

Cole → 1988

## CONTROL PARALLEL SKEL.

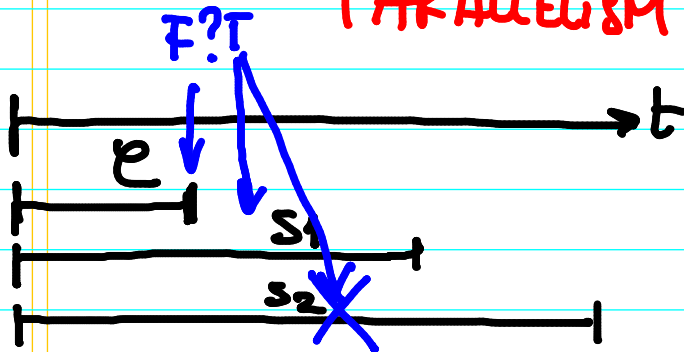
CONDITIONAL ITERATIONS  
(LOOP)

IF (C) THEN (S<sub>1</sub>)  
ELSE (S<sub>2</sub>)

FOR  
WHILE

↓  
unrolling

SEQ or SPECULATIVE  
PARALLELISM



for (i=0; i<N; i++)  
a[i] = f(b[i]); → unrolled  
as you want

↙  
for (i=0; i < ~~N~~<sup>N</sup>/<sub>2</sub>; i+=2) {  
run in parallel → a[i] = f(b[i]);  
a[i+1] = f(b[i+1]);

loop body :

$$a[i] = \underbrace{a[i] + a[i-1] + a[i+1]}_3$$

not suitable for parallel  
unrolling

while (e) do {S}  
repeat {S} until (e)

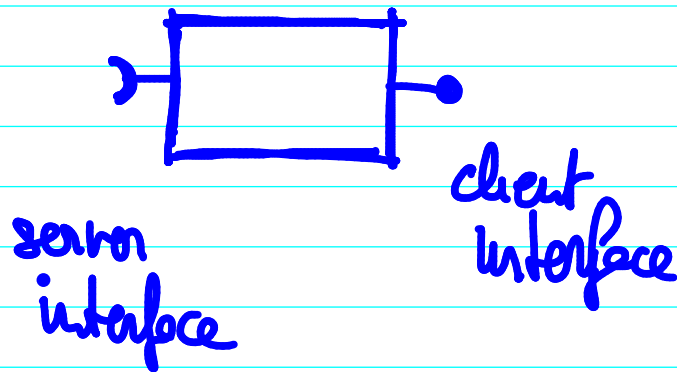
DATA PAR.	STREAM PAR	CONTROL PAR
'a collection	'a stream	'a
↓	↓	↓
'b collection	'b stream	'b

## COMPOSITIONALITY

$S_{k_1} \quad S_{k_2}$   
...  
 $S_{k_n}$

$S_{k_1} (\dots S_{k_2} \dots S_{k_3})$

SKELETONS  $\equiv$  SW COMPONENTS

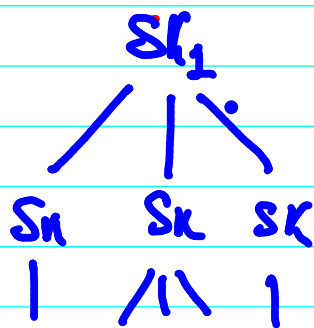


ASSUMPTIONS (to simplify)  
COMPOSITION

→  $\forall$  skeleton has 1 input  
and 1 output

# RESTRICTED COMPOSITION MODEL

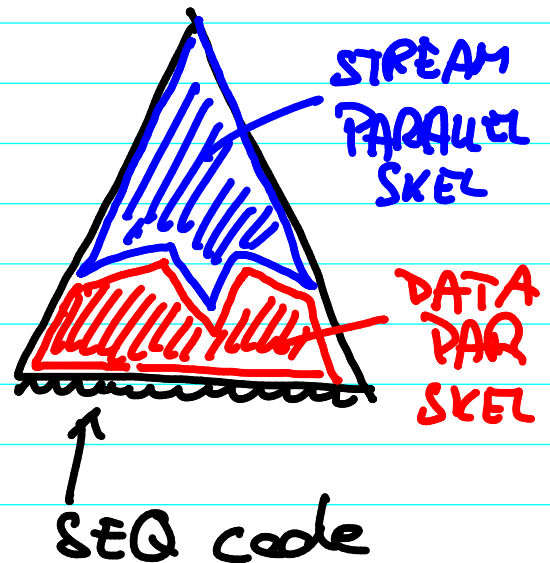
## TWO TIER COMPOSITION

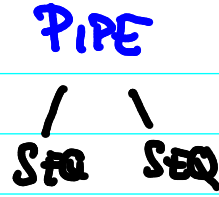
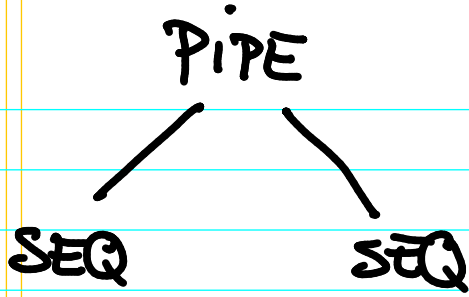


Skeleton TREE

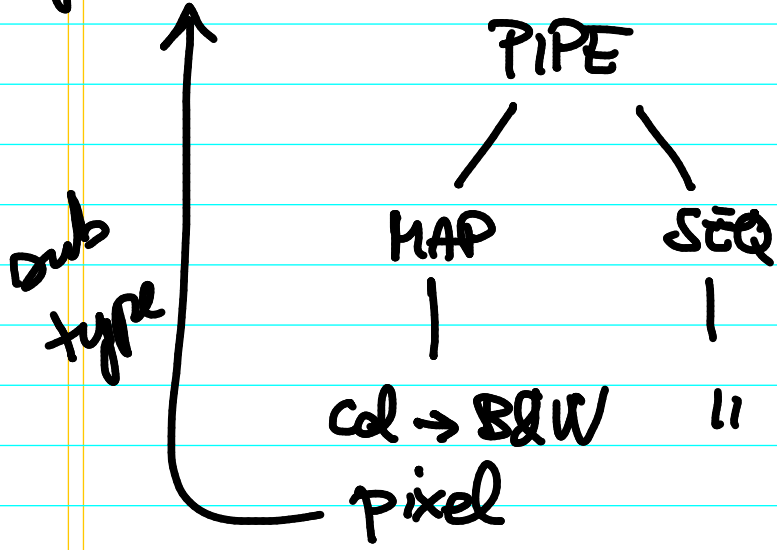
↳ ALL PAR in the application

ANY SKEL TREE has two tiers (levels)

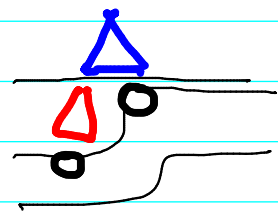




col  $\rightarrow$  B&W  
of IMG threshold



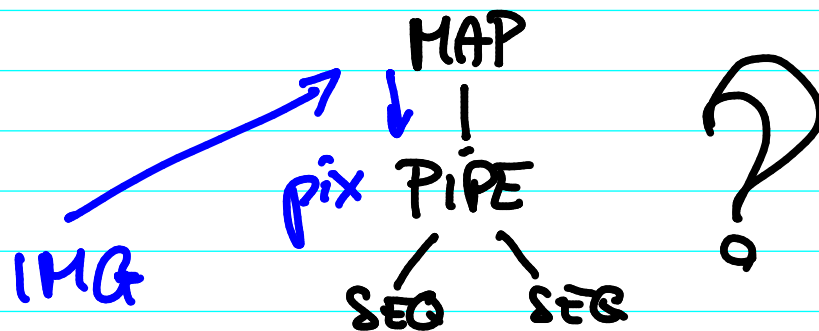
twotier!



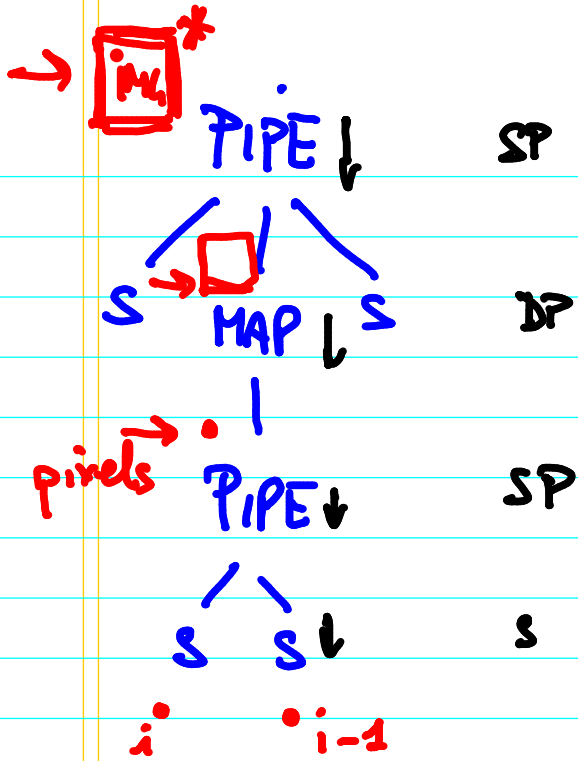
sub  
type

# Theoretic foundation

by hypothesis:  $\text{MAP}(\text{PIPE}(\text{SEQ}, \text{SEQ}))$



not convenient!  
(PIPE HAS NO STREAM)  
 $\Rightarrow \text{PIPE} \equiv \text{SEQ}; \text{SEQ}$



(FKD  
 PTR)  
 Performance  
 Models



# STREAM PAR SKELETONS

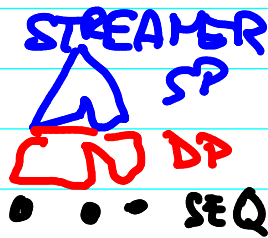
## TWO STEP DEFINITION

1) DEF PIPE, FARM

as working on a single  
item ( $\equiv$  DP SKEL)

2) "STREAMER" FUNCTION

( $a \rightarrow b$ )  $\rightarrow$  'a' stream  $\rightarrow$  'b' stream



$$\text{pipe } f_1 f_2 x = (f_2 (f_1 x))$$

$$\text{form } f x = f x$$



identity

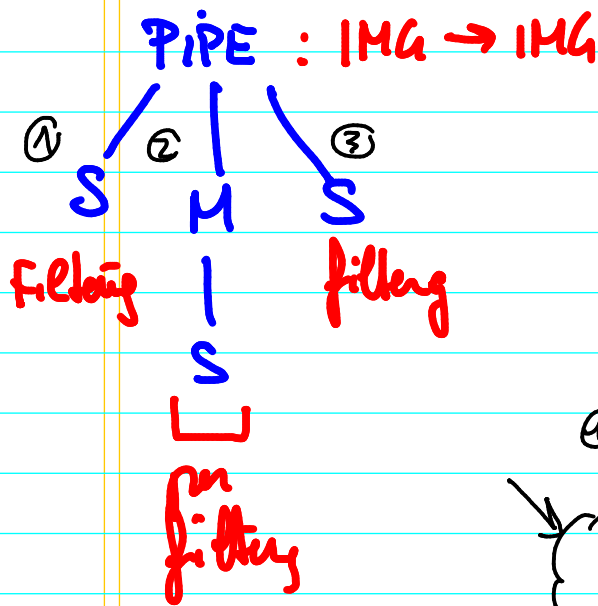
{ Sk set } → FUNCTIONAL SEMANTICS



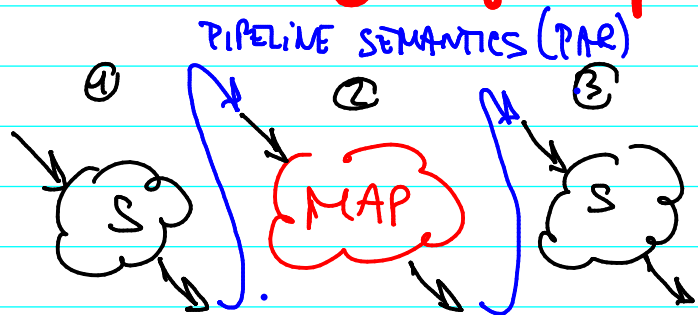
FOUND WAYS TO  
ALLOW  
COMPOSITION

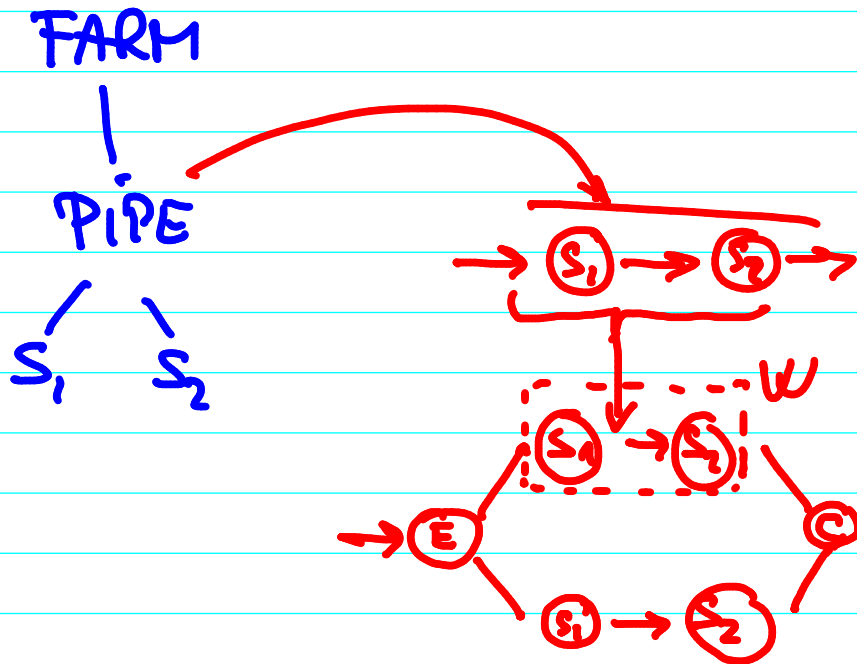
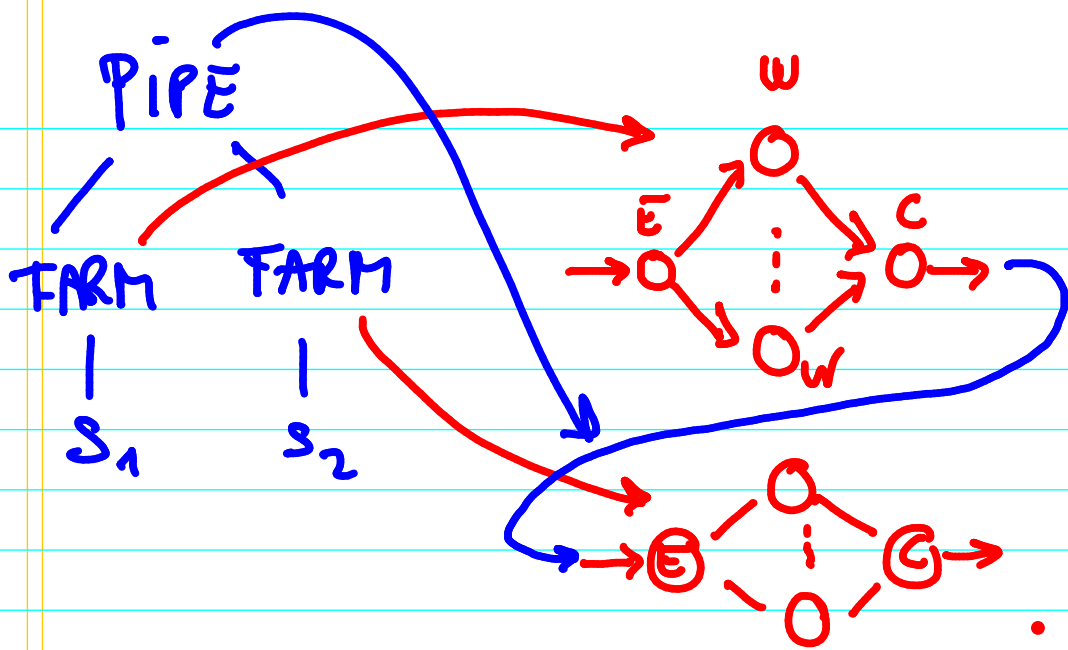
# WHAT ABOUT PARALLEL SEMANTICS?

we have to consider parallel implementation as well

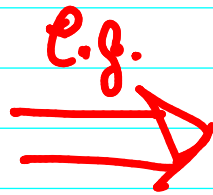
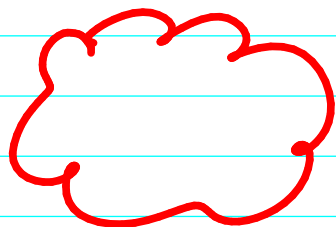


Hp: single input  
single output





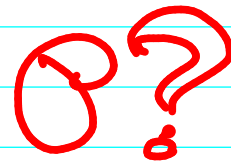
# WHAT ABOUT PERFORMANCE COMPOSITION?



FARM  
WORKER

WORKS in  
parallel

it is efficient



When using skeletons (properly  
designed ones) perf composition  
may be guaranteed!