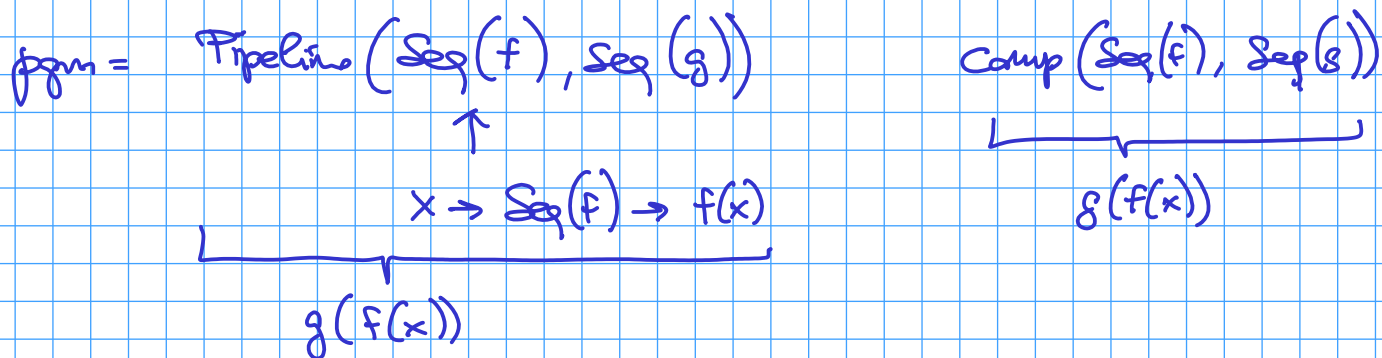


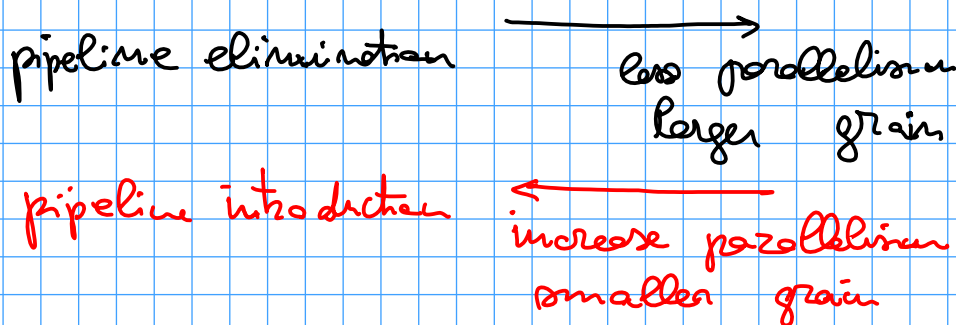
Rewrite rules

(skeletons & patterns)

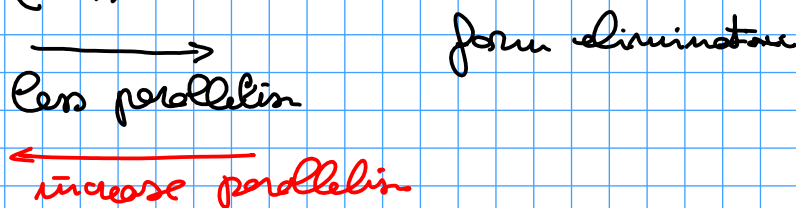
$$\text{Skel} ::= \underline{\text{Seq}(\dots) \mid \text{Pipeline}(\text{Skel}, \text{Skel}) \mid \text{Form}(\text{Skel}) \mid \text{Comp}(\text{Skel}, \text{Skel})} \mid \text{Map}(\text{Skel}) \mid \text{Reduce}(\text{Skel}) \mid \dots$$



Rev. rule ① $\text{Pipeline}(S_1, S_2) \equiv \text{Comp}(S_1, S_2)$



Rev. rule ② $\text{Form}(S_1) \equiv S_1$



$P(f, g)$

$\alpha \xrightarrow{\text{f}} \beta \xrightarrow{\text{g}} \gamma$
 $\alpha \xrightarrow{\text{f}} \beta \xrightarrow{\text{g}} \gamma$
 $\alpha \xrightarrow{\text{f}} \beta$

$P([f_1, f_2, f_3])$

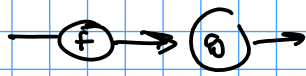
$f: \alpha \rightarrow \beta \quad g: \beta \rightarrow \gamma$
 $P(f, g): \alpha \rightarrow \gamma$

$\alpha \rightarrow \alpha$

Rev. rule ③ $\text{Pipe}(S_1, \text{Pipe}(S_2, S_3)) \equiv \text{Pipe}(\text{Pipe}(S_1, S_2), S_3)$

$\text{Comp}(S_1, \text{Comp}(S_2, S_3)) = \text{Comp}(\text{Comp}(S_1, S_2), S_3)$

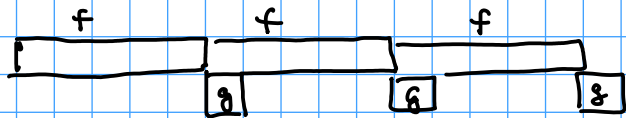
associativity rule



PIPE (SEQ(f), SEQ(g))

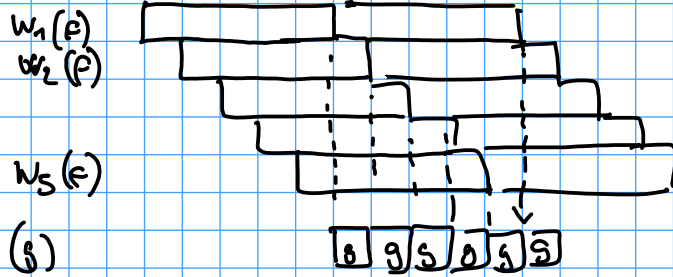
$X_{m-1} \dots X_{n+2} X_n \dots X_2$

$$t_f = 5t_g$$



RR₂

PIPE (FARM(SEQ(f)), SEQ(g))

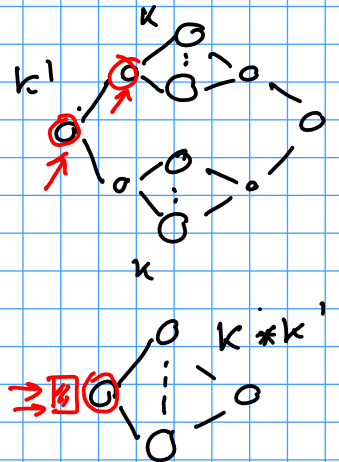
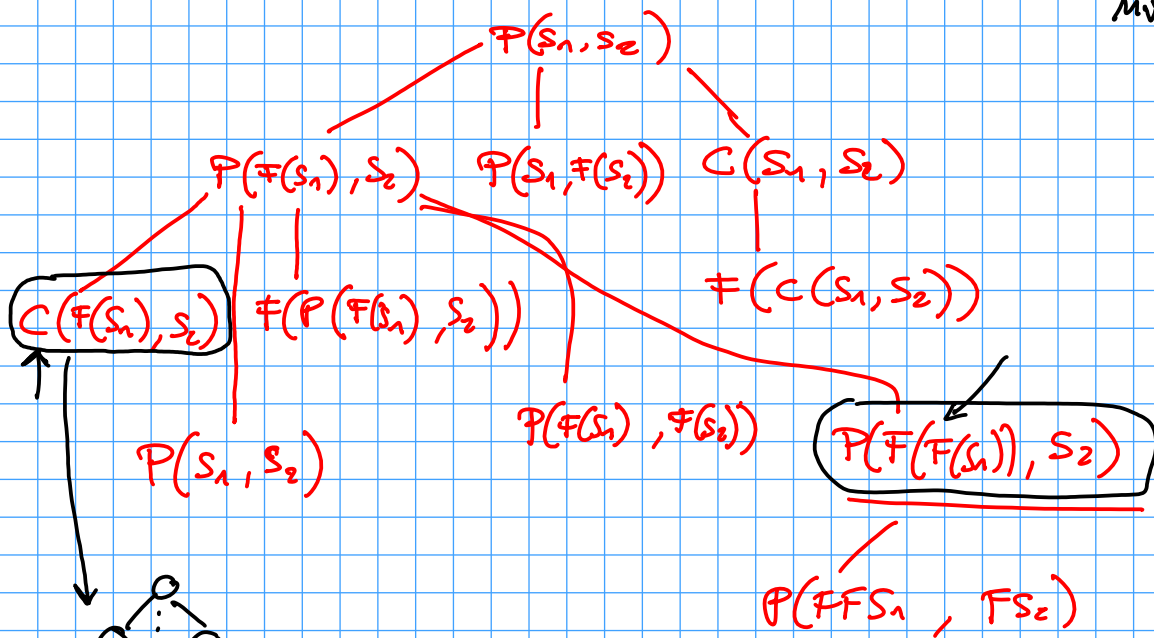


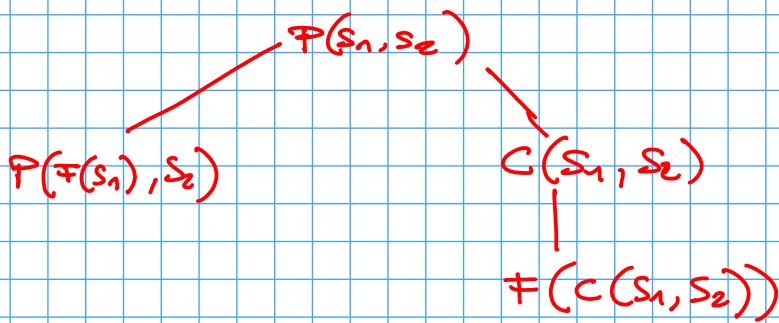
$P(\text{seq}(f), \text{seq}(g)) \xrightarrow{\text{pipe lin}} C(\text{seq}(f), \text{seq}(g)) \xrightarrow{\text{form into}} F(C(\text{seq}(f), \text{seq}(g)))$

$\underbrace{\hspace{10em}}_{6t_g}$

MWR=6

↳ 1 block computed each t_g





Visitors

n of PE needed

Ts of the pattern expr

$$\text{nofPE}(\text{Seq}()) = 1$$

$$\text{nofPE}(\text{Form}(S_1) \text{ with } mw \text{ workers}) = \text{nofPE}(S_1) \cdot mw + 2$$

$$\text{nofPE}(\text{PIPE}(S_1, S_2)) = \text{nofPE}(S_1) + \text{nofPE}(S_2)$$

$$\text{nofPE}(\text{COMP}(S_1, S_2)) = \max(\text{nofPE}(S_1), \text{nofPE}(S_2))$$

$$ts(\text{Seq}(f)) = t_f \quad \text{need to be computed (e.g. by profiling)}$$

$$ts(\text{pipe}(S_1, S_2)) = \max\{ts(S_1), ts(S_2)\}$$

$$ts(\text{Form}(S_1) \text{ with } mw \text{ workers}) = ts(S_1) / mw$$

$$ts(\text{Comp}(S_1, S_2)) = ts(S_1) + ts(S_2)$$

Skel ::= Seq(f) | ... | Skel with annotated list

form(S1) with [mw(10)]

seq(f) with [ts(10s)]

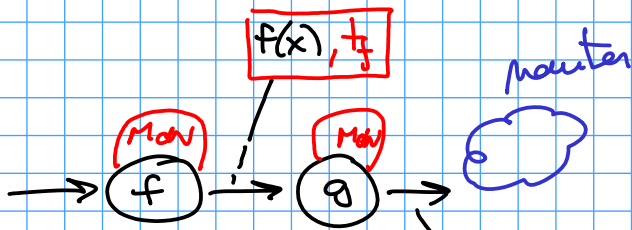
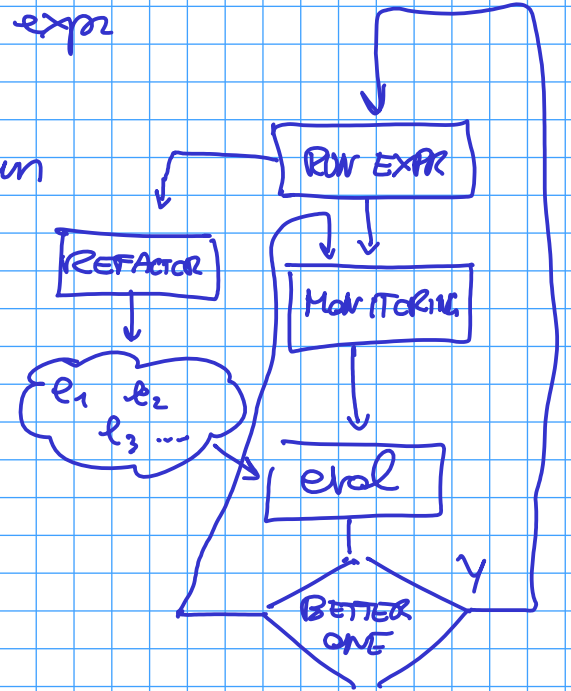
RR set

Shell expr

monitored values

target law

run



get time (x_1)
receive (x)
capture $f(x)$
deliver $f(x)$
get time (x_2)
 $diff = (x_2 - x_1);$
Symbol & seed

secret repository of monitored values