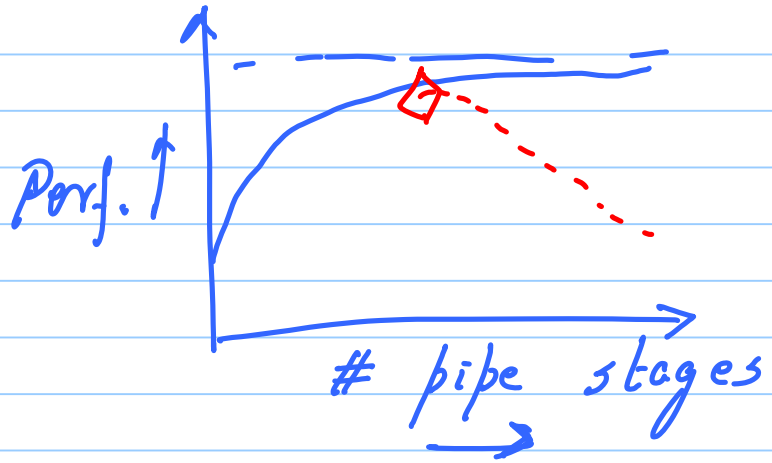
Sept 21st

Note Title 21-09-2011



$P = IPC \times f \times (\cdots)$ $T \propto CPI \times t_{clk}$

Ideal $CPI = 1$

$CPI = (1 + Kx)$

constant. # pipe stages

$$f_{clk} = A + \frac{B}{x}$$

$$f(x) = \left(A + \frac{B}{x}\right)(1 + Kx)$$

$$= A + AKx + \frac{B}{x} + BK$$

$$\frac{\partial f(x)}{\partial x} = AK - \frac{B}{x^2} = 0$$

$$x = \sqrt{\frac{B}{AK}}$$

opt # of pipe stages.

A → setup time + hold time

B → Algorithmic Work

K → Stage penalty

Non-Ideal Scenario.

Can we process one Inst. every cycle?

1) Data Hazard.

1) ADD r_1, r_2, r_3
2) ADD r_4, r_5, r_1

1) IF ID EX MEM WB
2) IF (ID) EX

Bubbles in the pipeline

2) Control Hazard.

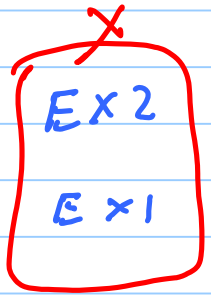
```
BEQ .L2
ADD r3, r1, r2
```

1	2	3	4	5
IF	ID	EX	MEm	WB
			IF	

3) Structural Hazard

Assume EX stage is split into two parts EX1 and EX2

ADD r_1, r_2, r_3	IF	ID	EX1	EX2	m	WB
ADD r_4, r_5, r_6		IF	ID	EX1	EX2	



What if you have one non-pipelined adder?

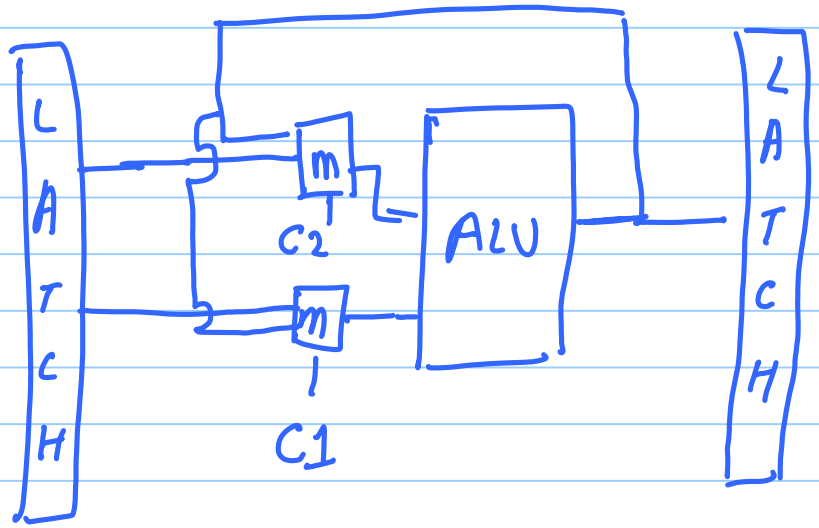
Solution:

IF	ID	EX1	EX2	MEM	WB
	IF	ID		EX1	EX2

Forwarding.

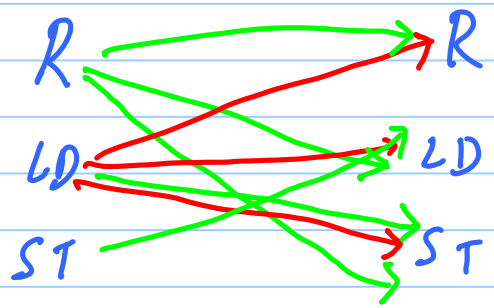
ADD r_1, r_2, r_3 IF ID EX MEM WB

ADD r_5, r_1, r_4 IF ID EX MEM



C1 and C2 has to be set appropriately.

Forwarding Avoids Data Hazards



R → LD

IF	ID	Ex	m	WB
	IF	ID	Ex	m

LD → R

IF	ID	Ex	m	WB
	IF	ID	Ex	m	WB

R - ST

IF	ID	Ex	m	WB
	IF	ID	Ex	m

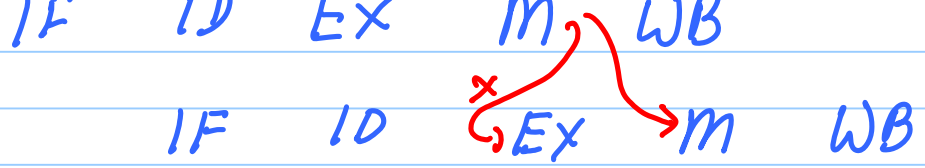
LD → LD

IF	ID	Ex	m	WB
	IF	ID	Ex	m	WB

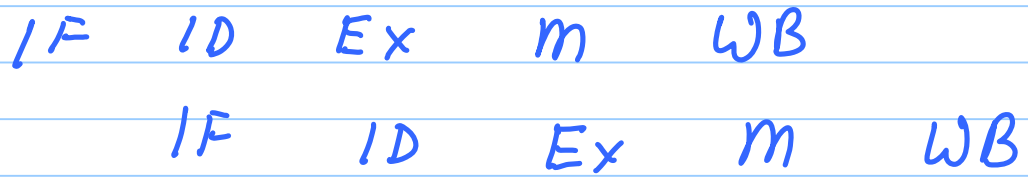
Address → Hazard

Data → No Hazard

LD → ST.



ST → LD



Forwarding Data Path

IF ID EX MEM WB

IF ID (safe)

IF ID (?)

Assumption in MIPS Pipeline.

WB → ID