

$a = f \# f \vee$ $a \mid b = a \# 0 \vee$ $10 \mid c = 2 \# 8 \vee$ $10 \mid d = c \# b \vee$ $a \mid e = f \# f \vee$ $a \mid x = e \# d \vee$ $x \mid g = b \# d \vee$ $x \mid h = b \# d \vee$ $x \mid i = g \# 1 \vee$ $y = i \mid h \vee$		#	val (hex)	Canonical
		0	f	f
		1	#0-#0	a
		1	a	a
		2	0	0
		1	#1 + #2	a
		1	b	a
		3	2	2
		4	8	8
		5	#3 + #4	10
		5	c	10
		5	10	10
		6	#1 * #5	d
		6	d	d
		1	2	a
		7	#1 + #6	x
		7	x	x
		7	g	x
		7	h	x
		8	1	1
		7	#7 #8	x
		7	i	x
		7	#7 / #7	x
		9		y
		9		y
		9		y

2+0 - algebraic simplification

precalc. constants =
= constant folding
2+8

VAR NUMBERS

$\Rightarrow a = j * f$	Da a eine $redefinieren$ Schreibung $name$ $a' = j * f$ $a'' = 10$ $j = j * f \Rightarrow j = a'$ a''' \vdots
$d = 10 a$	
$x = a * d$	
$y = x / x$	

C7G - Constant propagation

$$z = 3$$

$$b > 0$$



L1:

$$w = x + 1$$

$$x = 1$$

$$y = x + 1 / w$$

$$y = 2$$

$$z = \underset{1}{x} + \underset{2}{y} / 3$$

$$z = 3$$

$$z = 3$$

L2:

$$a = x + y$$

$$b = a \cdot \textcircled{2} \leftarrow 3$$

live
analysis

$$t_1 = t_0 + 15$$

$$t_2 = t_0 + 3$$

$$t_1 < t_2 \quad -1,2 \rightarrow \text{Remainder}$$

$$t_3 = t_1 * t_2$$

$$t_4 = t_1 * t_2$$

$$t_3 = t_1 + t_2$$

$$t_4 = t_1 + t_3$$

$$t_5 = t_4 - t_2$$

$$t_6 = t_5 + t_3$$

$$t_7 = t_5 + 1$$

$$t_7 = t_2 + t_3$$

$$t_6 < t_7$$

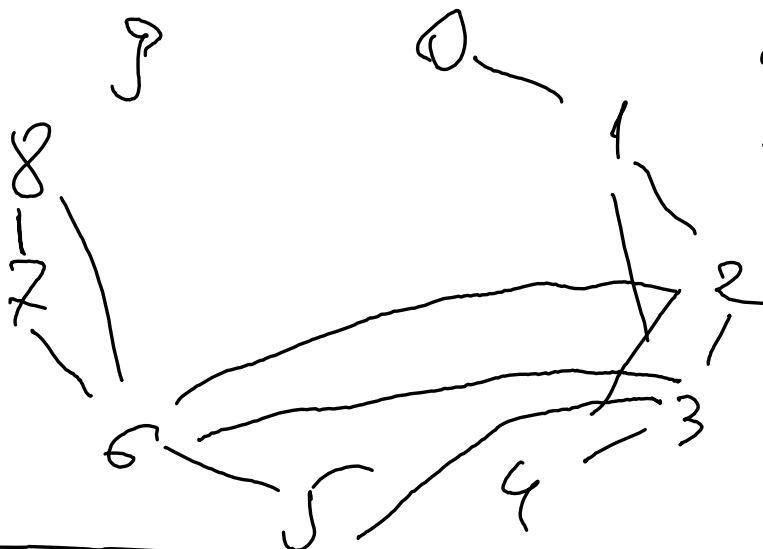
$$t_8 = t_6$$

$$t_8 = t_7$$

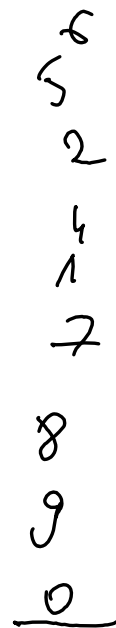
$$t_9 = t_8 * 2$$

Register
Interference
Graph

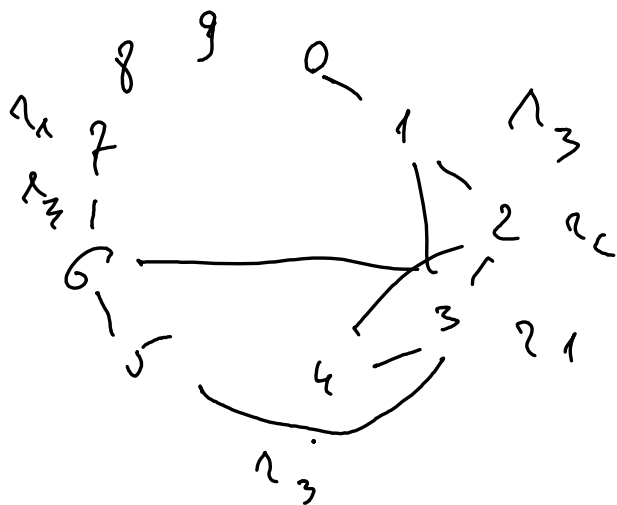
Reducare
la colorarea
grafului



Num. min. și max. spilling = max. dist



Intensitate maximă
scut maturi care au grad
nr. reg-1 (grad 2 la noi)



o/b ! # a b \$

J %qT U! U!

T { E qS bqT E

U E #qT

$$S \rightarrow A a$$

$$S' \rightarrow . S$$

$$S \rightarrow A b$$

$$S \rightarrow . A a$$

$$A \rightarrow A c$$

$$S \rightarrow . B b$$

$$A \rightarrow \epsilon$$

$$A \rightarrow . A c$$

$$B \rightarrow B c$$

$$A \rightarrow .$$

$$B \rightarrow \epsilon$$

$$B \rightarrow . B c$$

Reduce-Reduce $B \rightarrow .$

LR(0) X

SLR(1)

$$\text{First}(S) = \text{First}(Aa) \cup \text{First}(Ab) = \{a, b, c\}$$

$$\text{First}(Aa) = \{c, a\}$$

$$\text{First}(A) = \{\epsilon, c\}$$

$$\text{First}(B) = \{\epsilon, c\}$$

$$\text{Follow}(A) \cap \text{Follow}(B) \neq \emptyset$$

$\{a, c\} \quad \{b, c\}$

Conflict persists \Rightarrow not in SLR(1)

$O = [i: \text{Int}, j: \text{Int}, k: \text{Int}, \text{yes}: \text{bool},$
 $p: S_Tm, \text{self}: S_Tm] [\text{String} / r]$

$M(A, \text{foo}) = (\text{SELECT_TYPE}) = M(B, \text{foo})$

$M(A, \text{bar}) = (\text{Int}, \text{Int}) = M(B, \text{bar})$

$M(M, \text{test}) = (\text{object})$

$M(A, \text{type-name}) \dots$

$C = B$

$O, M, N + p: S_Tm$

$\alpha_j | \sim \text{Int} \xrightarrow[\text{qms} + 5: \text{Int}]{\text{split index}} \frac{\text{Int} \leq \text{Int}}{j}$

$O, M, N + j' \in 5: \frac{\text{Int}}{j} \rightarrow \text{base on } j: S_T$
 $M(M, \text{bar}) = (\text{Int}, \text{Int})^5 \Rightarrow \text{Typed} \Rightarrow S_Tm$

$\frac{\text{Int}}{j \in 5} \leq \frac{\text{Int}}{\text{param}}$

$O, M, N \vdash p.\text{bar}(j \in 5): \text{Int}$

Organizarea în memorie

X:

tag 0

dim: 5

dispatch pointer

b

c



Obj x 2

Obj type-name

Obj: short

X.foo

X.bar

Y: tag 1

dim: 6

disp p

b

c

d



Obj x 3

X.foo

Y.bar

Y.baz

Z: tag 2

dim 7

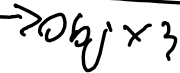
d.p

b

c

d

a



Z.foo

Y.bar

Y.baz

Z.gux

Gebe per

<u>So</u>	<u>ST1</u>
0	0
x	a
	0/1

class Main {

a:

{ (x: Int, y: Int): S_T s {

if 0 < x then

a ← a + y

else 0 fi ;

self ;

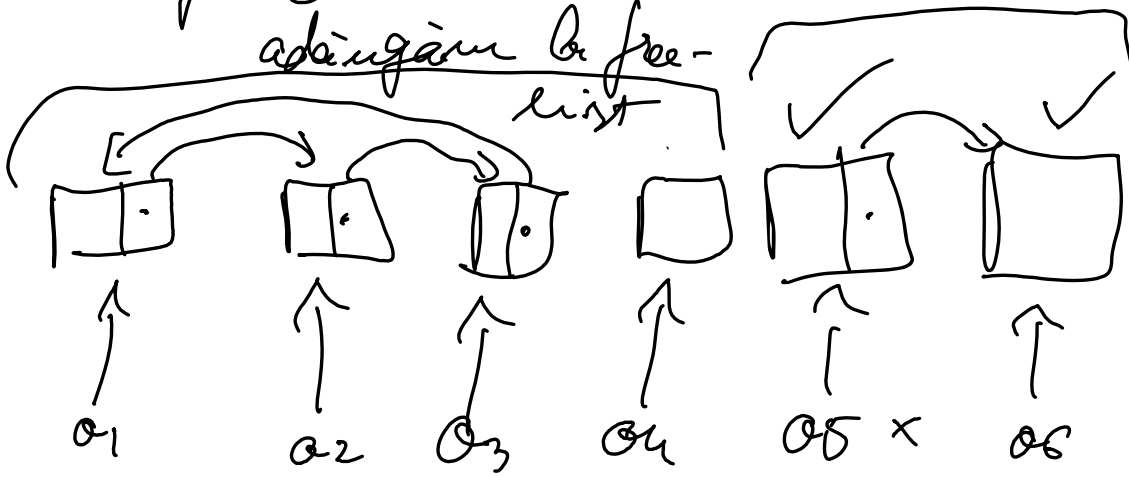
}

}

Garbage Collector

adgingam & free-
list

demarcam



I Mark and Sweep

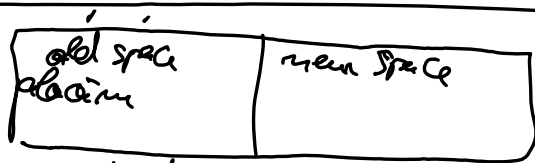
roots: \$a0
\$sp

(* gc *) - does x reachable

In \$a0 gcsim does a5

=> visitum 6 -> tot a reach

II Stop & Copy



visitum does reachable => 2

III Reference Counting

I mai put disposable
↳ pt. & ref. circular run & eliminating
the ref. cnt.

for ($i=0; i < 1000; i++$)

Ref. c: 1/2

mark & S: n

Step & opy: $n/2$

Barz \leq Mar \leq Foo \leq iO

Tipăm $f @ \text{Foo}. \text{foo}()$

$O = [f : \text{Foo}, \text{self} : \text{SELF_TYPE}_{\text{Foo}}]$

$M(\text{Foo}, \text{foo}) = \text{SELF_TYPE} = M(\text{Mar}, \text{foo}) = M(\text{Bar}, \text{foo})$

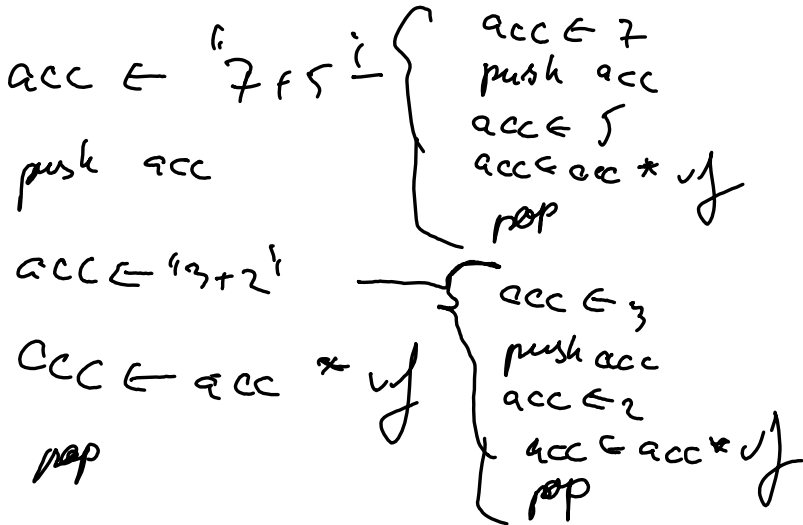
$\frac{O(f) = \text{Foo}}{O, M, C \vdash f : \text{Foo}} \quad T'0 = \text{Foo}$

$M(\text{Foo}, \text{foo}) = (\text{SELF_TYPE})$

$\text{Foo} \leq \text{Foo}$

$O, M, C \vdash f @ \text{Foo}. \text{foo}() : \text{Foo}$

$$(7+5) \times (3+2)$$



$$1 + (2 * 3) + 4$$

acc ← 1
push acc

acc ← 2
push acc

acc ← 3
acc ← acc + top
pop

3 push, 3 pop

4 increment

acc ← acc + top
pop

push acc

acc ← 4

acc ← acc + top
pop

push - 2 op

pop - 1 op

add - 2 op

increment - 1 op

7 push - 14

7 pop - 7

8 inc - 8

2 op - 14

43

$$(1) \quad (1010.1) \neq 0$$

$$(2) \quad 01 +$$

$$(3) \quad (10110) +$$

$$\underbrace{10101000100}_{(3)} \underbrace{1100011}_{(3)}$$

$$S \rightarrow A a l d$$

b a d b a h a

$$A \rightarrow S l b$$

$$\textcircled{1} \quad E \rightarrow E + T \mid T$$

$$E \rightarrow T E'$$

$$E' \rightarrow + T E' \mid \epsilon$$

$$\textcircled{2} \quad A \rightarrow A M \alpha \mid A_c \mid a$$

$$A \rightarrow a A' \mid a A''$$

$$A' \rightarrow B \alpha A' \mid \epsilon$$

$$A'' \rightarrow a A' \mid \epsilon$$

$$A \rightarrow a A'$$

$$A' \rightarrow M \alpha A' \mid a A' \mid \epsilon$$

$$\textcircled{3} \quad A \rightarrow A c \mid A a d \mid B d \mid c$$

$$A \rightarrow B d A' \mid c A'$$

$$A' \rightarrow c A' \mid a d A' \mid \epsilon$$

$$\textcircled{4} \quad A \rightarrow A A \mid A b$$

$$A' \rightarrow$$

?

$$S \rightarrow Sx \mid SSb \mid xS \mid a$$

$$X \rightarrow Sa \mid Xb \mid b$$

$$\rightarrow S \rightarrow aS' \mid \cancel{X}SS' \quad \checkmark \quad (1)$$

$$\cdot S' \rightarrow xS' \mid SbS' \mid \varepsilon \quad \checkmark \quad (2)$$

$$x \rightarrow Sa \mid xb \mid b$$

$$X \rightarrow aS'a \mid xSS'a \mid xb \mid b$$

$$\rightarrow X \rightarrow aS'aX' \mid bX' \quad \checkmark \quad (3)$$

$$\cdot X' \rightarrow SS'aX' \mid bX' \mid \varepsilon \quad \checkmark \quad (4)$$

$$\Rightarrow \left\{ \begin{array}{l} (1) \\ (2) \\ (3) \\ (4) \end{array} \right.$$

$$\textcircled{7} S \rightarrow Aa | b$$

$$A \rightarrow Ac | Sd | \epsilon$$

$$A \rightarrow Ac | Aad | bd | \epsilon$$

$$A \rightarrow bd A' | A'$$

$$A' \rightarrow cA' | ad A' | \epsilon$$

$$\Rightarrow \begin{cases} S \rightarrow da | b \\ A \rightarrow bd A' | A' \\ A' \rightarrow cA' | ad A' | \epsilon \end{cases}$$

$$\textcircled{8} S \rightarrow STS | ST | T$$

$$T \rightarrow Ta | Tb | U$$

$$U \rightarrow T | c$$

$$S \rightarrow TS'$$

$$S' \rightarrow TSS' | TS' | \epsilon$$

$$T \rightarrow UT'$$

$$T' \rightarrow aT' | bT' | \epsilon$$

$$U \rightarrow T | c \Rightarrow U \rightarrow cU'$$

$$U' \rightarrow T'U' | \epsilon$$

$$U \rightarrow UT' | c$$

$$\hookrightarrow U \rightarrow cU'$$

$$U' \rightarrow T'U' | \epsilon$$

$$S \rightarrow bAb \mid \gamma Ba$$

$$A \rightarrow aS \mid Cb$$

$$C \rightarrow c \mid cC$$

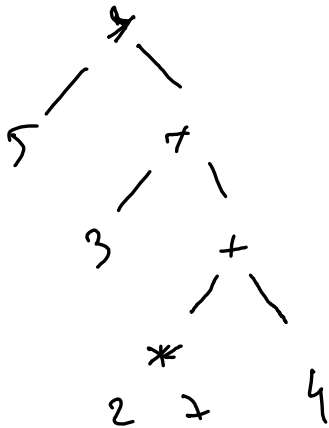
$$B \rightarrow bB'$$

$$B' \rightarrow CB' \mid \varepsilon$$

$$S \rightarrow b \quad \times$$

$$x \rightarrow Ab \mid Ba$$

$$5 * 3 \wedge (2 * 7) + 4$$



2, 1, 2

$$S \rightarrow A(S)B \mid \epsilon$$

$$A \rightarrow S \mid SB \mid x \mid \epsilon$$

$$B \rightarrow S \mid y$$

$$\text{First}(S) = \{ \epsilon, x, (, y \}$$

$$\text{First}(A) = \{ x, \epsilon, (, y \}$$

$$\text{First}(B) = \{ y, (, x \}$$

$$\text{Follow}(S) = \{ y, (, x,), \$ \}$$

$$\text{Follow}(A) = \{ (\}$$

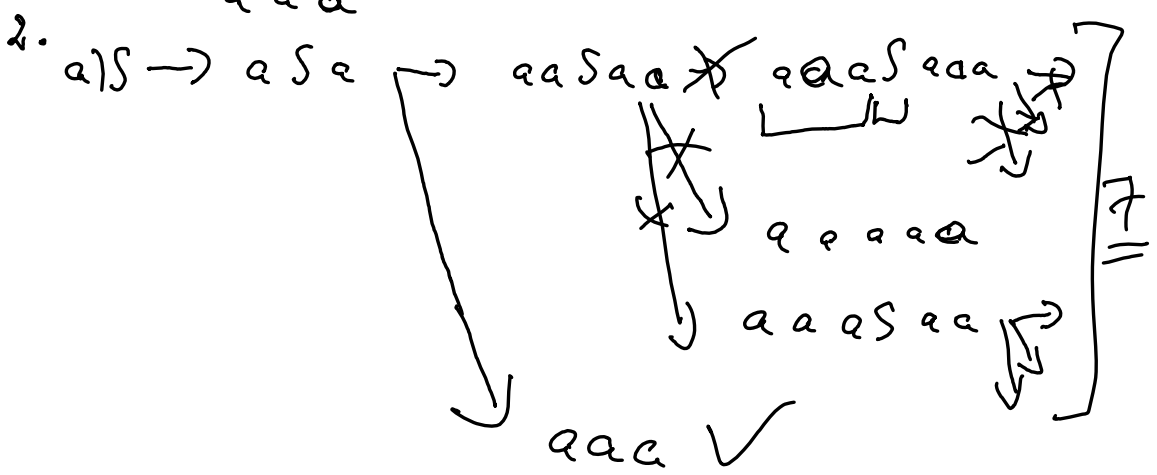
$$\text{Follow}(B) = \{ (, y,), x \}$$

1. a) $a b c a b c c c c b c a b a b b a b c$

2
3
4
2
4
1

b) $a a \checkmark$

$a a a$



b) $S \rightarrow \epsilon S \mid a \mid a S a$

3.

$$S \rightarrow \boxed{U \times S V} \mid a \mid b$$

$$U \rightarrow \boxed{c U S} \mid \epsilon$$

$$V \rightarrow d V S \mid \epsilon$$

$$\text{Follow}(U) \subseteq \text{Follow}(S)$$

$$F(V) \subseteq F(S)$$

$$\epsilon \in \text{First}(c)$$

$$\text{First}(S) = \{a, b, c, x\}$$

$$\text{First}(U) = \{\epsilon, c\}$$

$$\text{First}(V) = \{\epsilon, d\}$$

$$\text{Follow}(S) = \{\$, a, b, c, x\}$$

$$\text{Follow}(U) = \{a, b, c, x\}$$

$$\text{Follow}(V) = \{a, b, c, x, \$, d\}$$

conflicts

$$V \rightarrow c$$

$$V \rightarrow d \text{ or } \epsilon \quad (1)$$

~~A~~ → ... ~~B~~

	a	b	c	d	\$	x
S	a	b	$U \times S V$			$U \times S V$
U	ϵ	ϵ	$\underline{c U S \epsilon}$			ϵ
V	ϵ	ϵ	ϵ	$d V S$ ϵ	ϵ	ϵ

LR(0) LR(1)

$S \rightarrow .S$

$S \rightarrow .U \times S V$

$S \rightarrow .a$

$S \rightarrow .b$

$U \rightarrow .c U S$

$U \rightarrow .$

~~reduce~~
reduce

$\text{Follow}(S) = \{ d, \$, a, b, c, x \}$

$\text{Follow}(U) = \{ \underline{a, b, c}, x \}$

$\text{Follow}(V) = \{ a, b, c, x, \$, d \}$

shift

3 shift-reduce \rightarrow
move LR(0)

SLR(1)

$O = [\text{key: Int}, \text{left: Tree}, \text{right: Tree},$
 $\text{self: SELF_TYPE}_N, \text{K: Int}]$

$M(\text{NLTtree}, \text{init}) = (\text{Int}, \text{Tree}, \text{Tree}, \text{Tree})$

$M(\text{NT}, \text{isEmpty}) = (\text{Bool}) = M(\text{NT}, \text{isEmpty})$

$M(\text{NT}, \text{insert}) = (\text{Int}, \text{Tree}) = M(\text{Tree}, \text{insert})$

$M(\text{NT}, \text{sum}) = (\text{Int}) = M(\text{Tree}, \text{sum})$

$M(\text{NT}, \text{copy})$

$\text{new NLTtree .init (K, self, self)}$

new NETree .init (k, self, self)

$\vdash \text{new NETree} : \text{NETree}$

$O = [k : \text{Int}, \text{self} : \text{SELF_TYPE_Tree}]$

$O, M, \text{Tree} \vdash \text{new NETree} : \text{NETree}$

$O, M, \text{Tree} \vdash k : \text{Int}$

$O, M, \text{Tree} \vdash \text{self} : \text{SELF_TYPE_Tree}$

$T_0' = T_0 = \text{NETree}$

$M(\text{NETree}, \text{init}) = (\text{Int}, \text{Tree}, \text{Tree}, \text{Tree})$

$\text{Int} \leq \text{Int}$

$S \vdash T_7 \leq \text{Tree}$

$S \vdash T_7 \leq \text{Tree}$

$T_{\text{true}} = \text{Tree}$

$O, M, \text{Tree} \vdash \text{new NETree} . \text{init}(k, \text{self}, \text{self}) :$
 Tree

left ← 2

SELF_TYPE_{NETree} ≥ Tree
≤ NETree & Tree

Tree: tag: 0

dim: 3

disp_t: →

O.copy

O.type_name

O.abort

IO... (4)

Tree.isEmpty

Tree.insert

Tree.remove

NETree: tag: 1

dim: 6

disp_t: →

O.copy

key:

O.

left:

O.

right:

IO... (4)

NT.isEmpty

NT.insert

NT.remove

NT.init

$$\begin{aligned}
 NT(\text{sum}) &= \max(NT(\text{key}), \underbrace{1 + NT(\text{left.sum})}_{\substack{\downarrow \\ 0}}, \underbrace{1 + NT(\text{right.sum})}_{\substack{\downarrow \\ 0}}) \\
 &\quad + \underbrace{N_{\text{param}}}_{\substack{\downarrow \\ 0}} + \underbrace{\text{result}}_{\substack{\downarrow \\ 1}} + \underbrace{fp}_{\substack{\downarrow \\ 1}} \\
 &= 3 \left[\text{key} + \underbrace{\text{sum}(\text{sum})}_{\substack{\downarrow \\ 1}} + \text{sum} \right]
 \end{aligned}$$

$$\underline{12} (\$50)$$

$$\underline{16} (\$50)$$

$$\underline{36} (\$41)$$

$$\underline{12} (\$90)$$

a) 1 - new Tree

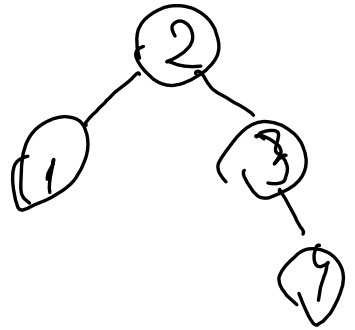
1 - insert(2)

2 - insert(1)

2 - insert(3)

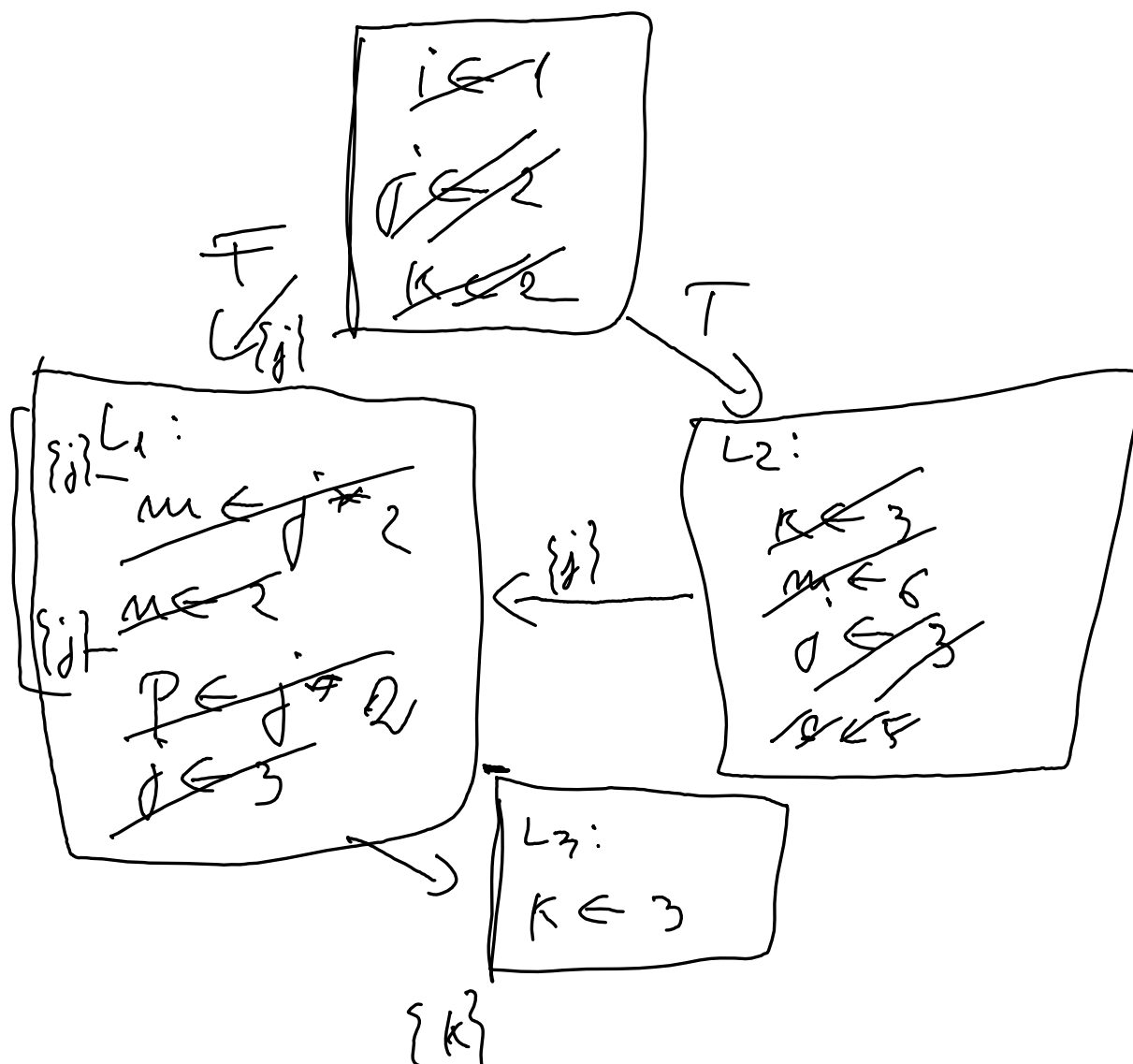
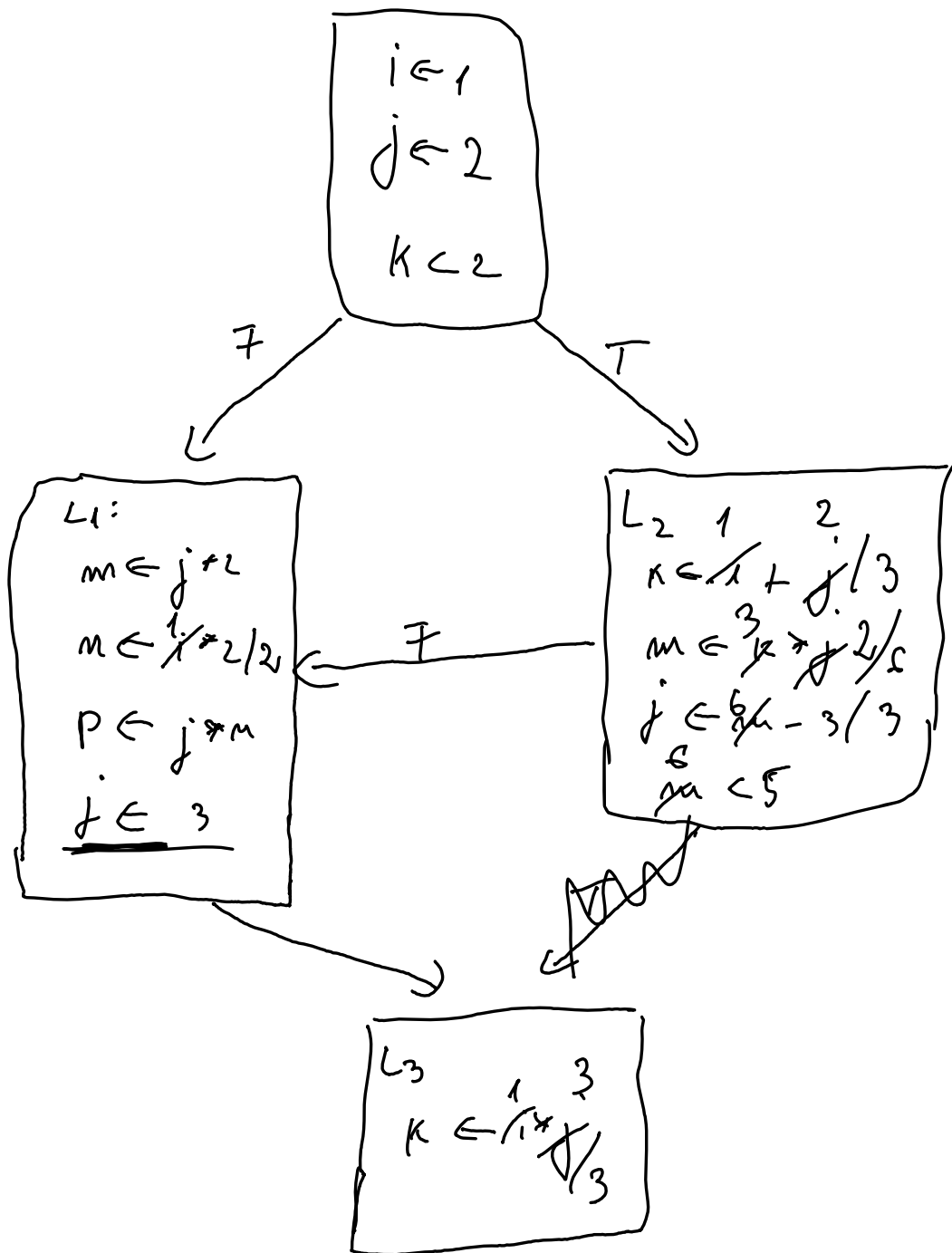
3 - insert(4)

3 - delete

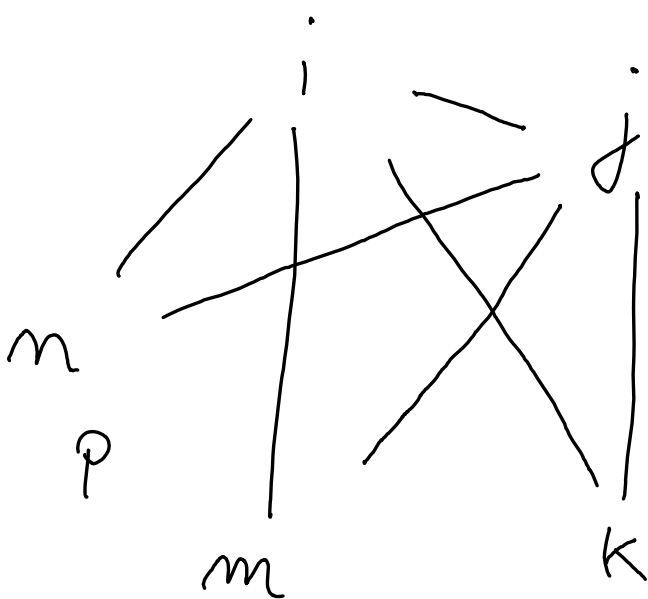
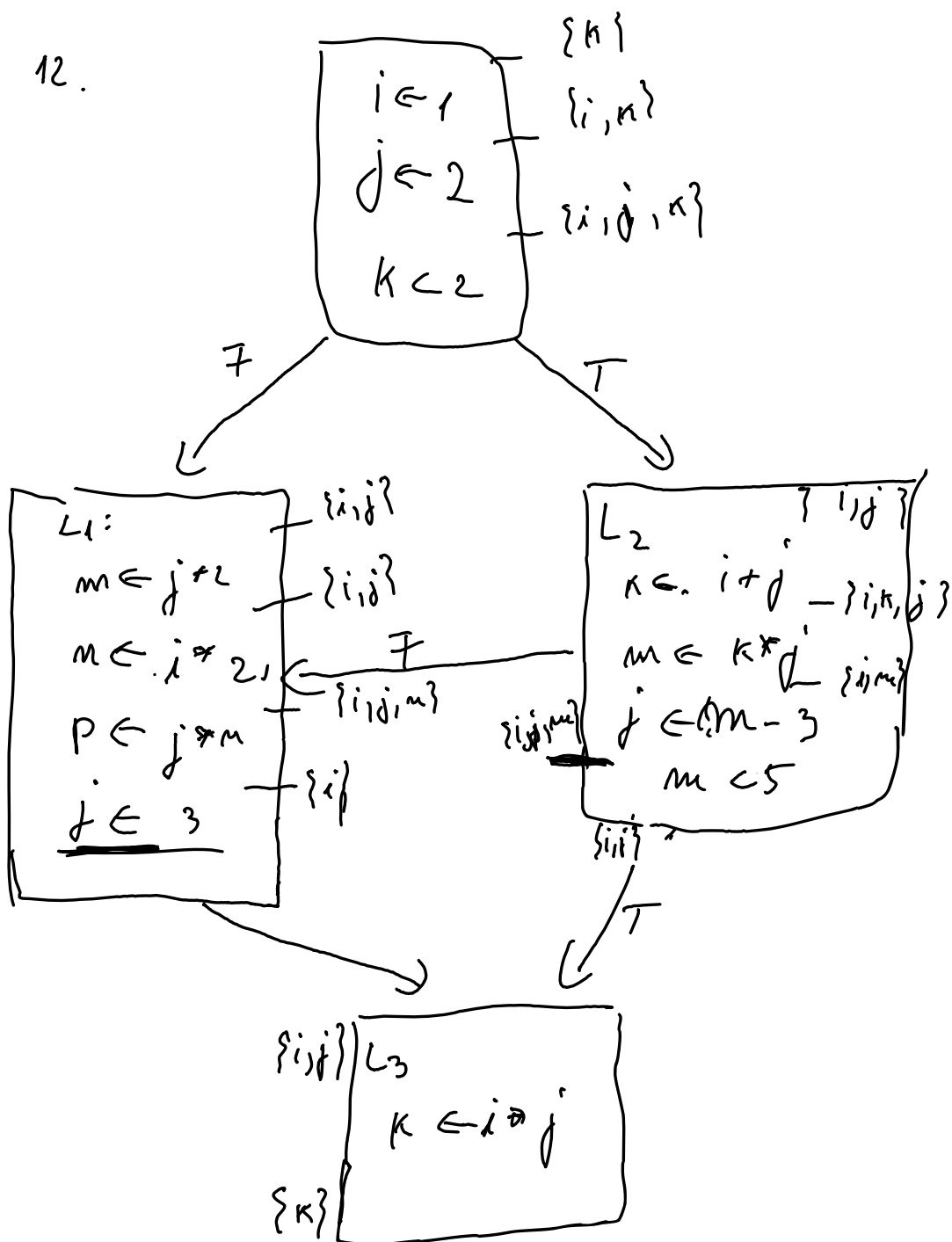


b) $P_2 : 3$

$P_3 : 0$



12.



$k = 3$

