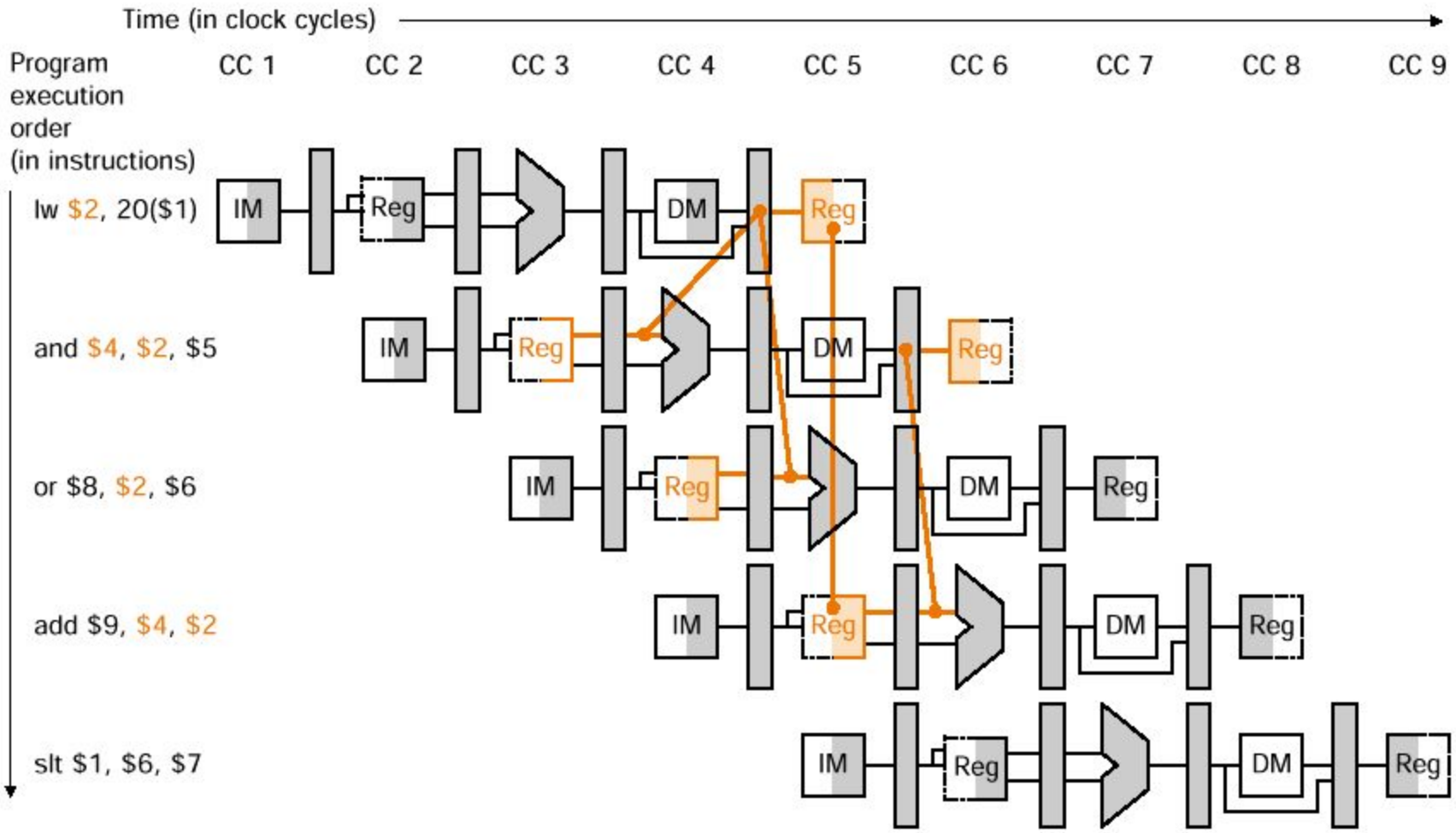
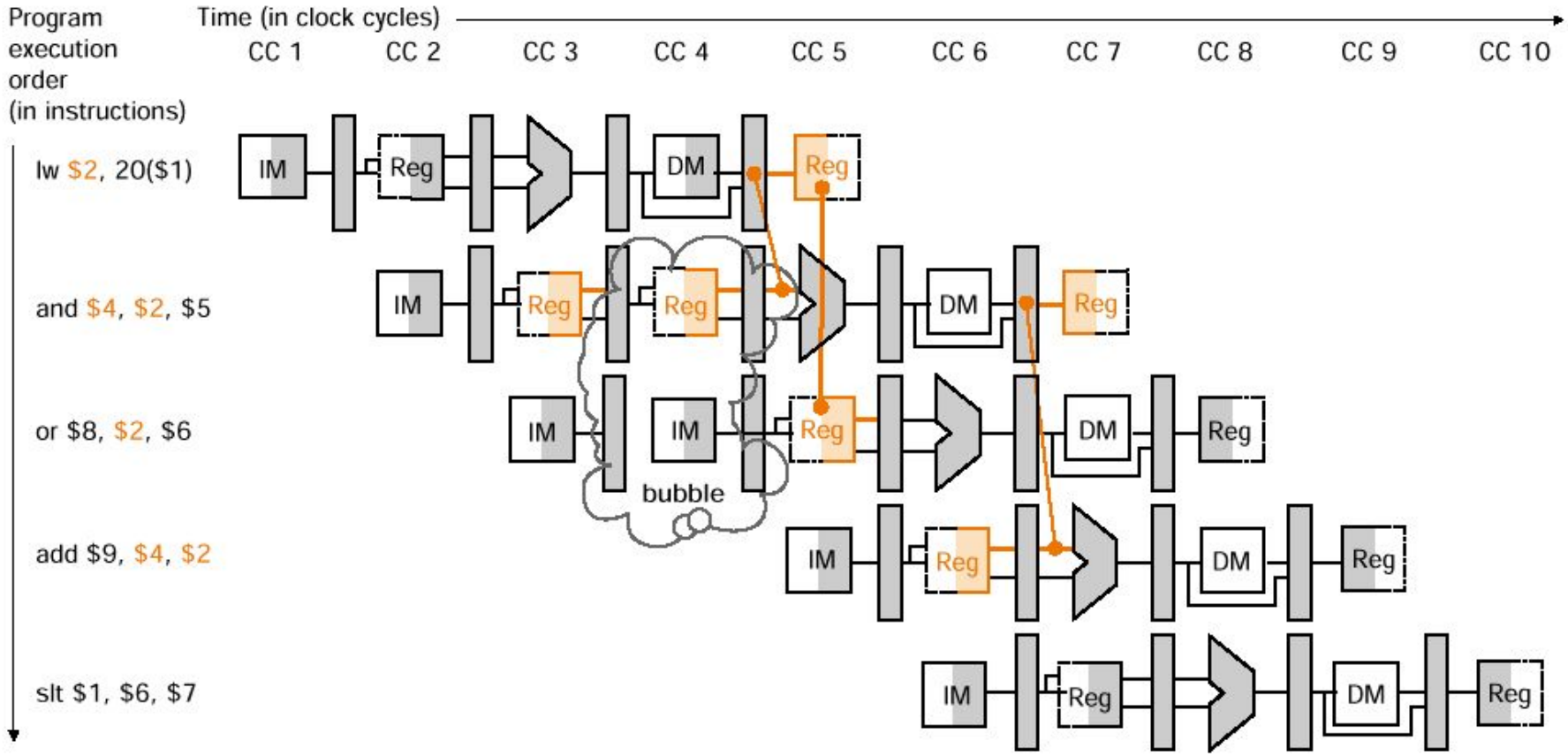
Enhancing Performance with Pipelining

Chapter Four of David A. Patterson

Data Hazard Requiring a Stall



Data Hazard Requiring a Stall



Hazard Detection Unit

- ✔ We need hazard detection unit beside the forwarding unit.
- ✔ It operates during the ID stage so that it can insert the stall between the load and it's use.
- ✔ Condition:

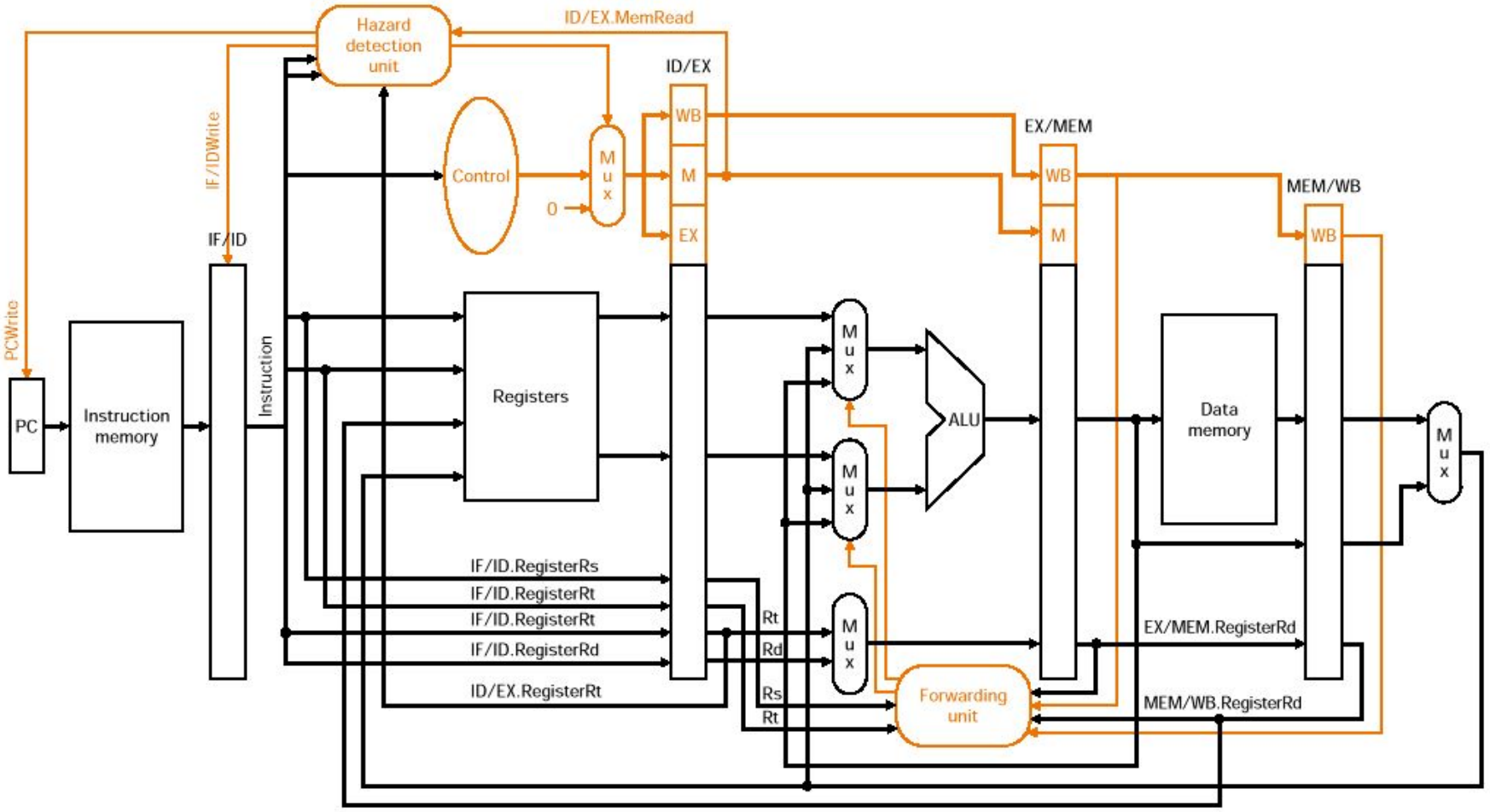
  if (ID/EX.MemRead and

  ((ID/EX.RegisterRt = IF/ID.RegisterRs) or

  (ID/EX.RegisterRt = IF/ID.RegisterRt)))

  stall the pipeline

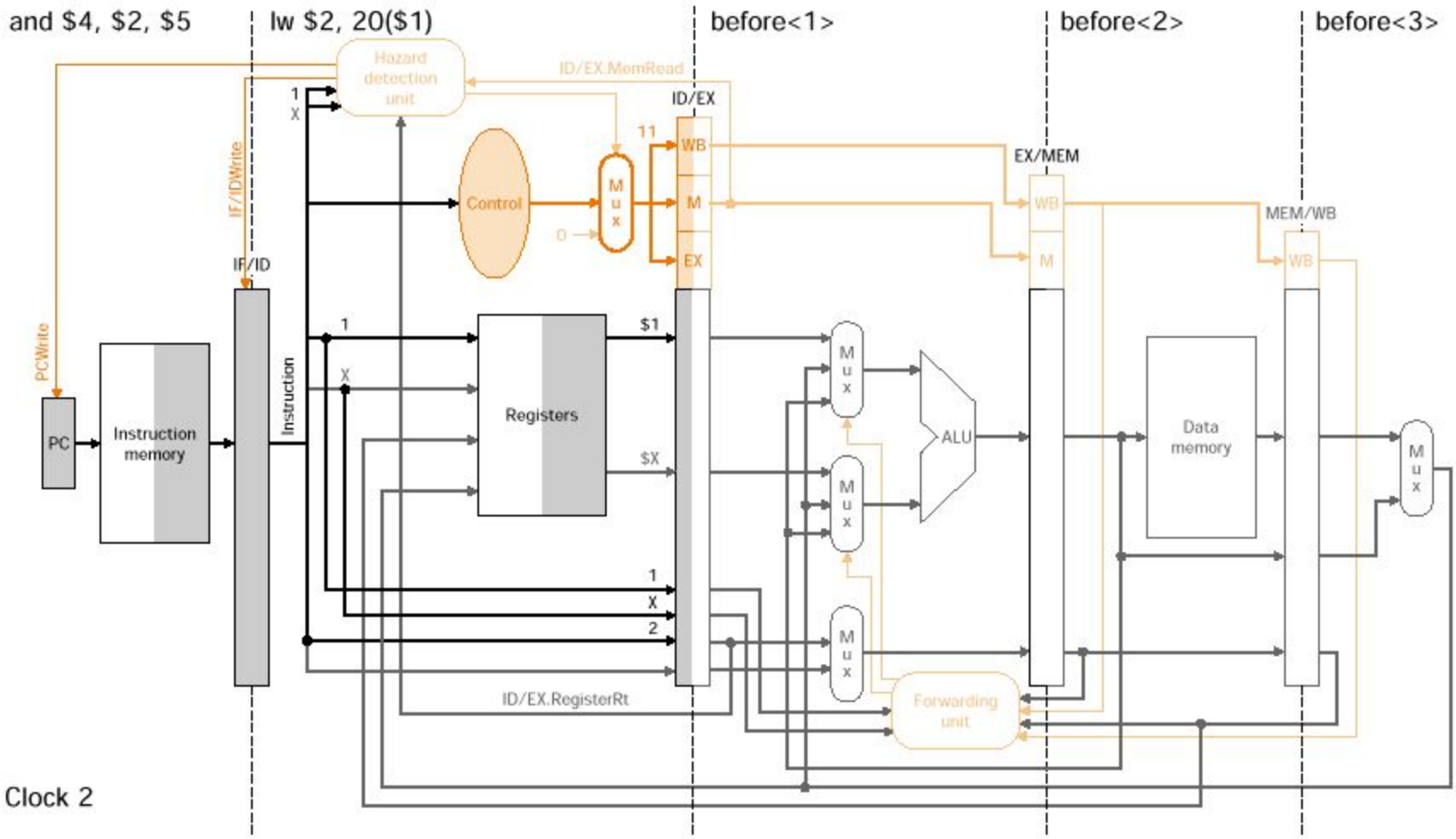
Stall Logic


Hazard detection unit
ID/EX.MemRead
ID/EX
WB
M
EX
Control
M u x
0
IF/IDWrite
IF/ID
EX/MEM
WB
M
MEM/WB
WB
PCWrite
PC
Instruction memory
Instruction
Registers
M u x
ALU
Data memory
M u x
M u x
M u x
IF/ID.RegisterRs
IF/ID.RegisterRt
IF/ID.RegisterRt
IF/ID.RegisterRd
ID/EX.RegisterRt
Rt
Rd
Rs
Rt
Forwarding unit
EX/MEM.RegisterRd
MEM/WB.RegisterRd

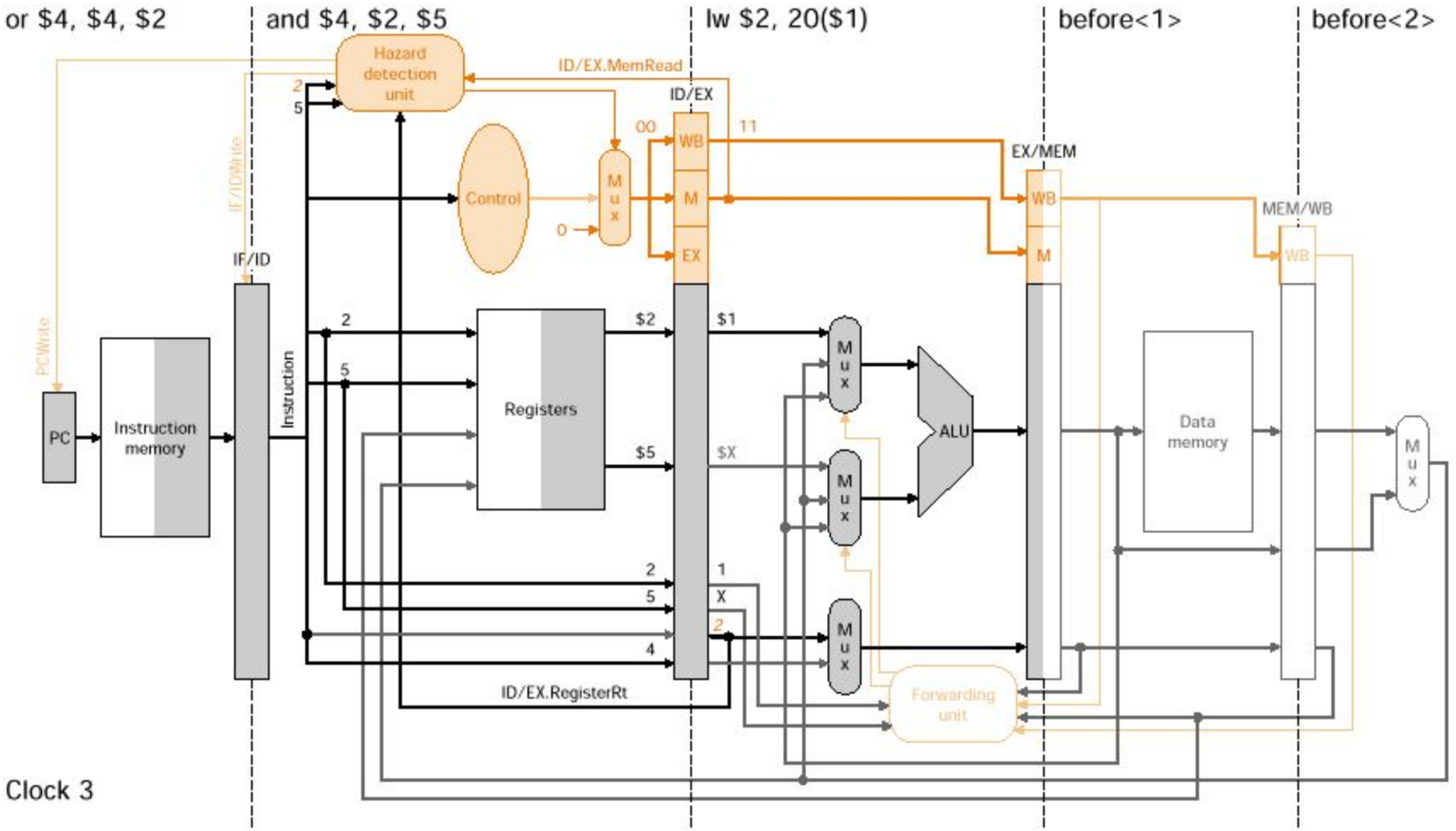
Nops

- ✔ Both instructions in ID and IF stage must be stalled.
- ✔ For this reason, the PC register and the IF/ID register are preserved.
- ✔ The EX stage must do **nops**.
- ✔ To insert **nops** we must deassert all nine control signal in EX, MEM and WB stage.

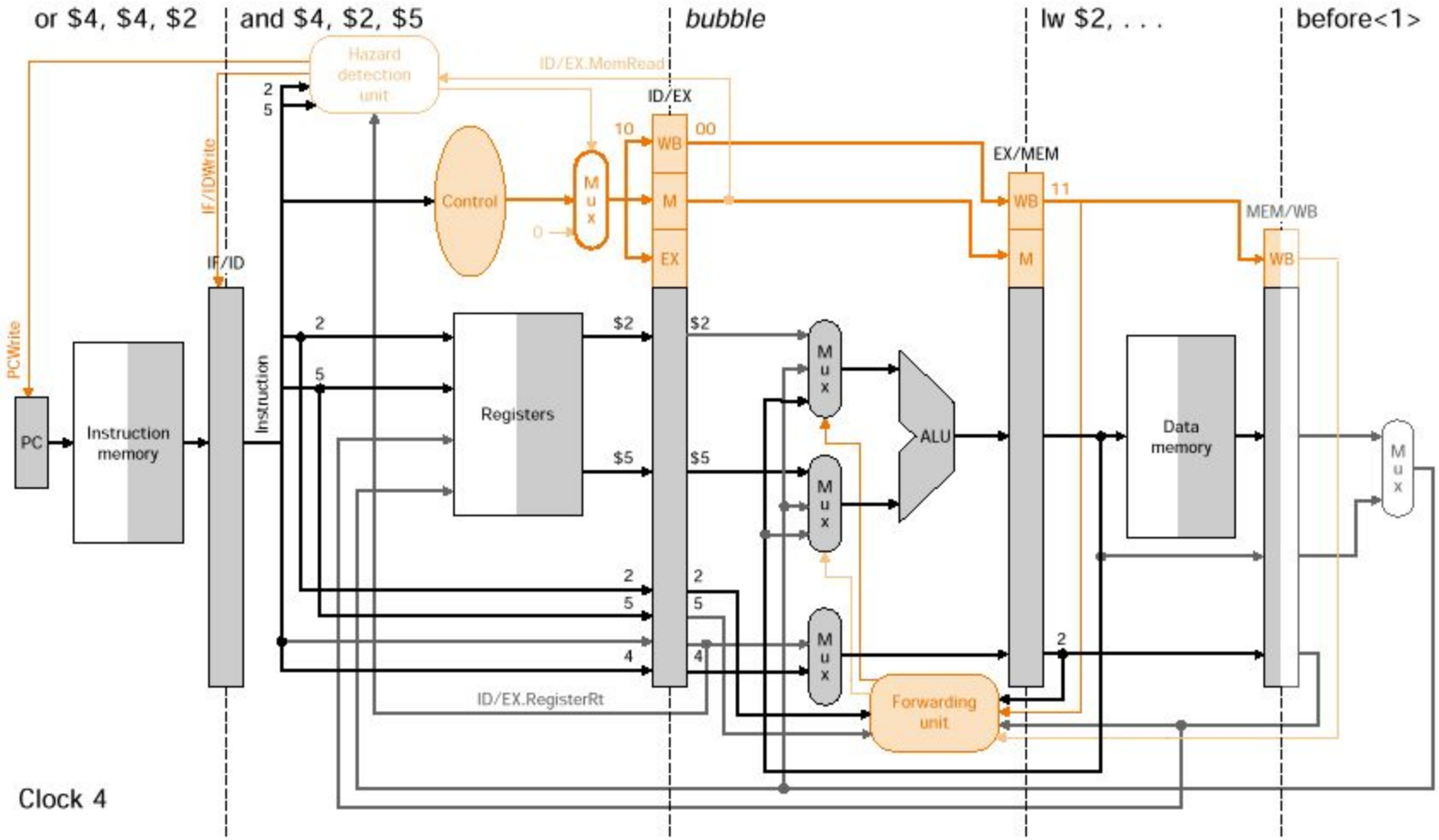
Stall Example



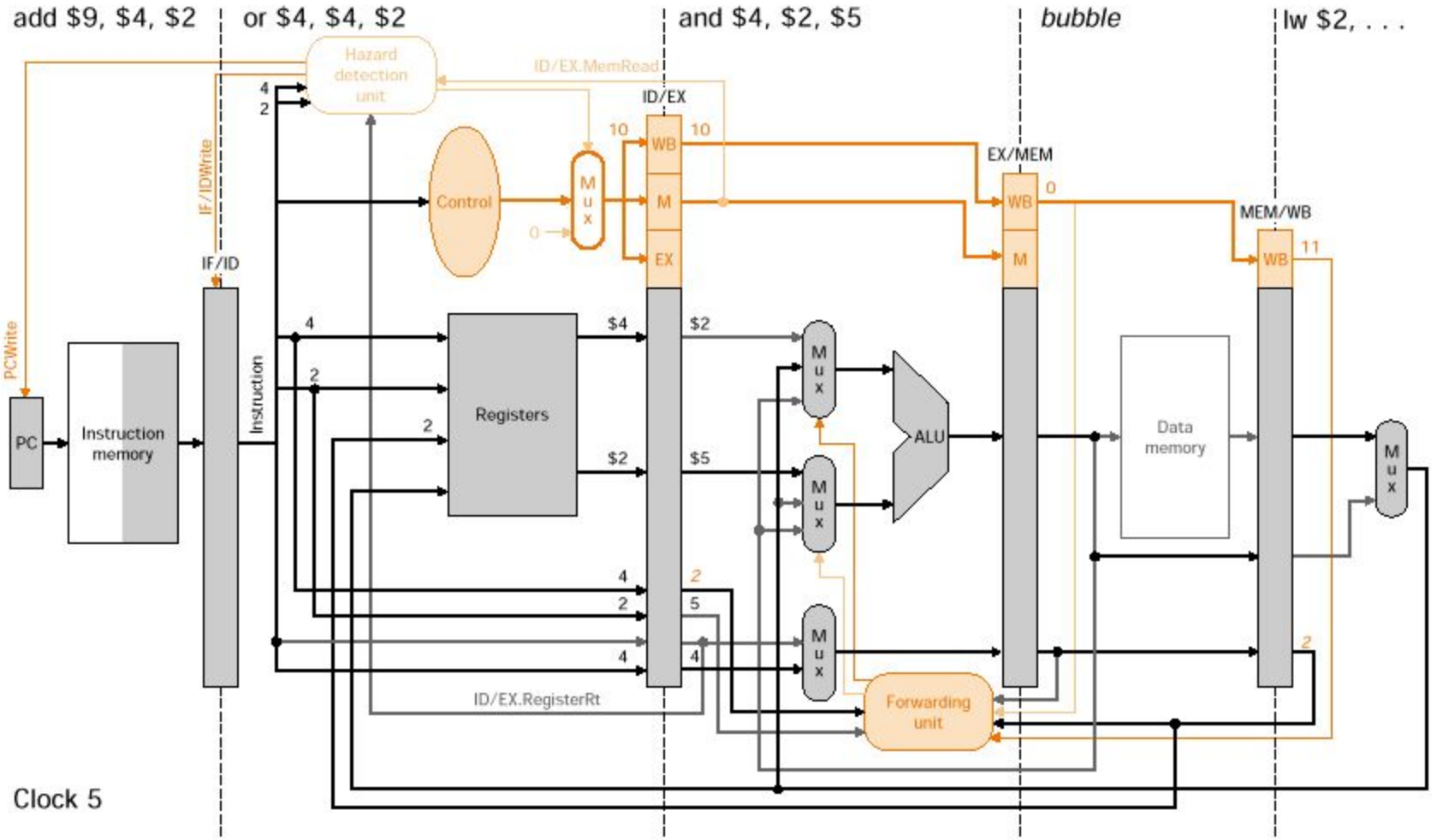
Stall Example



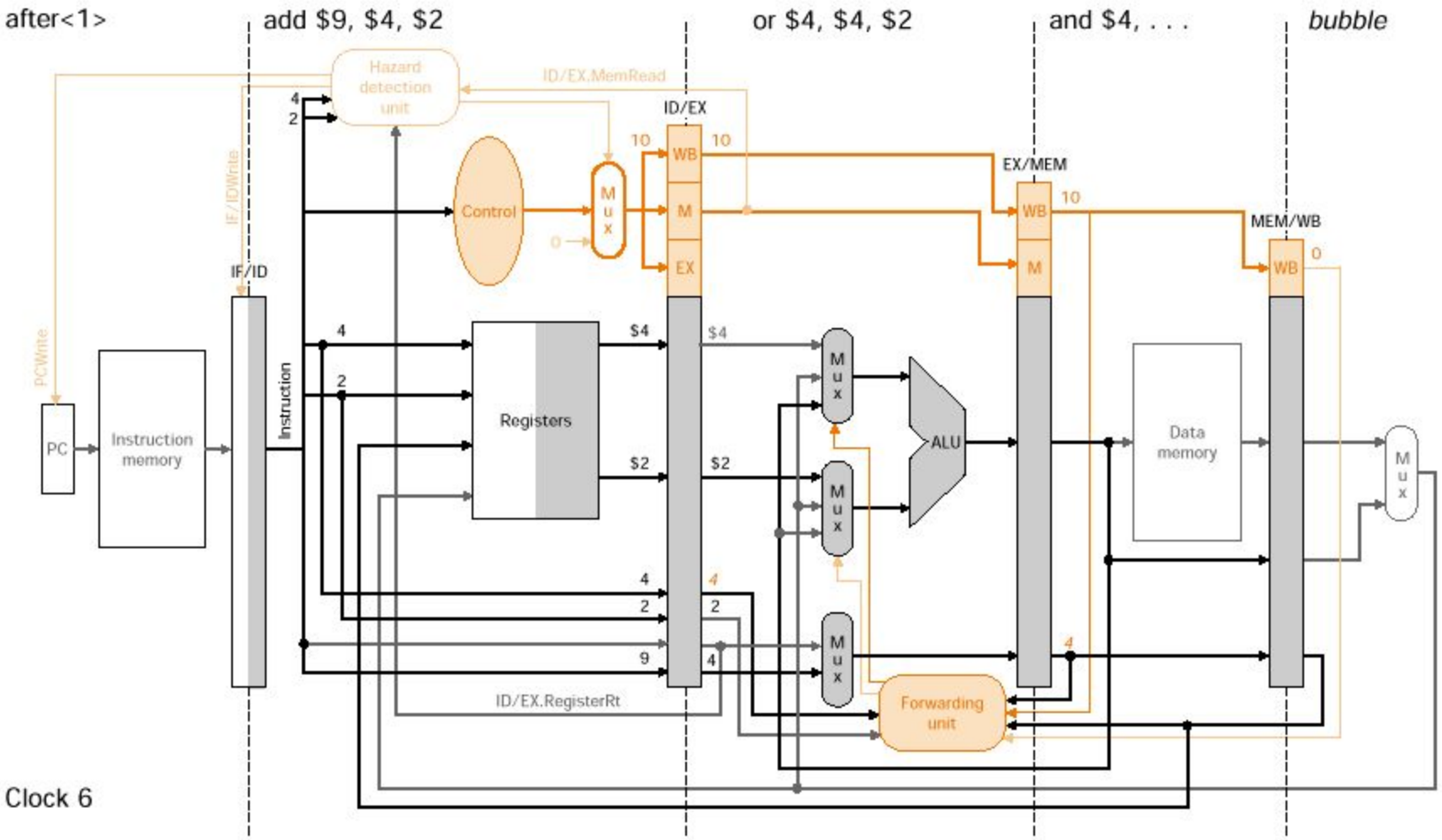
Stall Example



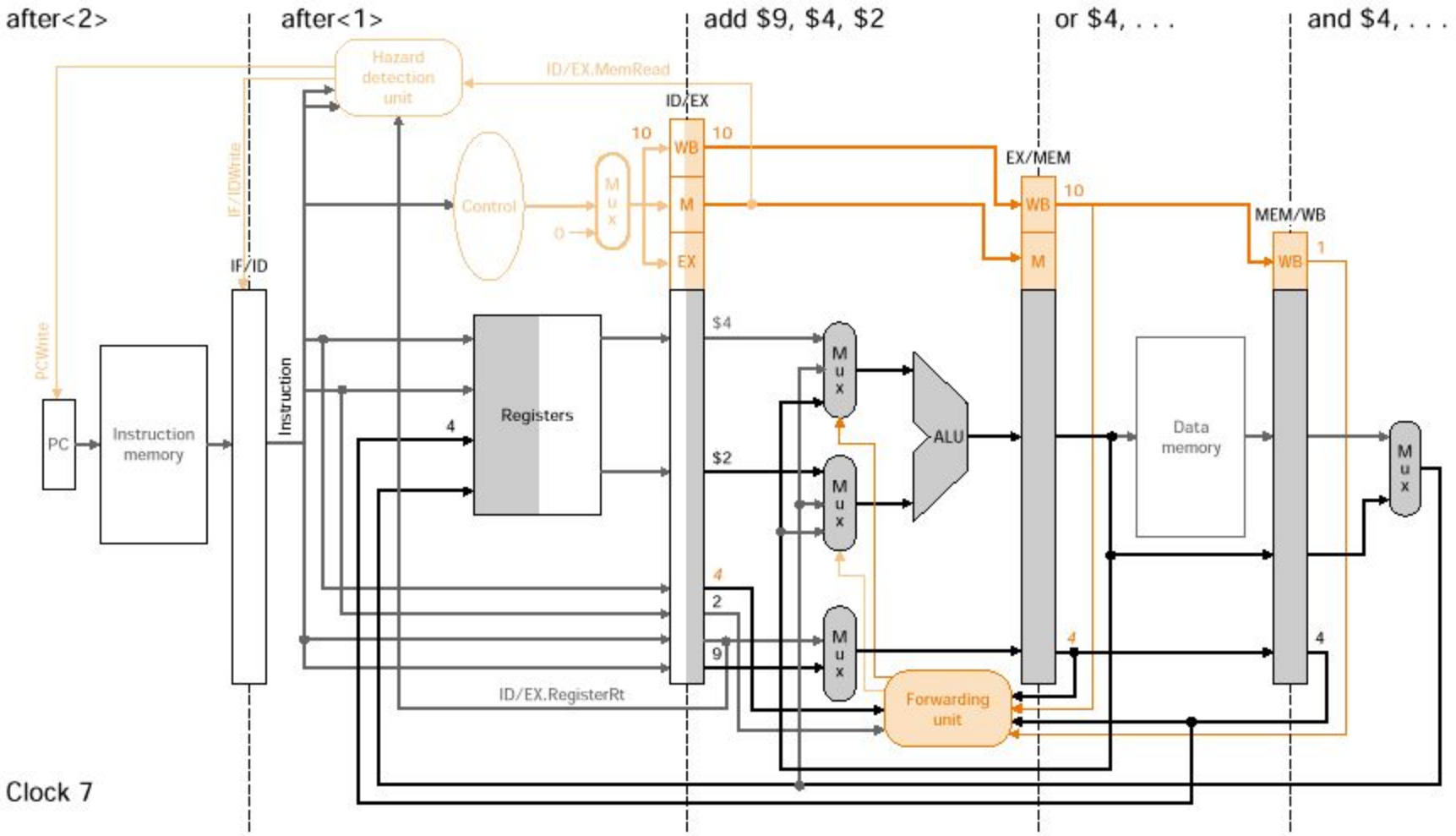
Stall Example



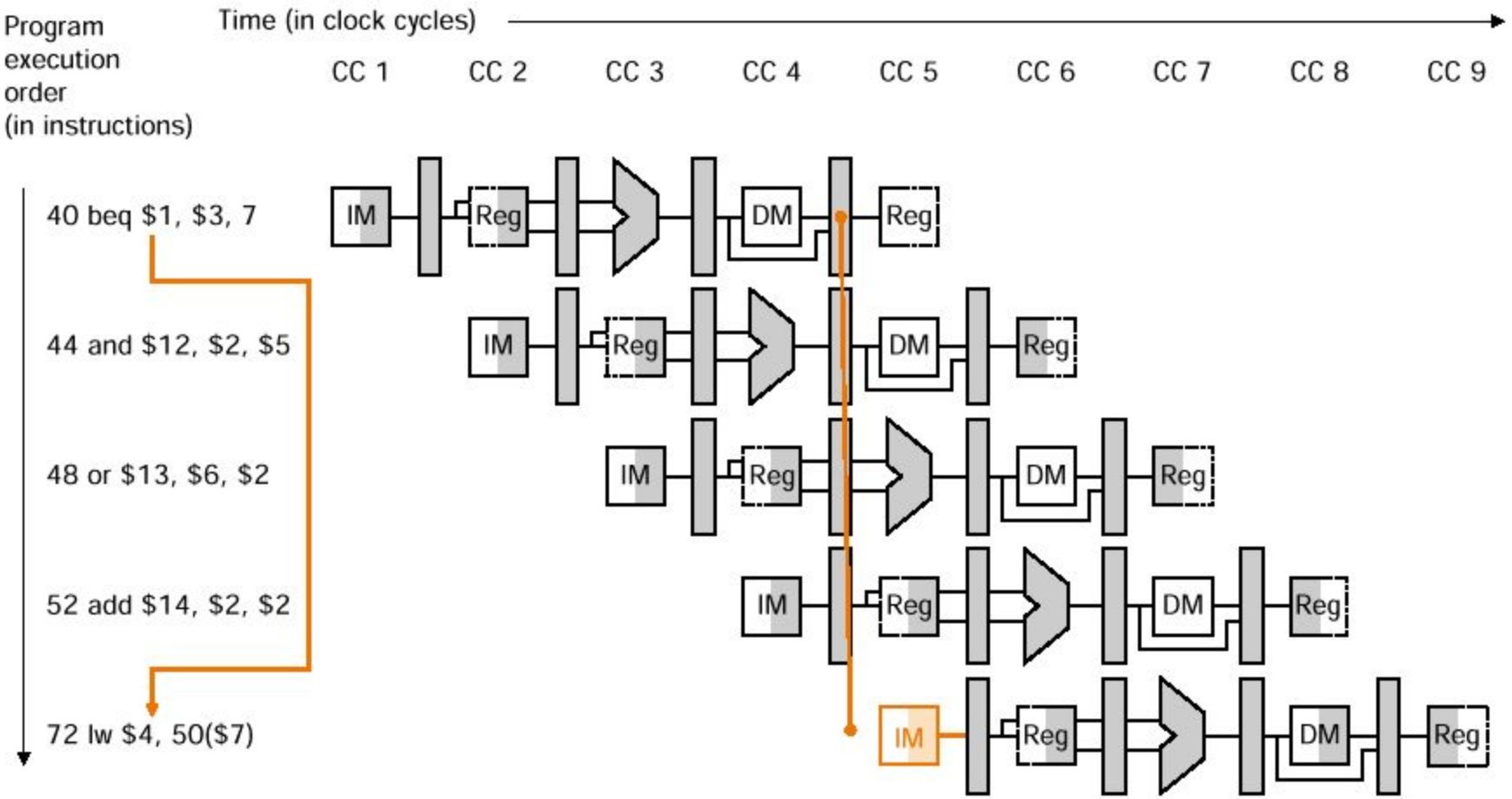
Stall Example



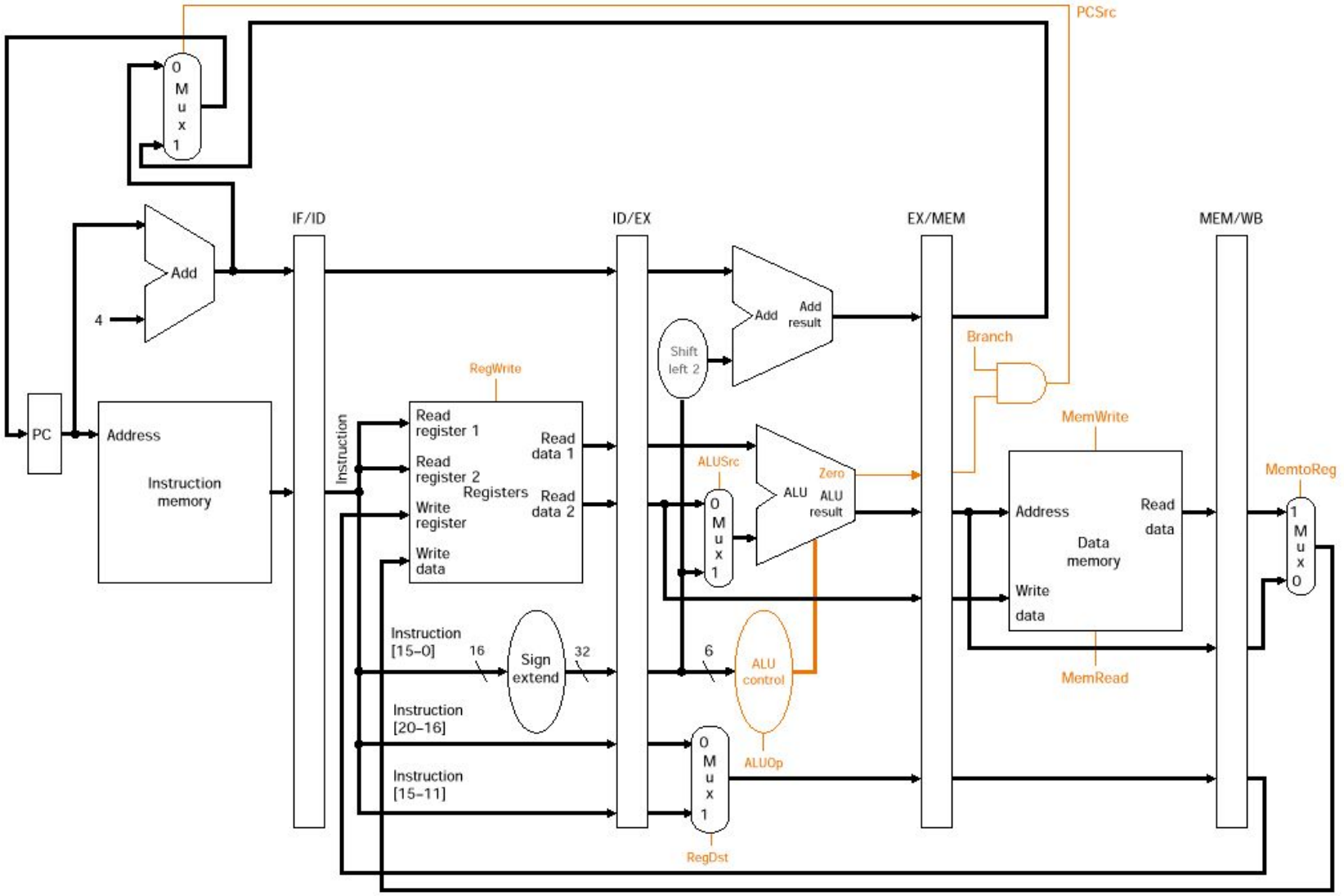
Stall Example



Control (Branch) Hazard Example



Pipelined Datapath with Control Signals



Solution of the Control Hazards

1. We can wait until decision to take a branch is not taken in MEM stage. It slow down the pipeline.
2. **Assume Branch not Taken:**

- ✔ Assume branch not will not be taken and continue execution with the next sequential instruction.
- ✔ If branch is taken in MEM stage, all the instructions in IF, ID and EX stages must be discarded by setting the control signal 0 and the execution continues at the branch target.
- ✔ Reduces the cost of control hazard.

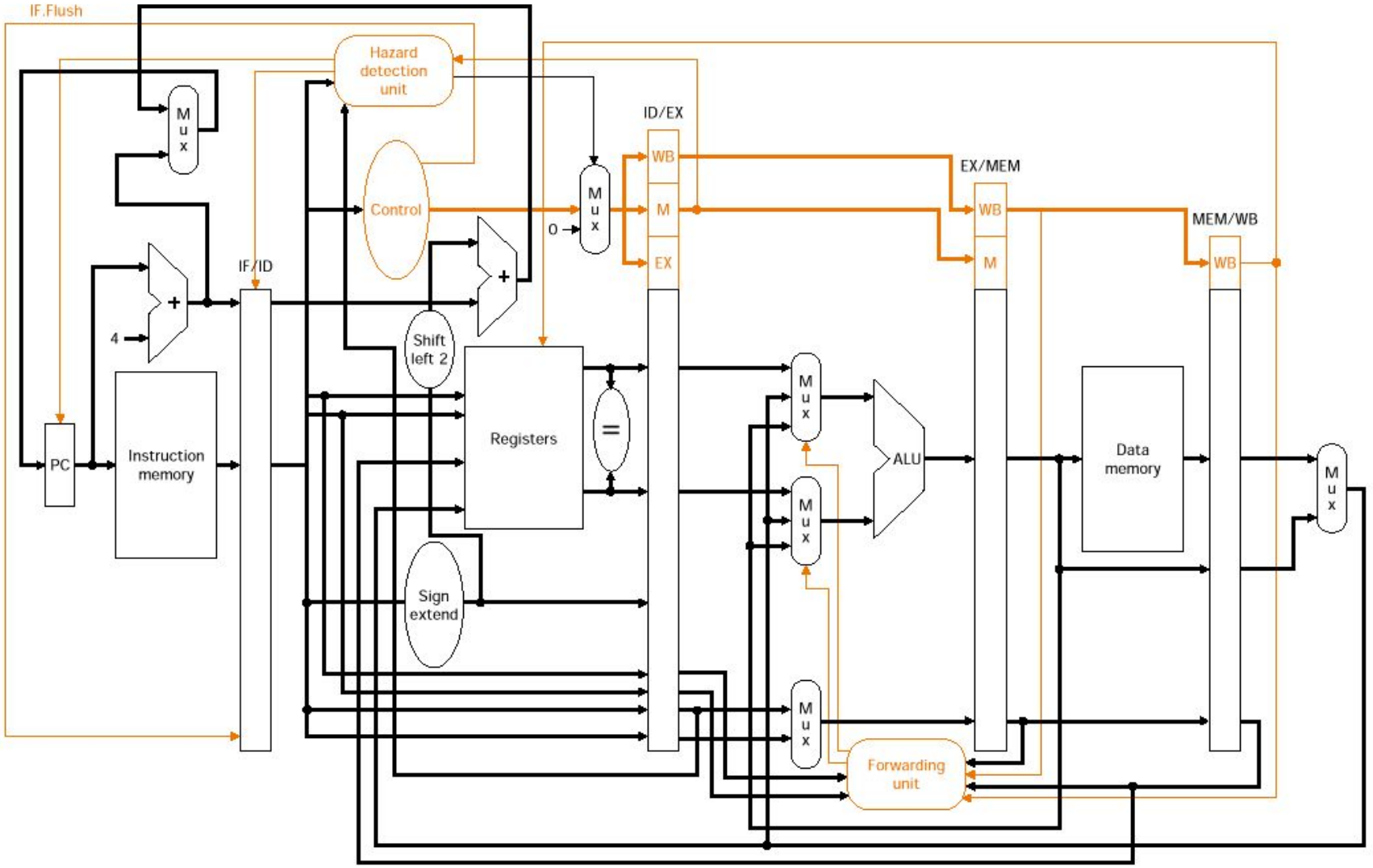
Reducing the Delay of Branches

- ✔ If a branch is selected in MEM stage, then we need to flush three instructions.
- ✔ By moving the branch selection to the ID stage we need to flush only one instruction.
- ✔ This requires:

  1.computing branch target address

  2. Evaluating branch decision in ID stage

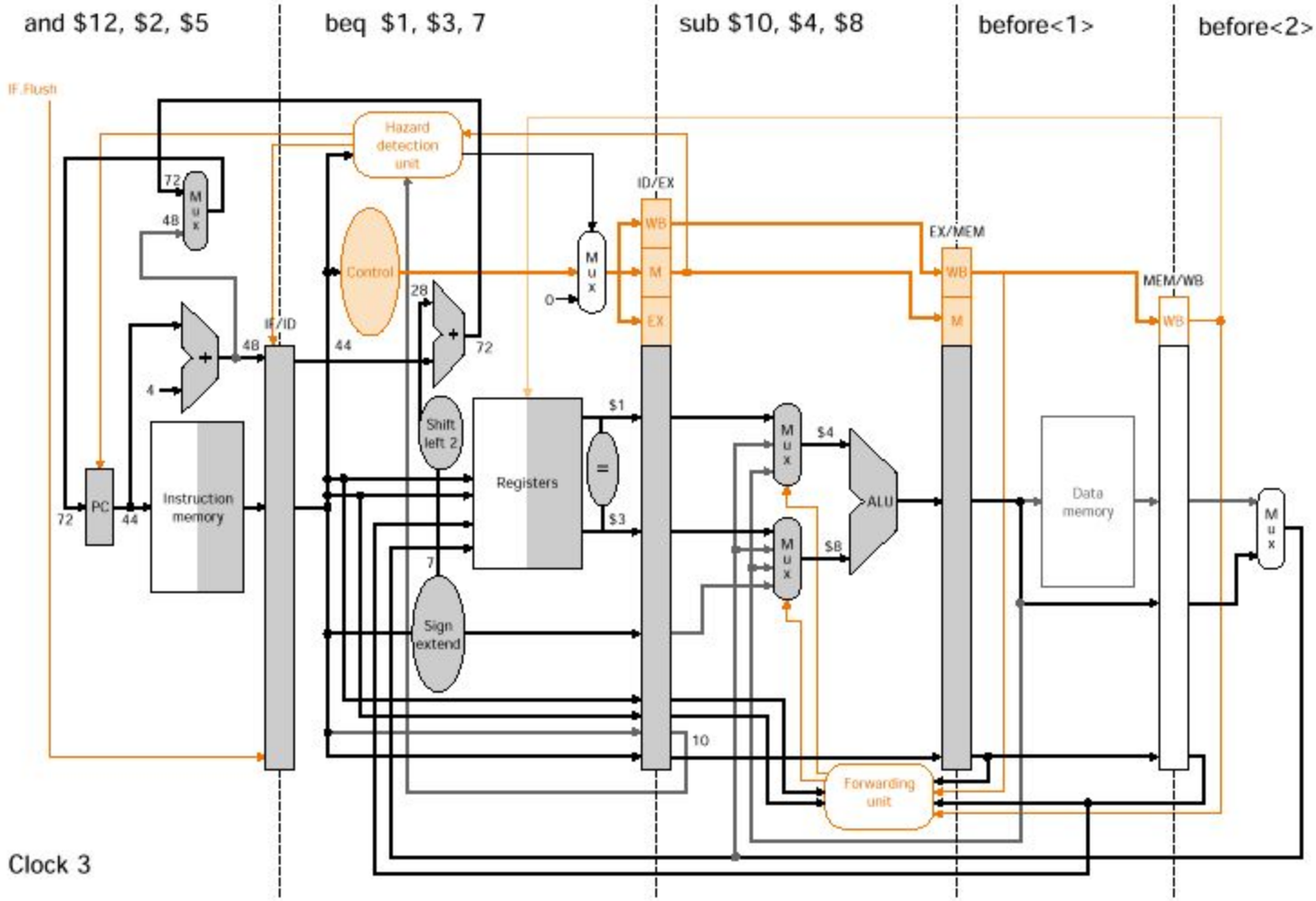
Control Hazard Logic



Control (Branch) Hazard Example

```
36  sub $10, $4, $8
40  beq $1, $3, 7
44  and $12, $2, $5
48  or  $13, $2, $6
52  add $14, $4, $2
56  slt $15, $6, $7
. . .
72  lw  $4, 50($7)
```

Control (Branch) Hazard Example



Control (Branch) Hazard Example