Overview of processor operation

Fetch the next instruction from Mem[PC]

Read from registers

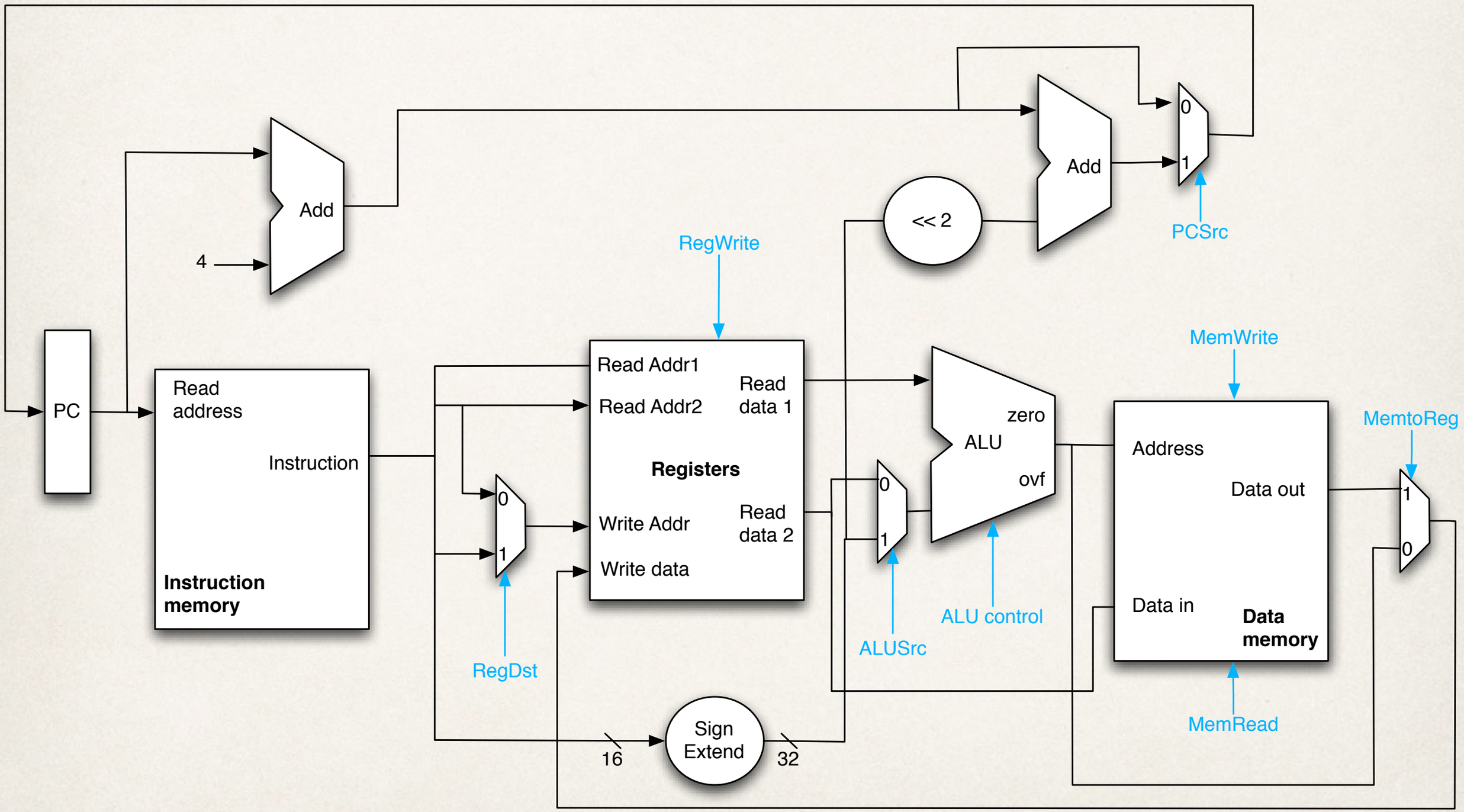
Perform ALU operation

Access memory (load or store)

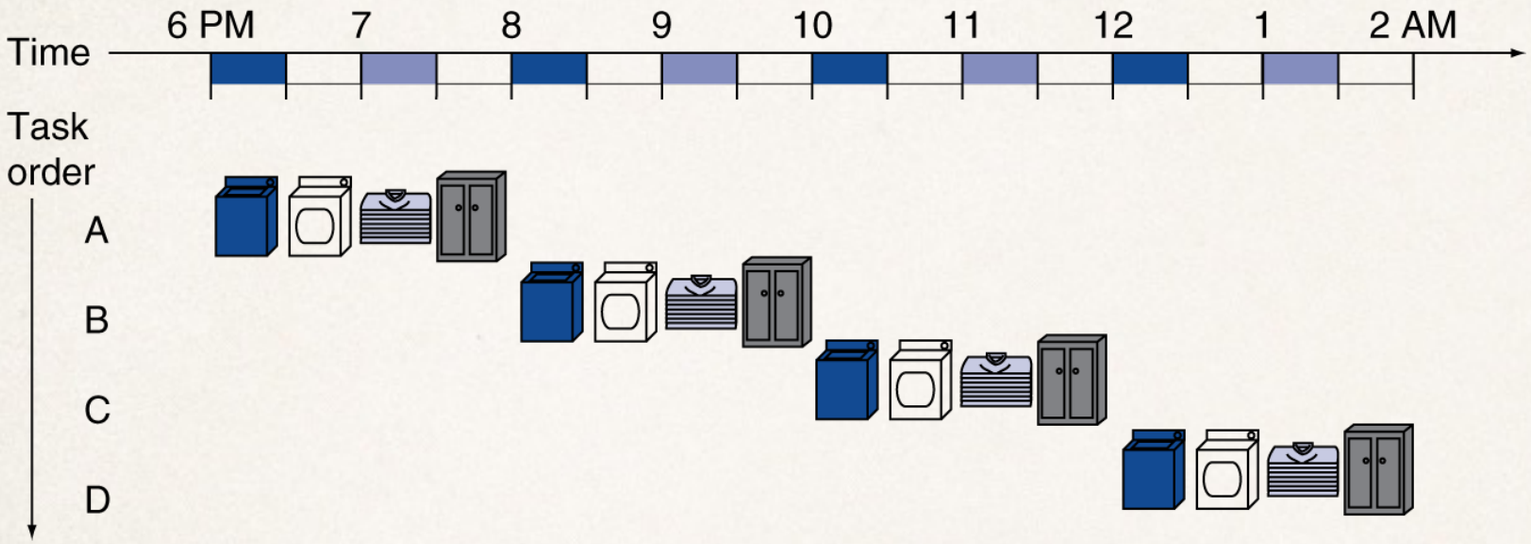
Load result into register

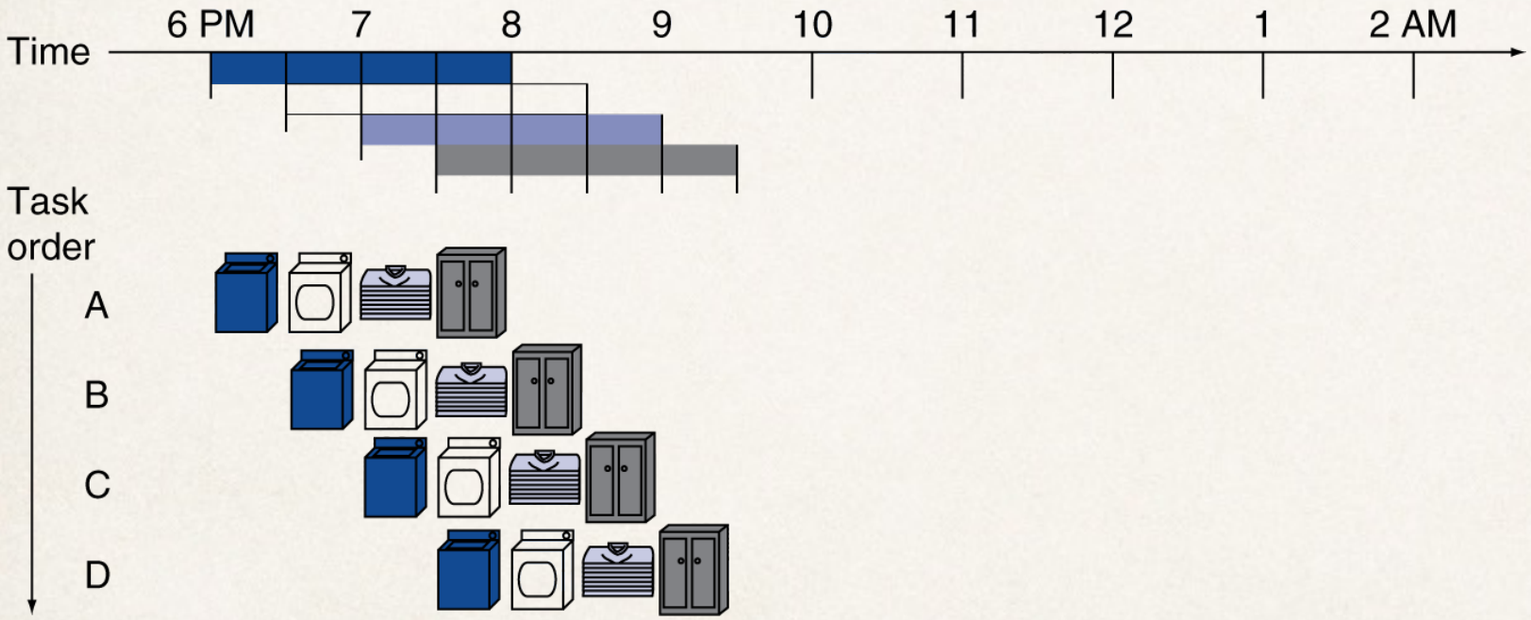
Update the PC

A more complex architecture



Pipelining laundry





Speed up for 4 loads:

8 / 3.5 = 2.3

Basic operations

Fetch the next instruction from Mem[PC]

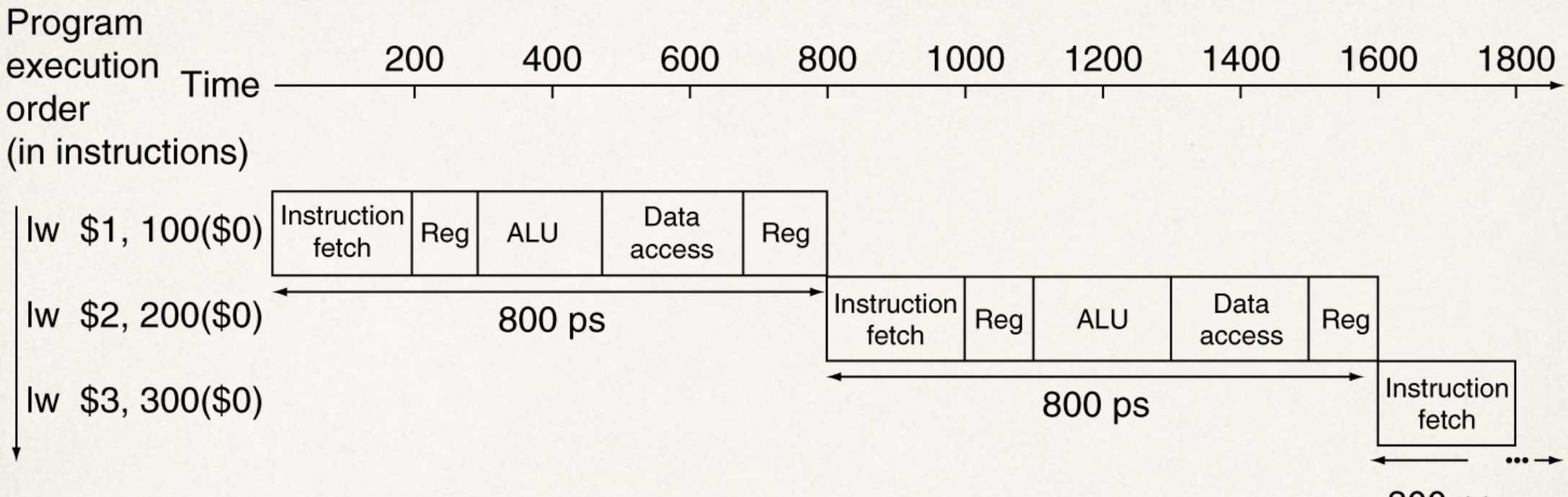
Read from registers

Perform ALU operation

Access memory (load or store)

Load result into register

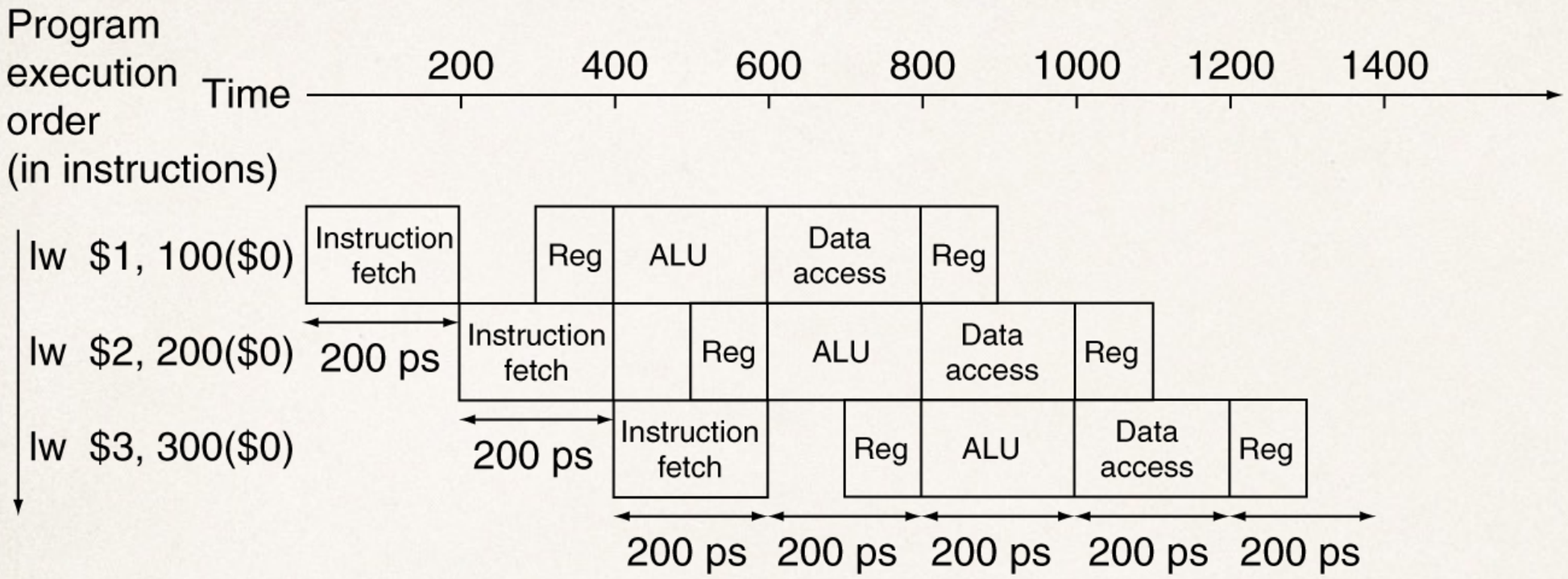
Pipelined execution



$$Latency = 800\text{ps}$$

$$Throughput = \frac{1 \text{ instruction}}{800\text{ps}} \times \frac{1000\text{ps}}{1\text{ns}} = 1.25\text{GIPS}$$

Pipelined execution

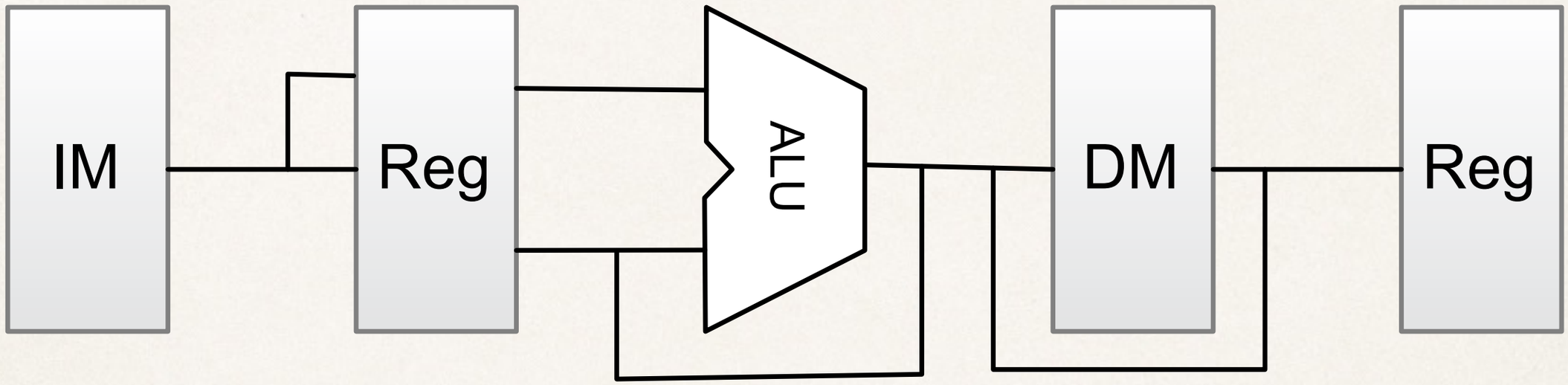


$$Latency = 1000\text{ps}$$

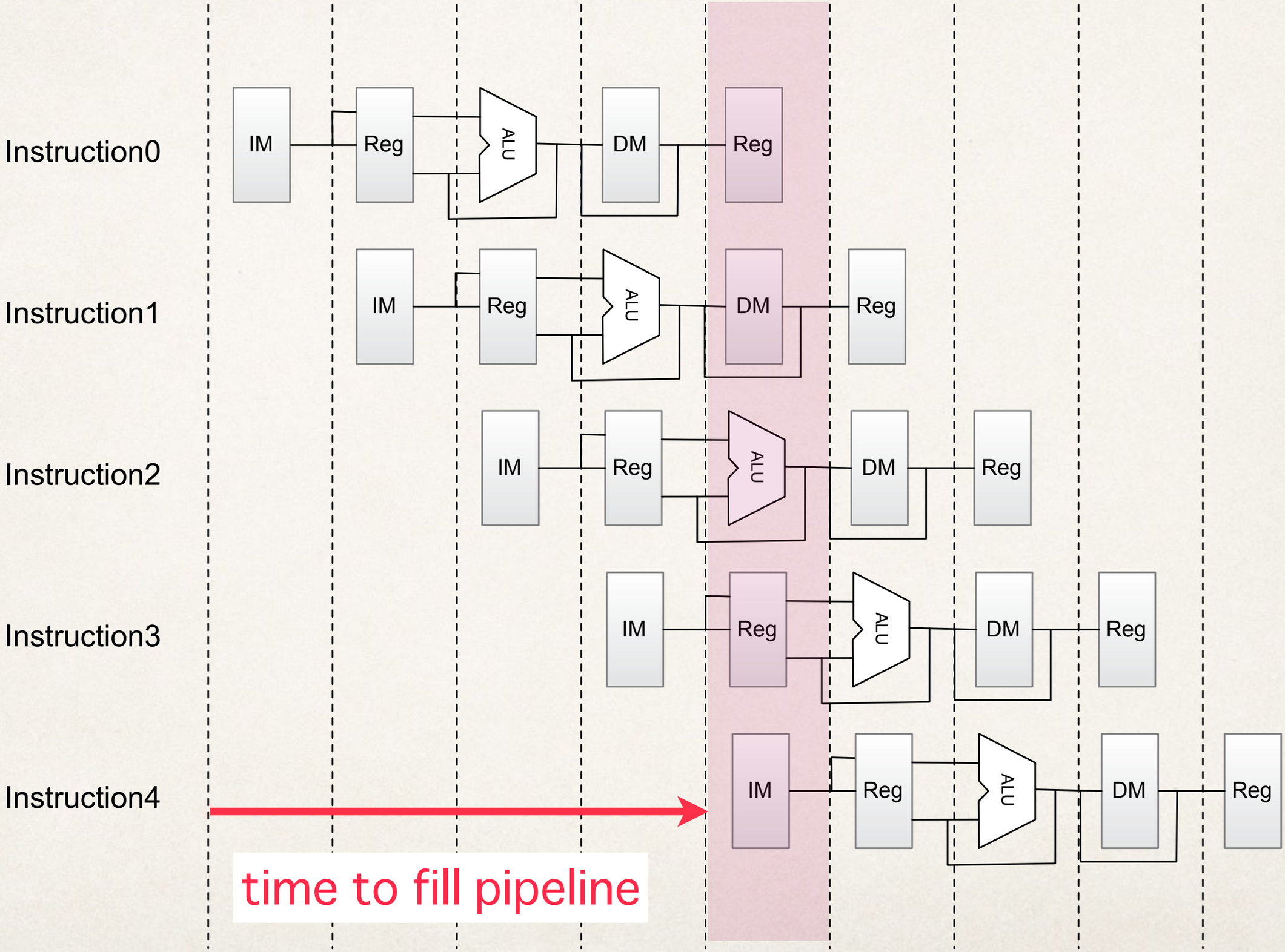
$$Throughput = \frac{1 \text{ instruction}}{200\text{ps}} \times \frac{1000\text{ps}}{1\text{ns}} = 5\text{GIPS}$$

$$Increase = \frac{5}{1.25} = 4$$

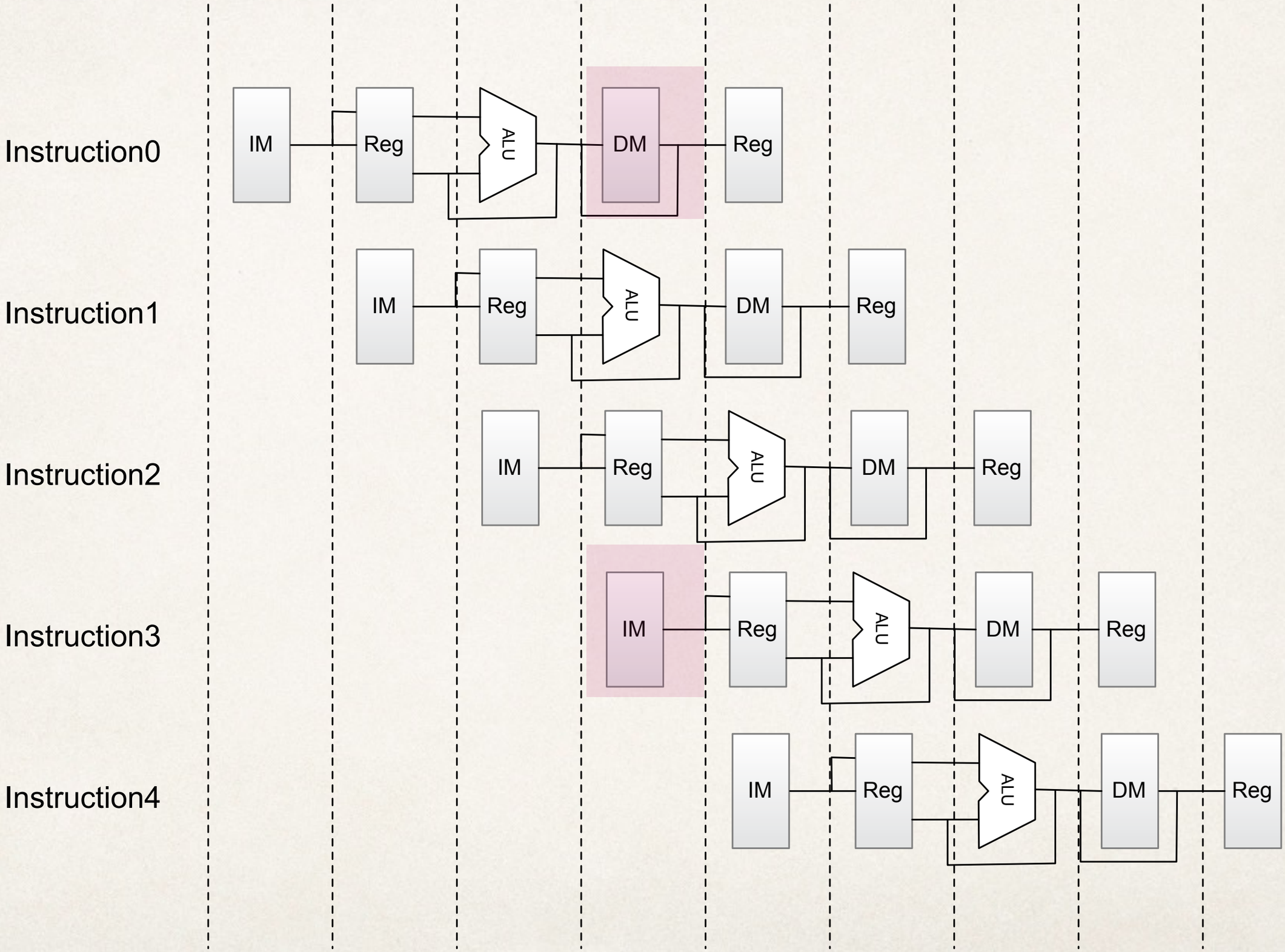
A simplified pipeline



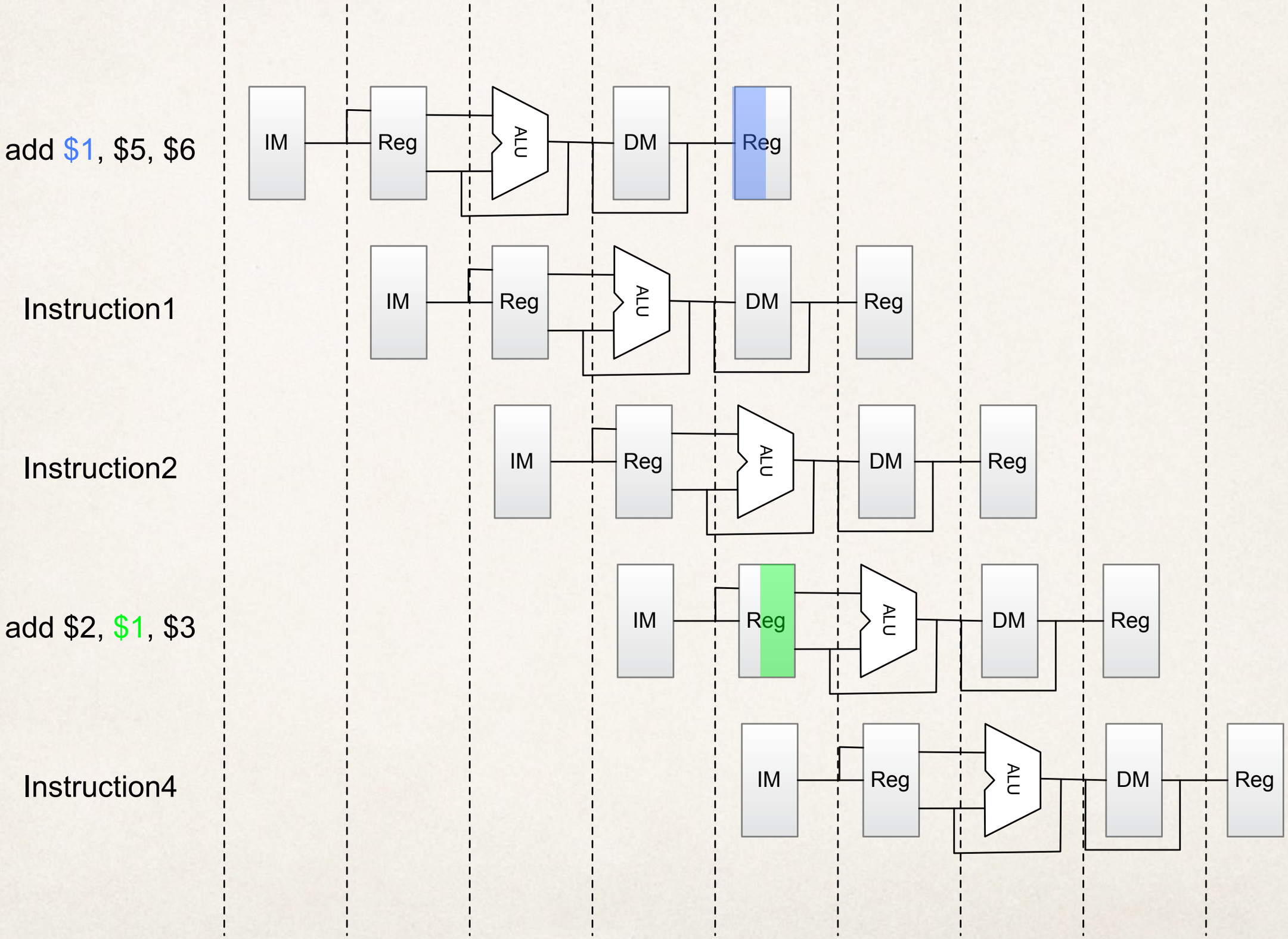
Pipelined instructions



Structural hazard

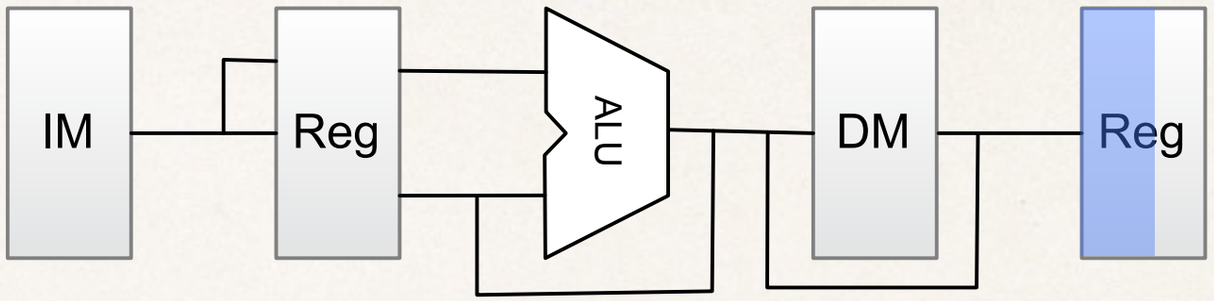


What about the registers?

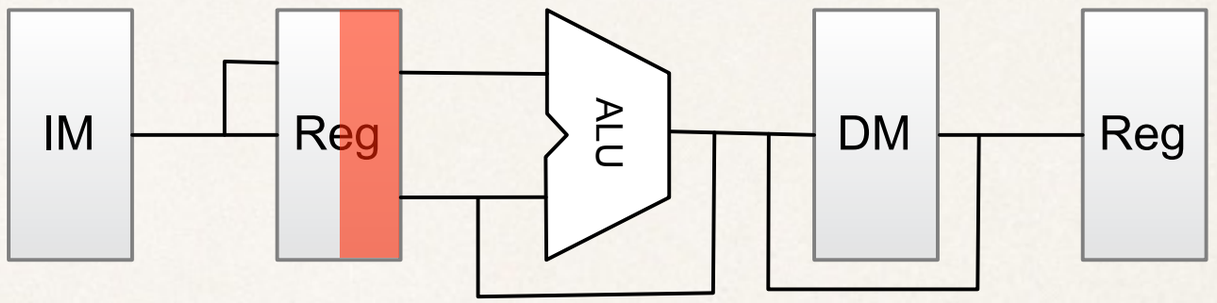


Data hazards

add $1, $5, $6

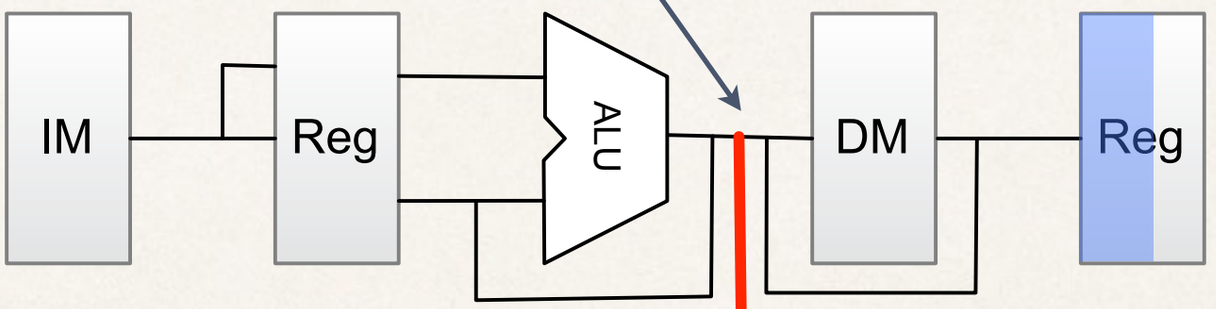


add $2, $1, $6

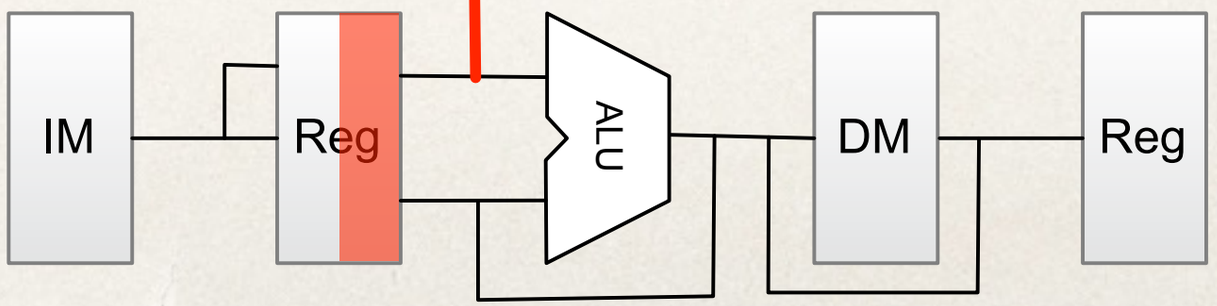


Forwarding

add $1, $5, $6

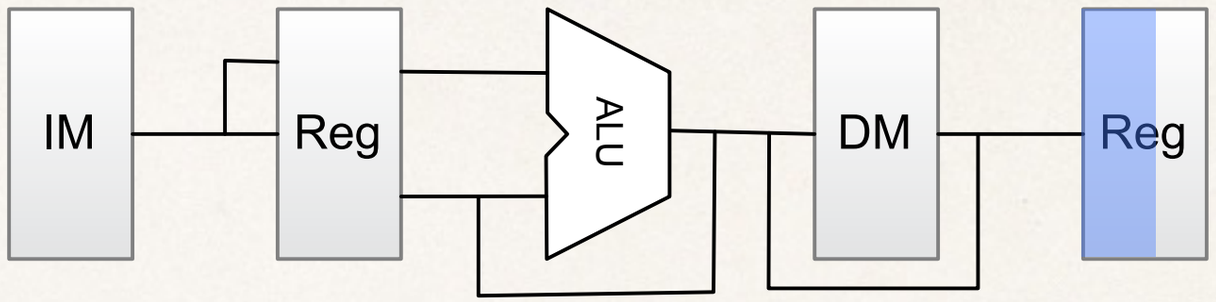


add $2, $1, $6

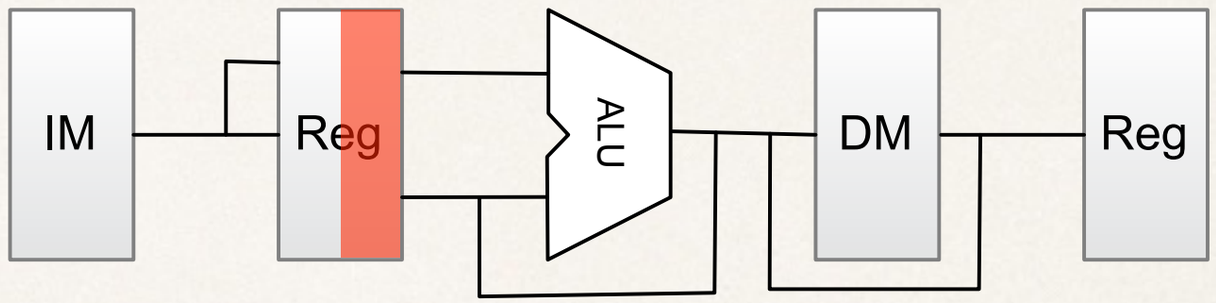


Data Hazards

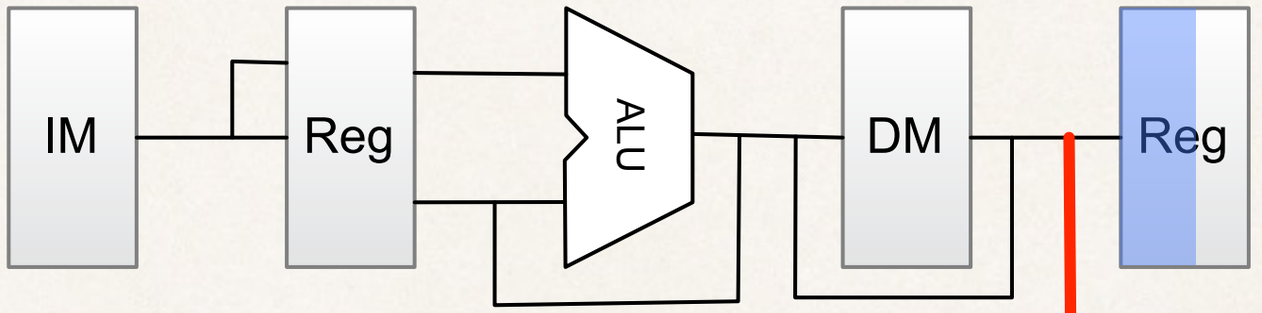
lw $1, 12($2)



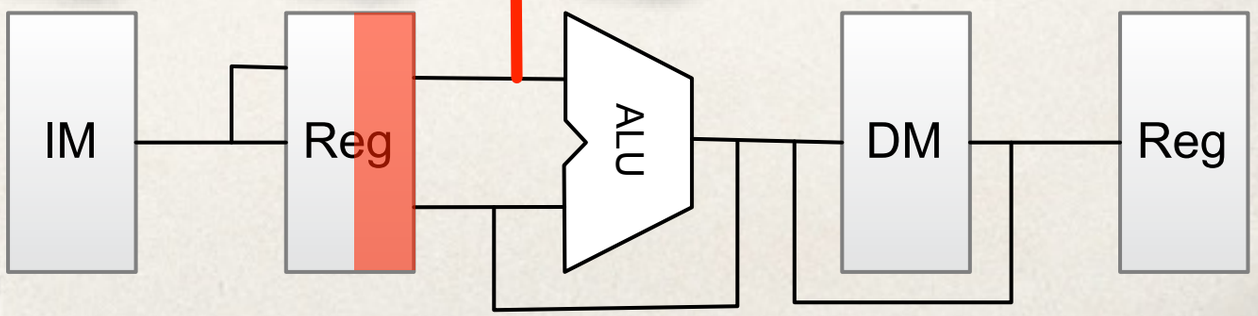
add $2, $1, $6



lw $1, 12($2)

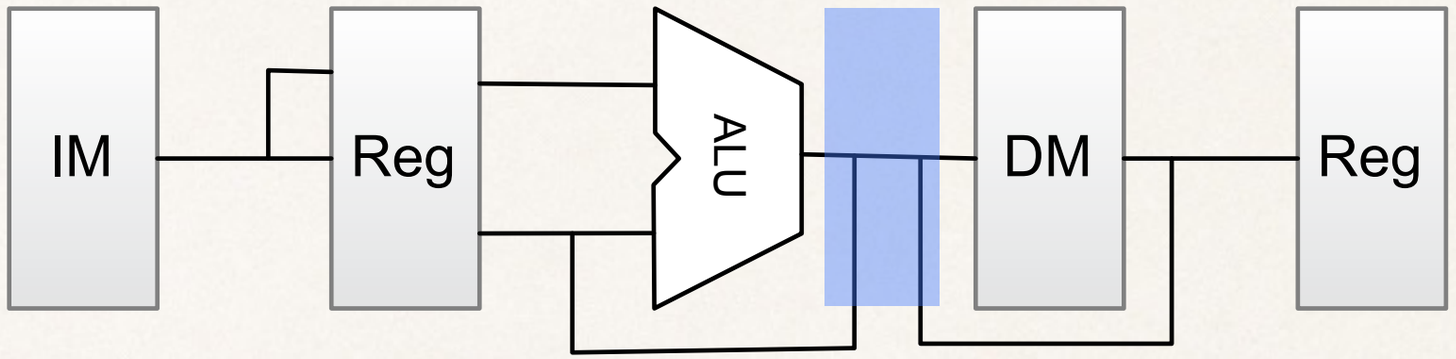


add $2, $1, $6

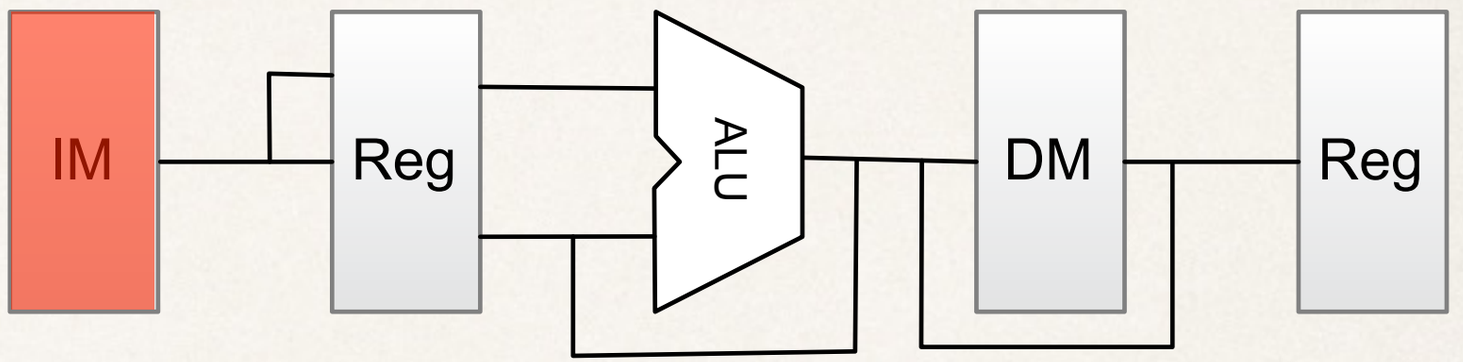


Control Hazards

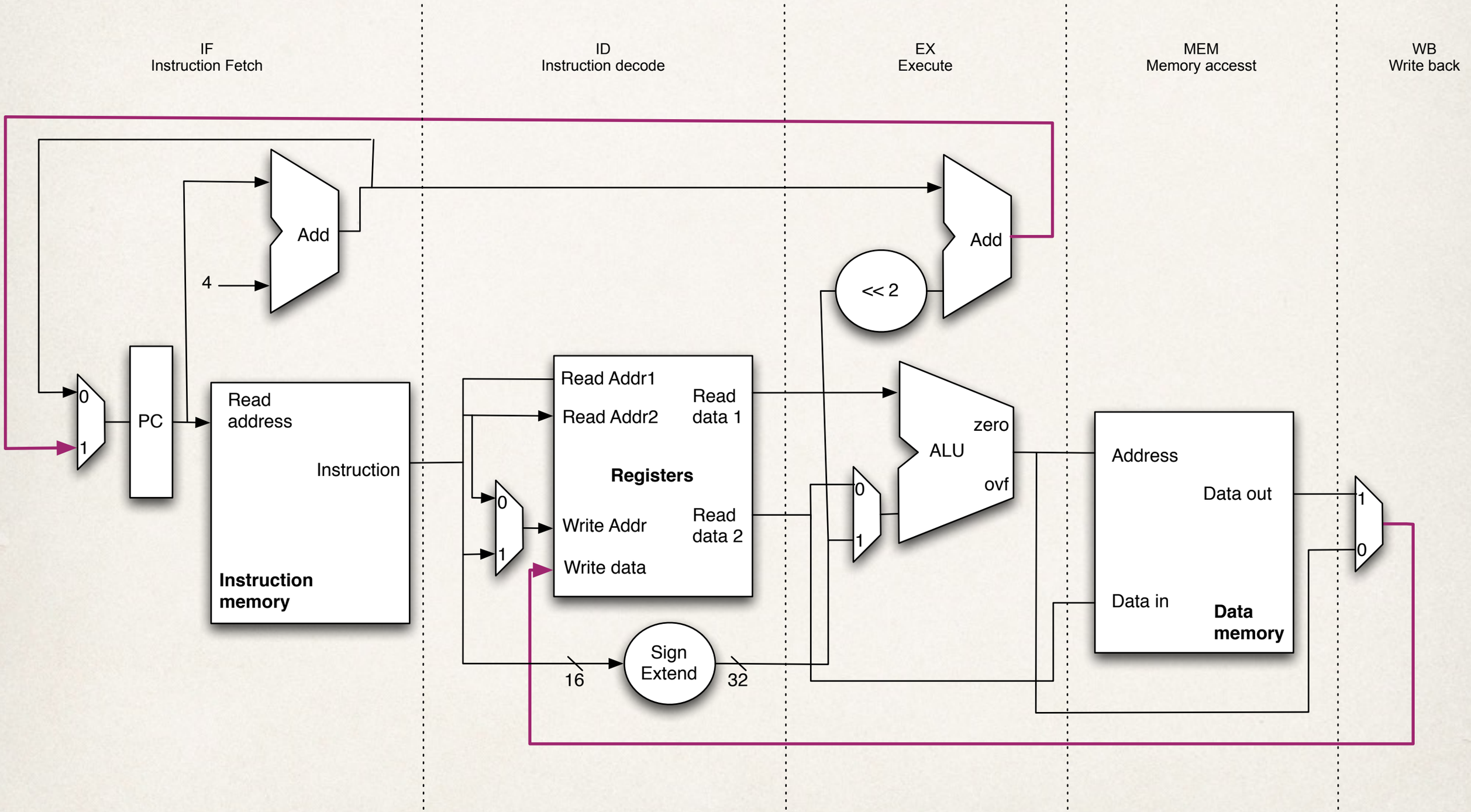
beq



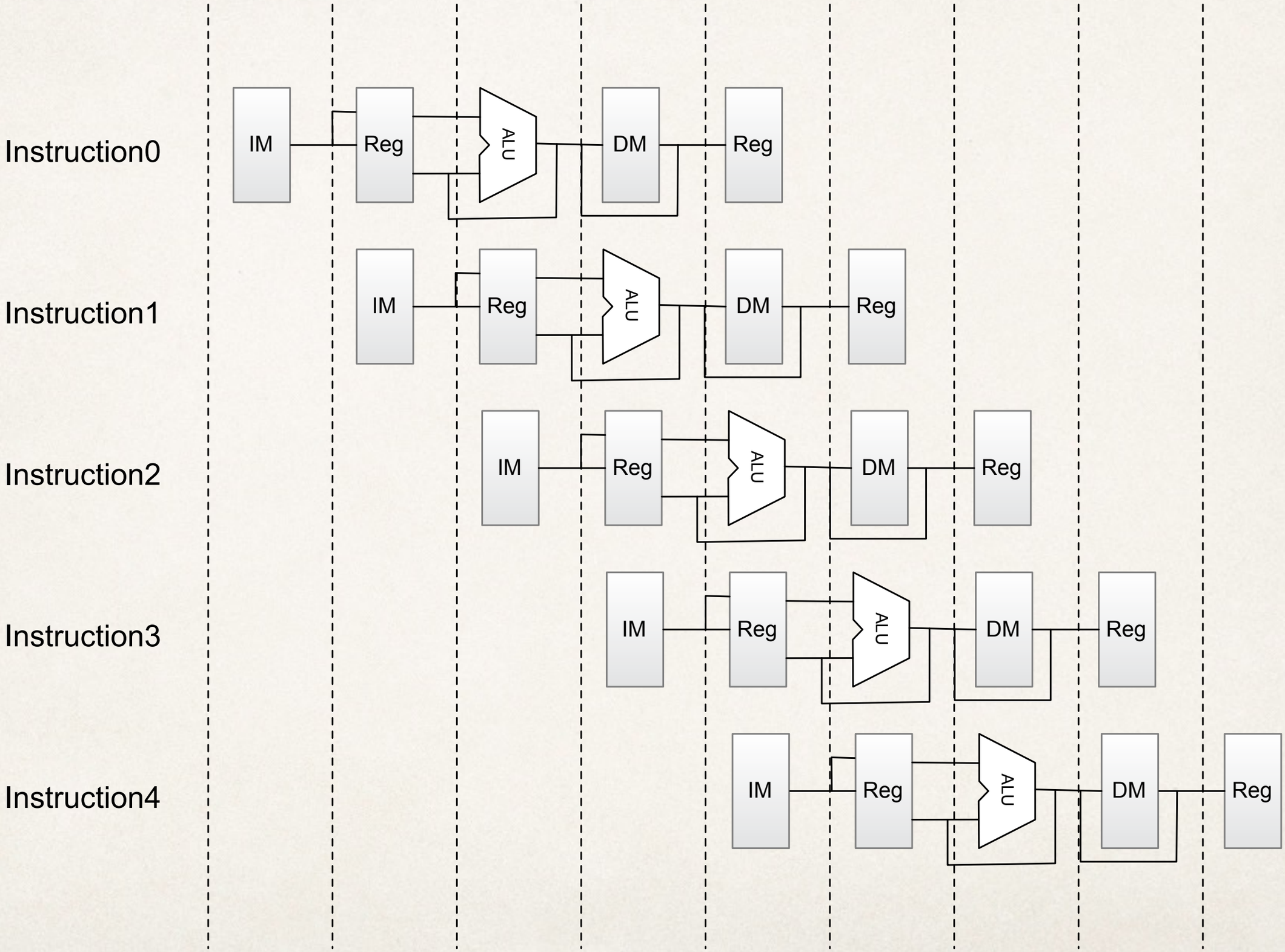
lw



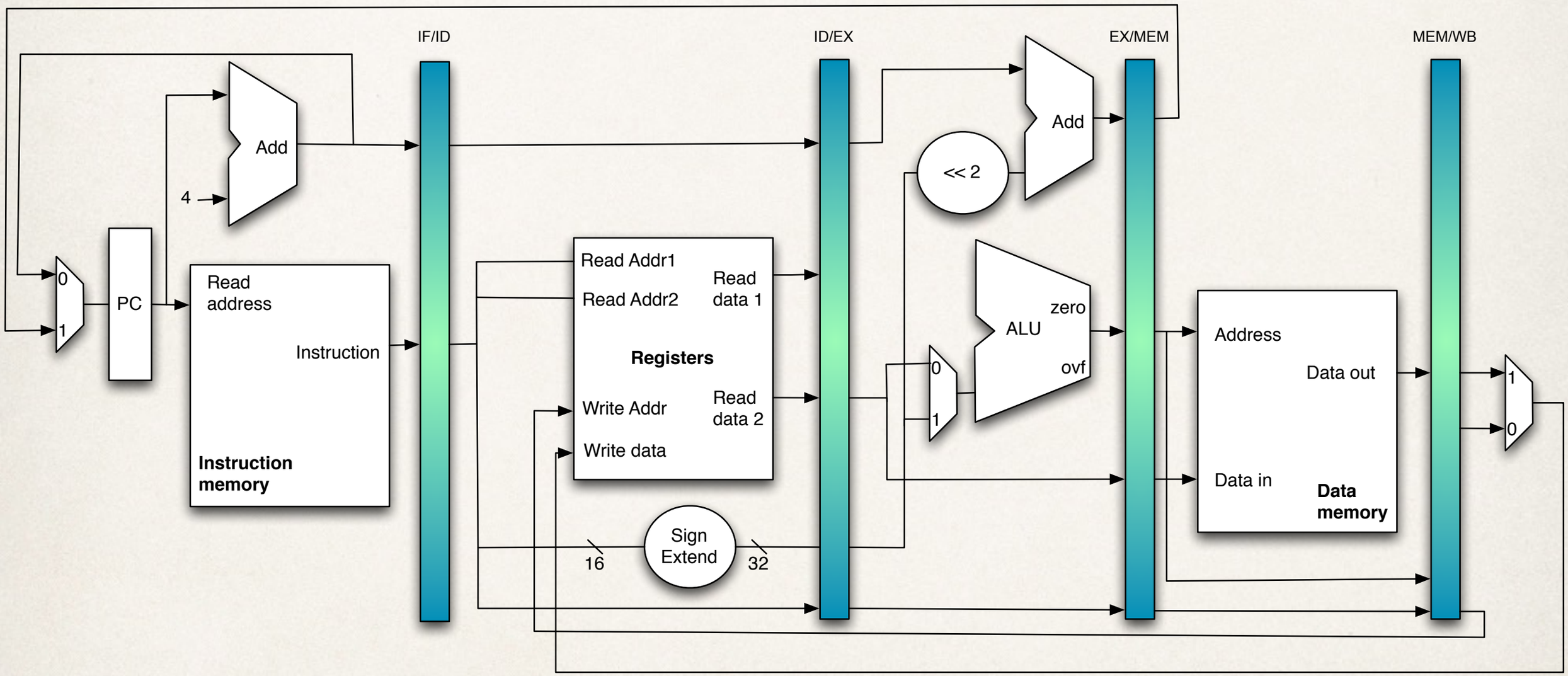
Datapath revisited



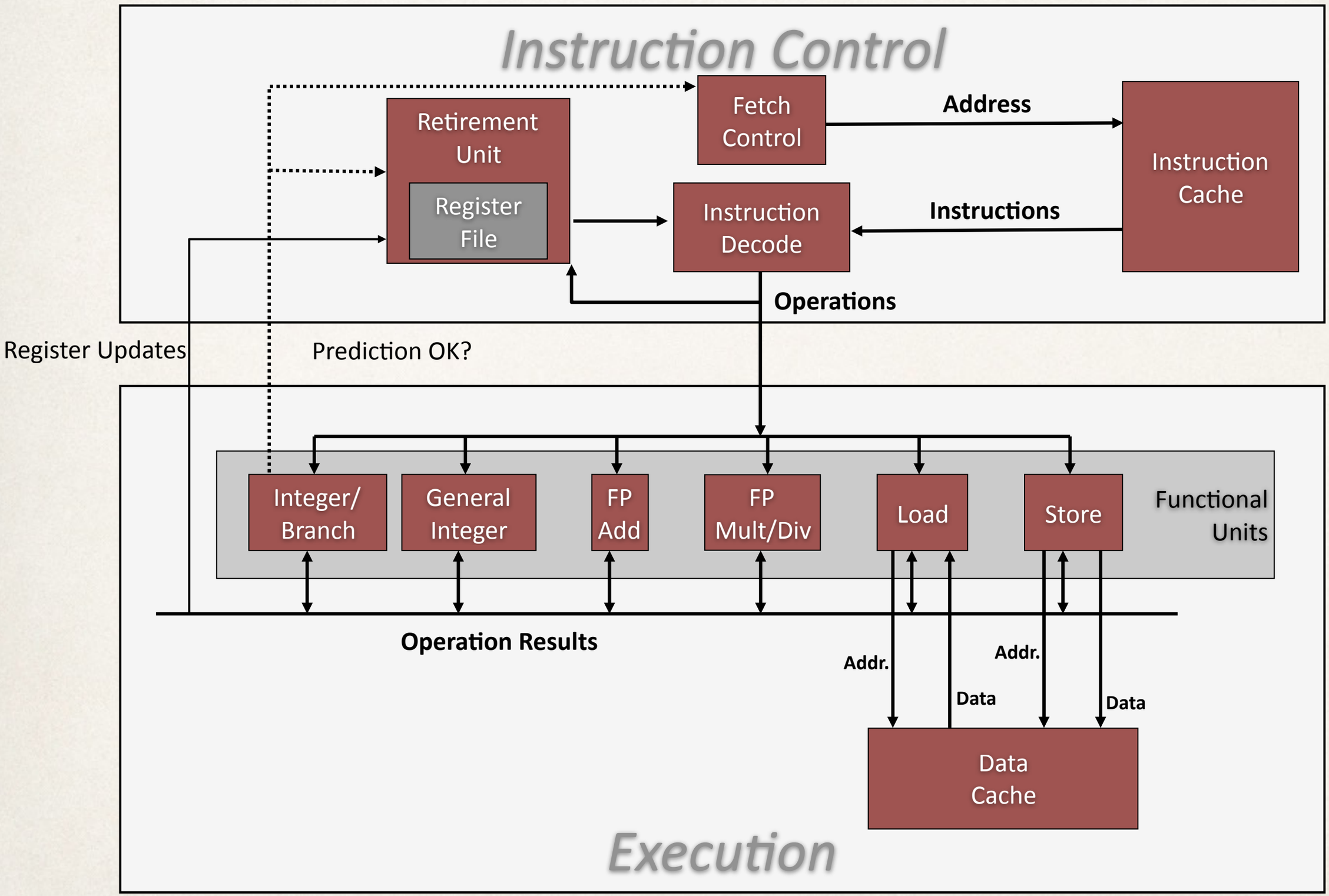
Datapath revisited



Pipelined datapath



Superscalar



Nehalem CPU (i7)

- Multiple instructions can execute in parallel
  1 load, with address computation
  1 store, with address computation
  2 simple integer (one may be branch)
  1 complex integer (multiply/divide)
  1 FP Multiply
  1 FP Add

- Some instructions take > 1 cycle, but can be pipelined

Instruction	***Latency***	***Cycles/Issue***
Load / Store	4	1
Integer Multiply	3	1
Integer/Long Divide	**11--21**	**11--21**
Single/Double FP Multiply	4/5	1
Single/Double FP Add	3	1
Single/Double FP Divide	**10--23**	**10--23**