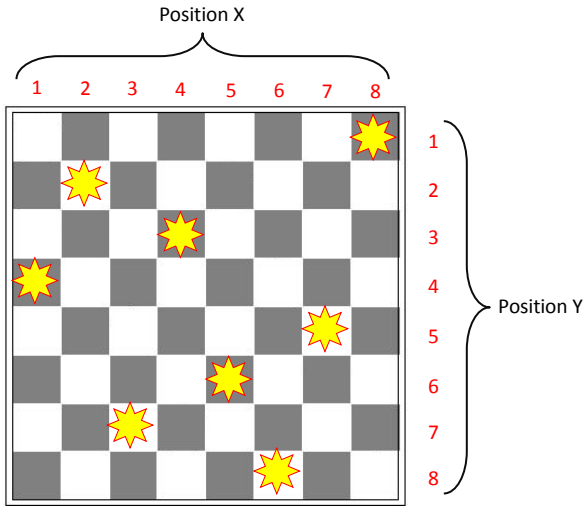
Eight Queen Problem

File: queen8.pro

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

sol([]).
sol([X / Y | Other]) :-
        sol(Other),
        member(Y, [1,2,3,4,5,6,7,8]),
        noattack(X / Y, Other).

noattack(_, []).
noattack(X / Y, [X1 / Y1 | Other]) :-
        Y =\= Y1,
        Y1 - Y =\= X1 - X,
        Y1 - Y =\= X - X1,
        noattack(X/Y, Other).

template([1/Y1, 2/Y2, 3/Y3, 4/Y4,
          5/Y5, 6/Y6, 7/Y7, 8/Y8]).

?- template(S), sol(S), writeln(S).
```

Output

```
[pos(1, 4), pos(2, 2), pos(3, 7), pos(4, 3),
pos(5, 6), pos(6, 8), pos(7, 5), pos(8, 1)]
yes
```

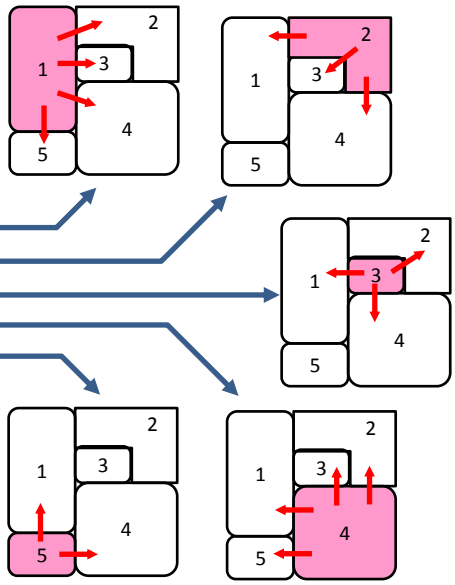


Four Color Map

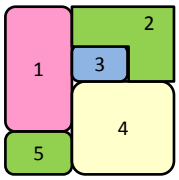
File: map4color.pro

```
color(red).
color(green).
color(blue).
color(yellow).

n(StateAColor, StateBColor) :- color(StateAColor),
    color(StateBColor),
    not(eq(StateAColor, StateBColor)).


not(G) :- G, !, fail.
not(G).
eq(X, X).

%*********************************
% Define states in a Country
%*********************************

country(S1, S2, S3, S4, S5) :-
   n(S1, S2), n(S1, S3), n(S1, S4), n(S1, S5),
   n(S2, S1), n(S2, S3), n(S2, S4),
   n(S3, S1), n(S3, S2), n(S3, S4),
   n(S4, S1), n(S4, S2), n(S4, S3), n(S4, S5),
   n(S5, S1), n(S5, S4).



?-  R is country(S1, S2, S3, S4, S5),
    R,
    writeln(R).
```

Output



country(red, green, blue, yellow, green)
yes



Basic Sorting Algorithm

File: sortbubble.pro	Output
sort(L, S) :- swap(L, L1), !, sort(L1, S). sort(S, S). swap([X, Y | R], [Y, X | R]) :- X > Y. swap([Z | R], [Z | R1]) :- swap(R, R1). ?- sort([6, 45, 30, 21, 23, 20, 8, 7, 32, 1], S), writeln(S).	[1, 6, 7, 8, 20, 21, 23, 30, 32, 45] yes

File: sortquick.pro	Output
qsort([], []). qsort([X|T], S) :- split(X, T, SM, BI), qsort(SM, SSM), qsort(BI, SBI), conc(SSM, [X|SBI], S). split(X, [], [], []). split(X, [Y|T], [Y|S], B) :- X > Y, !, split(X, T, S, B). split(X, [Y|T], S, [Y|B]) :- split(X, T, S, B). conc([],L,L). conc([X|L1],L2,[X|L3]) :- conc(L1,L2,L3). ?- qsort([6, 45, 30, 21, 23, 20, 8, 7, 32, 1], S), writeln(S).	[1, 6, 7, 8, 20, 21, 23, 30, 32, 45] yes

Computer Language Prototype

File: parser.pro

```
eat(err, L, L) :- !.
eat(X, [X|T], T) :- !.
true.

%*****************************************************
block(Va, Vb, Vc) :-
   eat(begin, Vb, Vd), actions(Va, Vd, Ve), eat(end, Ve, Vc).
actions([Va|Vb], Vc, Vd) :-
   action(Va, Vc, Ve), more_actions(Vb, Ve, Vd).
more_actions(Va, Vb, Vc) :- eat(sep, Vb, Vd), actions(Va, Vd, Vc).
more_actions([], Va, Va) :- true.
action(if(Va, Vb, Vc), Vd, Ve) :-
   eat(if, Vd, Vf), cond(Va, Vf, Vg), eat(then, Vg, Vh), block(Vb, Vh, Vi),
   eat(else, Vi, Vj), block(Vc, Vj, Ve).
action(while(Va, Vb), Vc, Vd) :-
   eat(while, Vc, Ve), cond(Va, Ve, Vf), eat(do, Vf, Vg), block(Vb, Vg, Vd).
action(assign(Va, Vb), Vc, Vd) :-
   eat(id(Va), Vc, Ve), eat(eq, Ve, Vf), expr(Vb, Vf, Vd).
expr(Va, Vb, Vc) :-
   term(Vd, Vb, Ve), exprtail(Vd, Va, Ve, Vc).
exprtail(Va, add(Va, Vb), Vc, Vd) :-
   eat(add, Vc, Ve), term(Vf, Ve, Vg), exprtail(Vf, Vb, Vg, Vd).
exprtail(Va, sub(Va, Vb), Vc, Vd) :-
   eat(sub, Vc, Ve), term(Vf, Ve, Vg), exprtail(Vf, Vb, Vg, Vd).
exprtail(Va, mul(Va, Vb), Vc, Vd) :-
   eat(mul, Vc, Ve), term(Vf, Ve, Vg), exprtail(Vf, Vb, Vg, Vd).
exprtail(Va, div(Va, Vb), Vc, Vd) :-
   eat(div, Vc, Ve), term(Vf, Ve, Vg), exprtail(Vf, Vb, Vg, Vd).
exprtail(Va, Va, Vb, Vb) :- true.
term(id(Va), Vb, Vc) :- eat(id(Va), Vb, Vc).
term(const(Va), Vb, Vc) :- eat(const(Va), Vb, Vc).

cond(Va, Vb, Vc) :- eat(id(Vd), Vb, Ve), ctail(Vd, Va, Ve, Vc).
ctail(Va, eq(Va, Vb), Vc, Vd) :- eat(eq, Vc, Ve), expr(Vb, Ve, Vd).
ctail(Va, ne(Va, Vb), Vc, Vd) :- eat(ne, Vc, Ve), expr(Vb, Ve, Vd).
ctail(Va, idtest(Va), Vb, Vb) :- true.
```

File: proc_1.pas

```
?- L = [begin, id("X"), eq, const(5), add, const(3), sep, id("Y"), eq, id("X"), sub, const(2),
end], block(T, L, R), writeln(T).

?- L = [if, id("X"), eq, const(3), add, id("Y"), then, begin, id("X"), eq, const(3), end,
else, begin, id("X"), eq, const(4), end], actions(T, L, R), writeln(T).
```

Command line> awk -f awkprolog.awk parser.pro proc_1.pas

Orginal code:

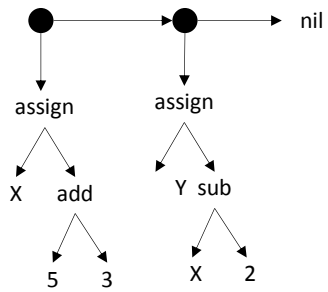
```
begin
   X = 5 + 3 ;
   Y = X - 2 ;
end
```

Prolog list format:

```
[begin,
  id("X"), eq, const(5), add, const(3), sep,
  id("Y"), eq, id("X"), sub, const(2),
end]
```

Parse to Abstract Syntax Tree:

```
[ assign(X, add(const(5), const(3))),
  assign(Y, sub(id(X), const(2))) ]
```



File: compiler.pro

```
cg(I, [pushc(I)]) :- number(I).
cg(A, [push(A)]) :- atomic(A).

cg(add(X, Y), [CX, CY, add]) :- cg(X, CX), cg(Y, CY).
cg(sub(X, Y), [CX, CY, sub]) :- cg(X, CX), cg(Y, CY).
cg(mul(X, Y), [CX, CY, mul]) :- cg(X, CX), cg(Y, CY).

cg(cmp(s_gt, X, Y), [CX, CY, gt]) :- cg(X, CX), cg(Y, CY).
cg(cmp(s_lt, X, Y), [CX, CY, lt]) :- cg(X, CX), cg(Y, CY).
cg(cmp(s_equ, X, Y), [CX, CY, equ]) :- cg(X, CX), cg(Y, CY).
cg(cmp(not_equ, X, Y), [CX, CY, not_equ]) :- cg(X, CX), cg(Y, CY).
cg(cmp(s_ge, X, Y), [CX, CY, ge]) :- cg(X, CX), cg(Y, CY).
cg(cmp(s_le, X, Y), [CX, CY, le]) :- cg(X, CX), cg(Y, CY).

cg(func(main, X, Y), [CY, halt]) :- cg(Y, CY).
cg(func(F, X, Y), [pushc(R1), pop(F), bz(R2), label(R1), CY, ret, label(R2)]) :- cg(Y, CY).

cg(assign_stm(X, Y), [CY, pop(X)]) :- cg(Y, CY).
cg(while_stm(X, S), [label(R1), CX, bz(R2), SX, br(R1), label(R2)]) :-
          cg(X, CX), cg(S, SX).

cg([], []).
cg([A|B], [CA, CB]) :- cg(A, CA), cg(B, CB).


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

flatten([], []).
flatten([H|T], L3) :- flatten(H, L1), flatten(T, L2), append(L1, L2, L3).
flatten(X, [X]).

find_symbol([], D, D) :- !.
find_symbol([push(X) | T], D, D3) :- add_sym(X, D, D2), find_symbol(T, D2, D3).
find_symbol([pop(X) | T], D, D3) :- add_sym(X, D, D2), find_symbol(T, D2, D3).
find_symbol([H | T], D, DD) :- find_symbol(T, D, DD).

member(X, [X | L]) :- !.
member(X, [Y | L]) :- member(X, L).

add_sym(X, L, L) :- member(X, L).
add_sym(X, L, [X | L]).

allocate([], N, []).
allocate([H | T], N, [sym(H, N) | T2]) :- N2 is N + 1, allocate(T, N2, T2).

relocate([], SYM, []) :- !.
relocate([push(X) | T], D, [push(Y) | T2]) :-
          member(sym(X, Y), D), relocate(T, D, T2).
relocate([pop(X) | T], D, [pop(Y) | T2]) :-
          member(sym(X, Y), D), relocate(T, D, T2).
relocate([H | T], D, [H | T2]) :- relocate(T, D, T2).

out_code([], N) :- !.
out_code([label(A)|T], N) :- !, out_code(T, N).
out_code([H|T], N) :- !, write(N), write(':'), writeln(H), N2 is N + 1, out_code(T, N2).

ass([], N, N, D, D) :- !.
ass([label(A)|T], A, B, D, D2) :- !, ass(T, A, B, D, D2).
ass([H|T], N, NN, D, D2) :- !, N2 is N + 1, ass(T, N2, NN, D, D2).


gen(T) :- writeln('compile...'), cg(T, C), flatten(C, L),
          writeln('assemble...'), ass(L, 0, HEAP, [], FUN_LIST),
          writeln('generate symbol table...'), find_symbol(L, [], SYM_LIST),
          writeln('allocate...'), allocate(SYM_LIST, HEAP, SYM_ADDR),
          writeln('relocate...'), relocate(L, SYM_ADDR, L2),
          out_code(L2, 0),
          writeln(SYM_ADDR),
          writeln(FUN_LIST).
```

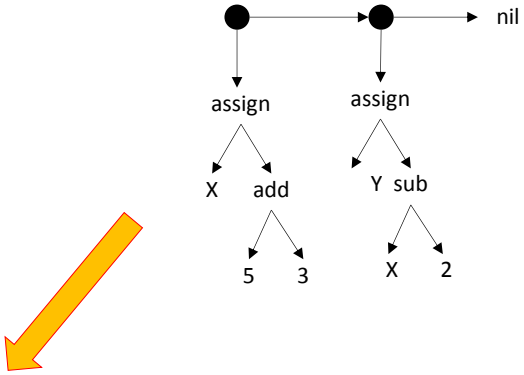
File: proc_2.ast

```
?- AST = func(main, void,
        [assign_stm(a, 10),
         assign_stm(b, add(a, 2))]
), gen(AST).
```

Command line> awk -f awkprolog.awk compiler.pro proc_2.ast

Parse to Abstract Syntax Tree:

[assign(x, add(5, 3)),
assign(y, sub(x, 2))]



Intermediate Instruction Generation:

```
ast
compile...
assemble...
generate symbol table...
allocate...
relocate...
0:pushc(5)
1:pushc(3)
2:add
3:pop(10)
4:push(10)
5:pushc(2)
6:sub
7:pop(9)
8:halt
[sym(y, 9), sym(x, 10)]
[]
yes
```

Memory Slot Allocation:

Addr	Instruction	Description
0	pushc 5	Push const 5
1	pushc 3	Push const 3
2	add	Calculate (add) and return result to stack
3	pop 10	Pop a value(8) from stack to address 10 (var X's addr.)
4	push 10	Push from address 10 (var X's addr.)
5	pushc 2	Push const 2
6	sub	Calculate (subtract) and return result to stack
7	pop 9	Pop a value(7) from stack to address 9 (var Y's addr.)
8	halt	Stop te program
9	Y	Address of Variable Y
10	X	Address of Variable X

Symbol Table:

Symbol	Address
Y	9
X	10