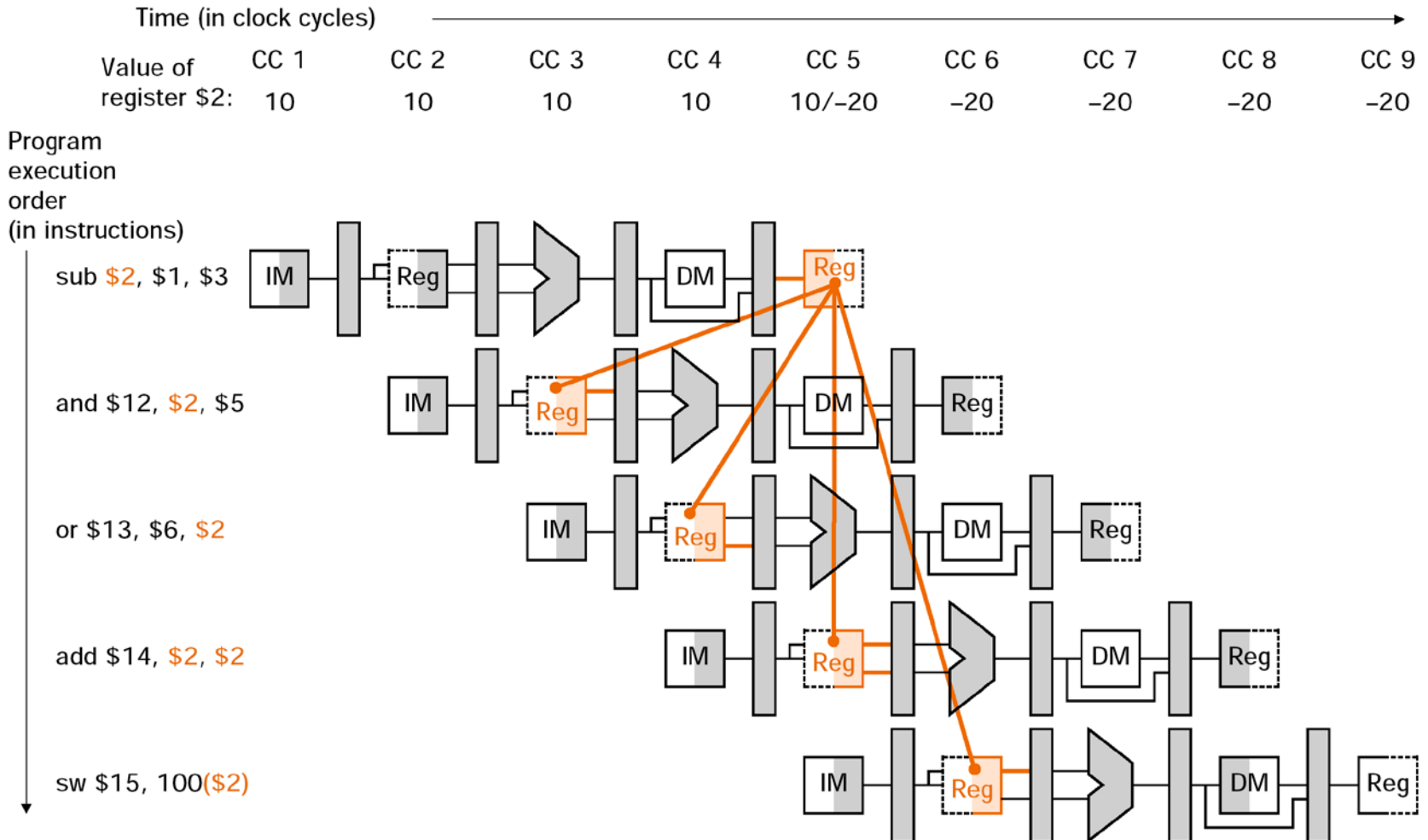
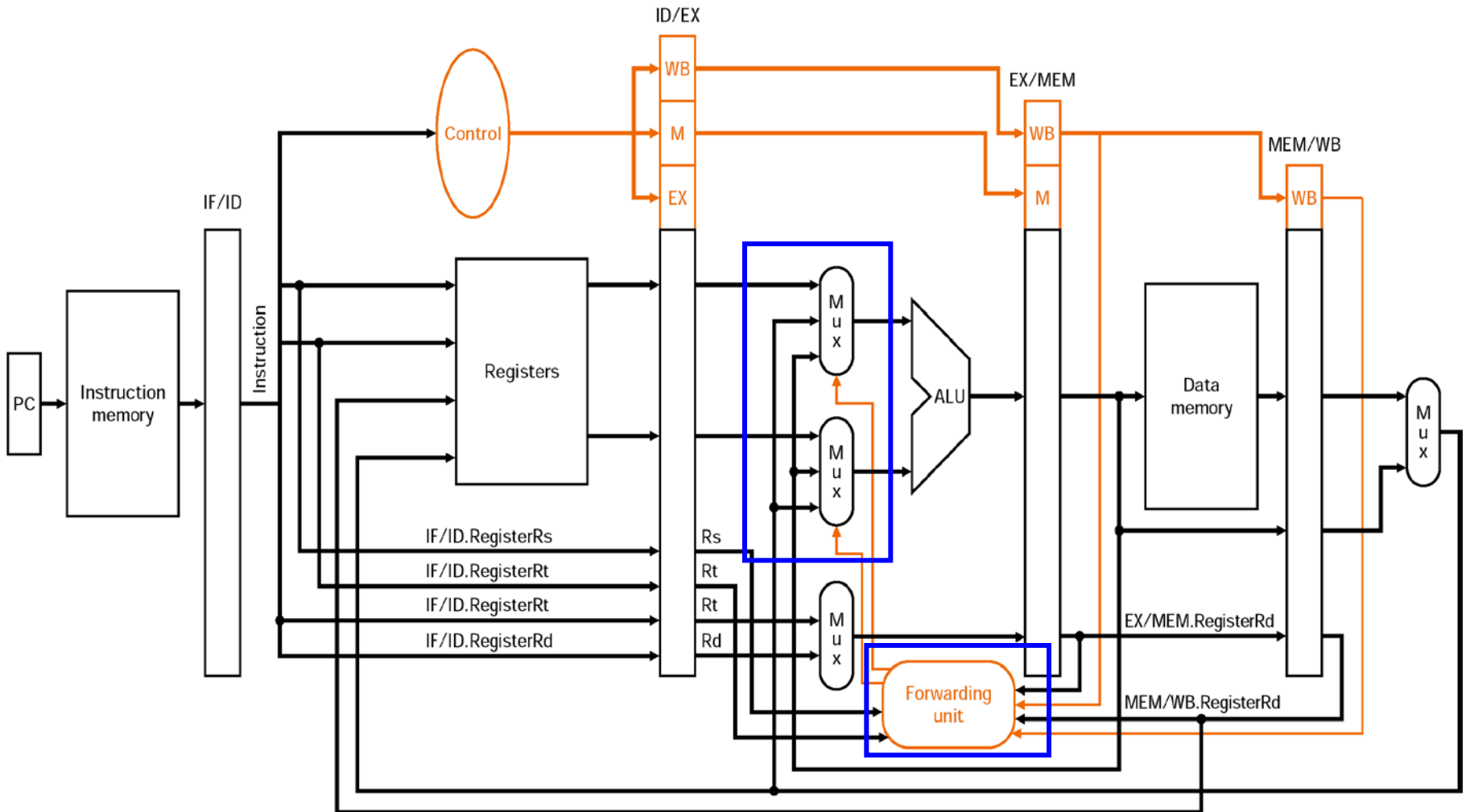

Computer Architecture

Datapath and Control for Data
and Control Hazards

Data Hazard Example



Forwarding Logic



Forwarding Example

sub \$2 , \$1 , \$3

and \$4 , \$2 , \$5

or \$4 , \$4 , \$2

add \$9 , \$4 , \$2

Forwarding Example

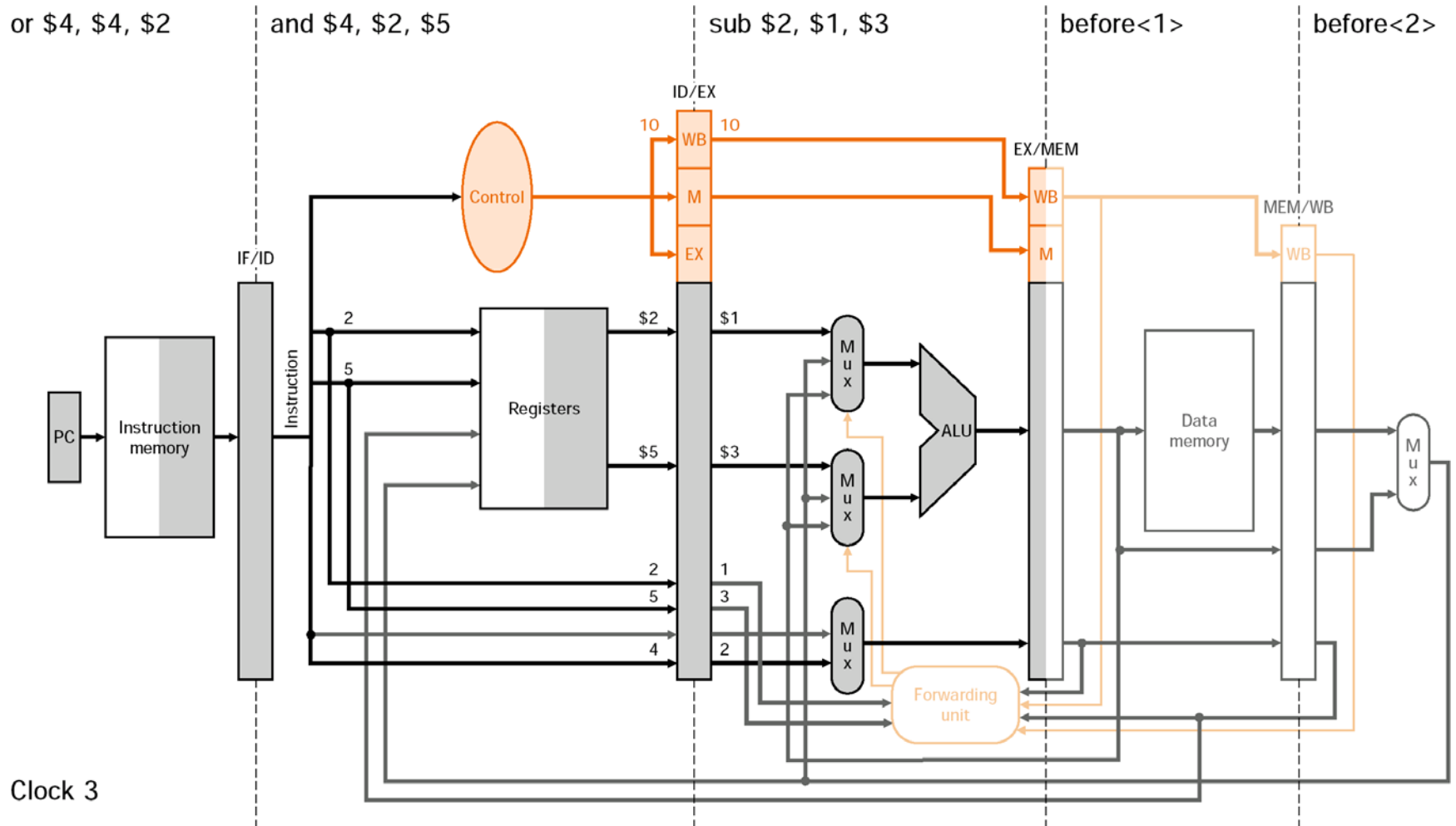
or \$4, \$4, \$2

and \$4, \$2, \$5

sub \$2, \$1, \$3

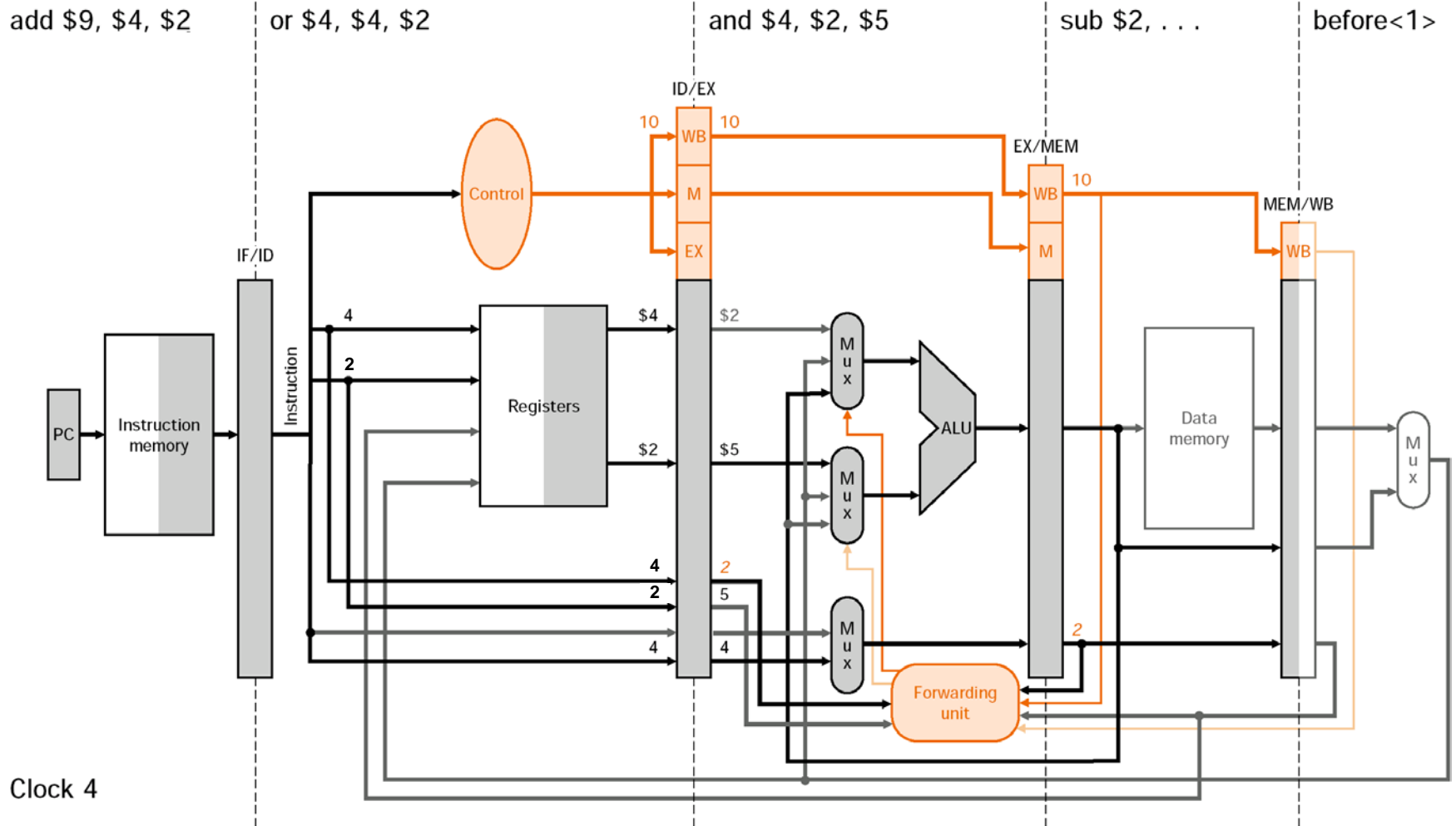
before<1>

before<2>



Clock 3

Forwarding Example



Forwarding Example

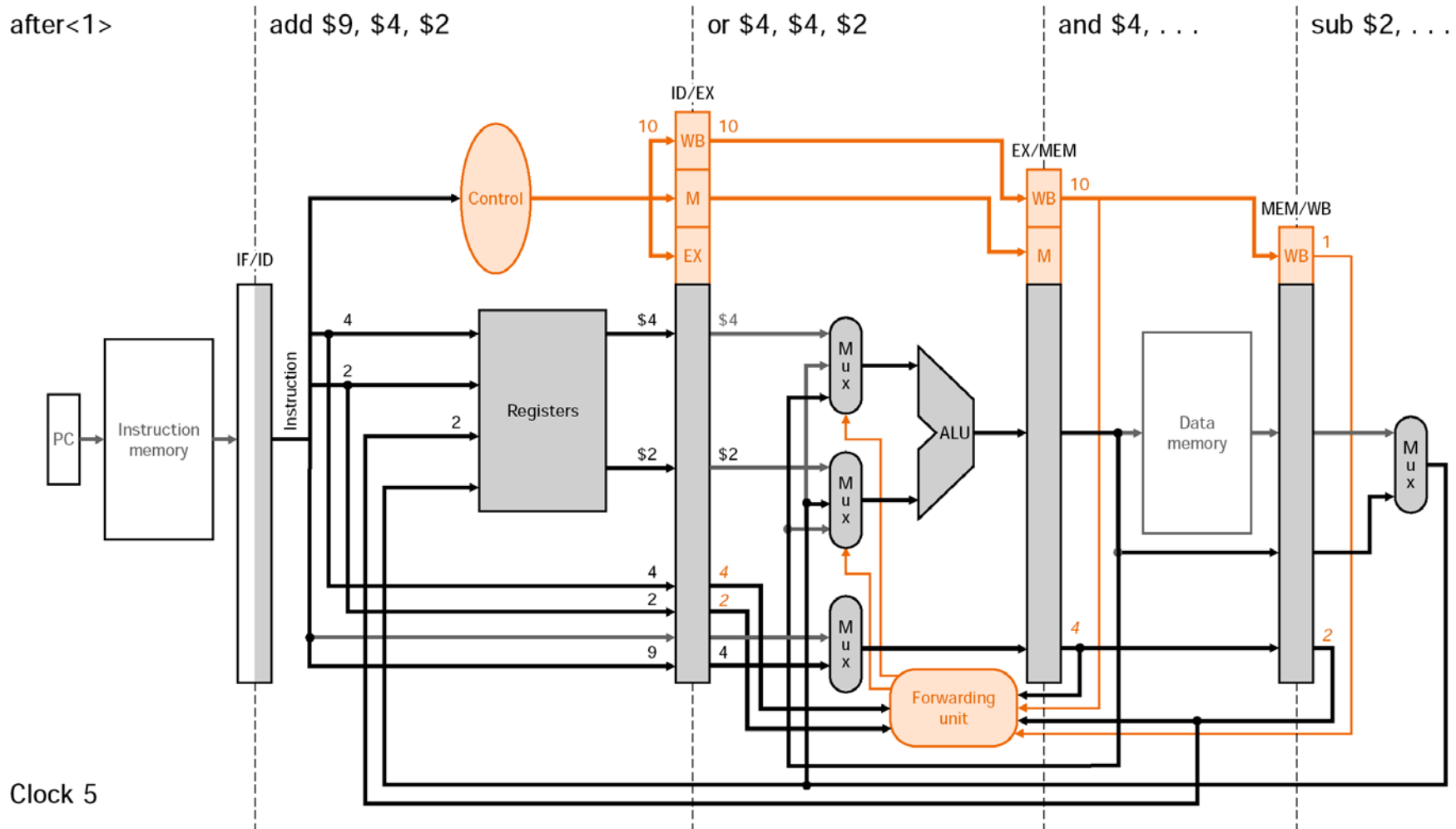
after<1>

add \$9, \$4, \$2

or \$4, \$4, \$2

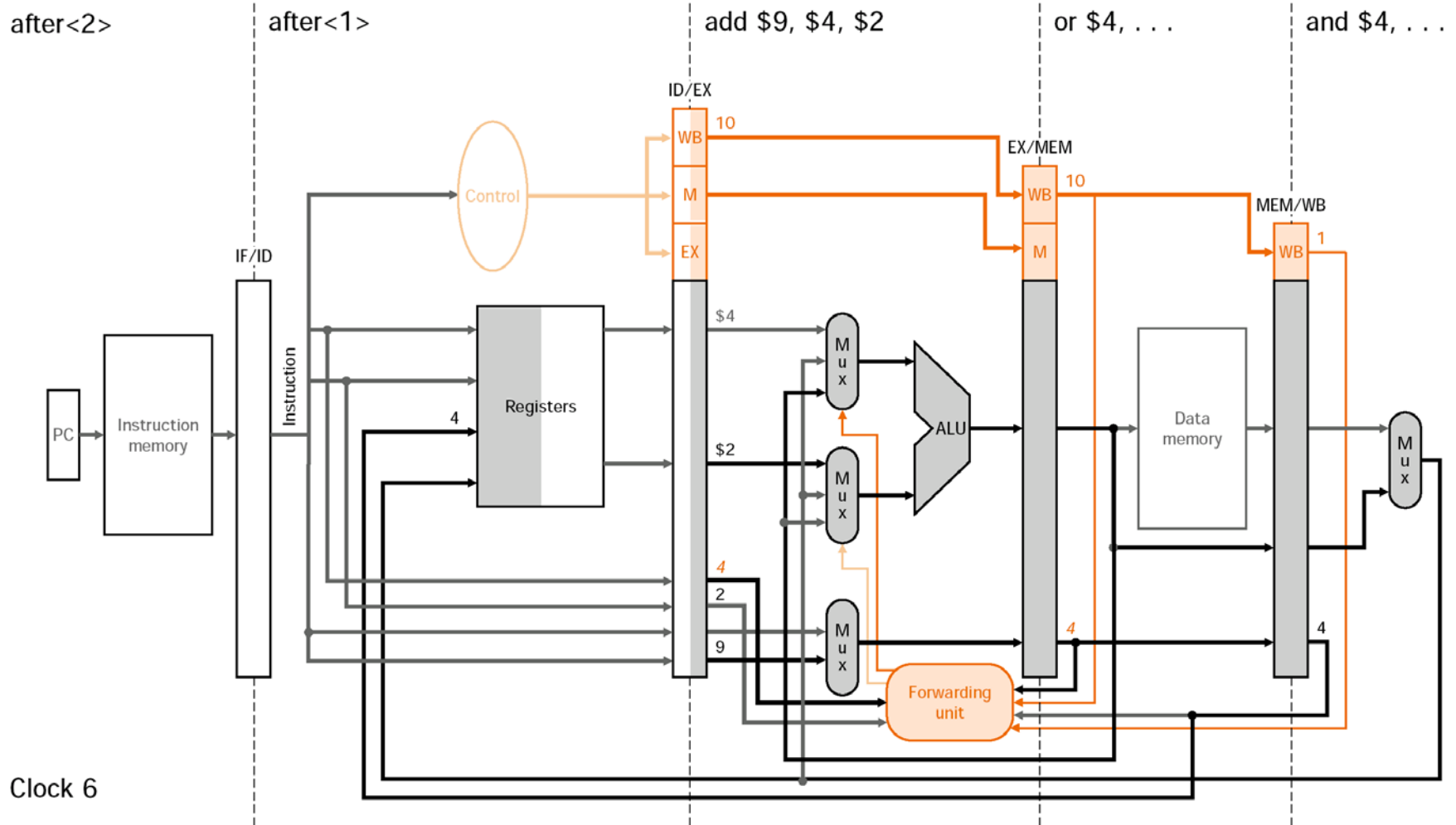
and \$4, ...

sub \$2, ...



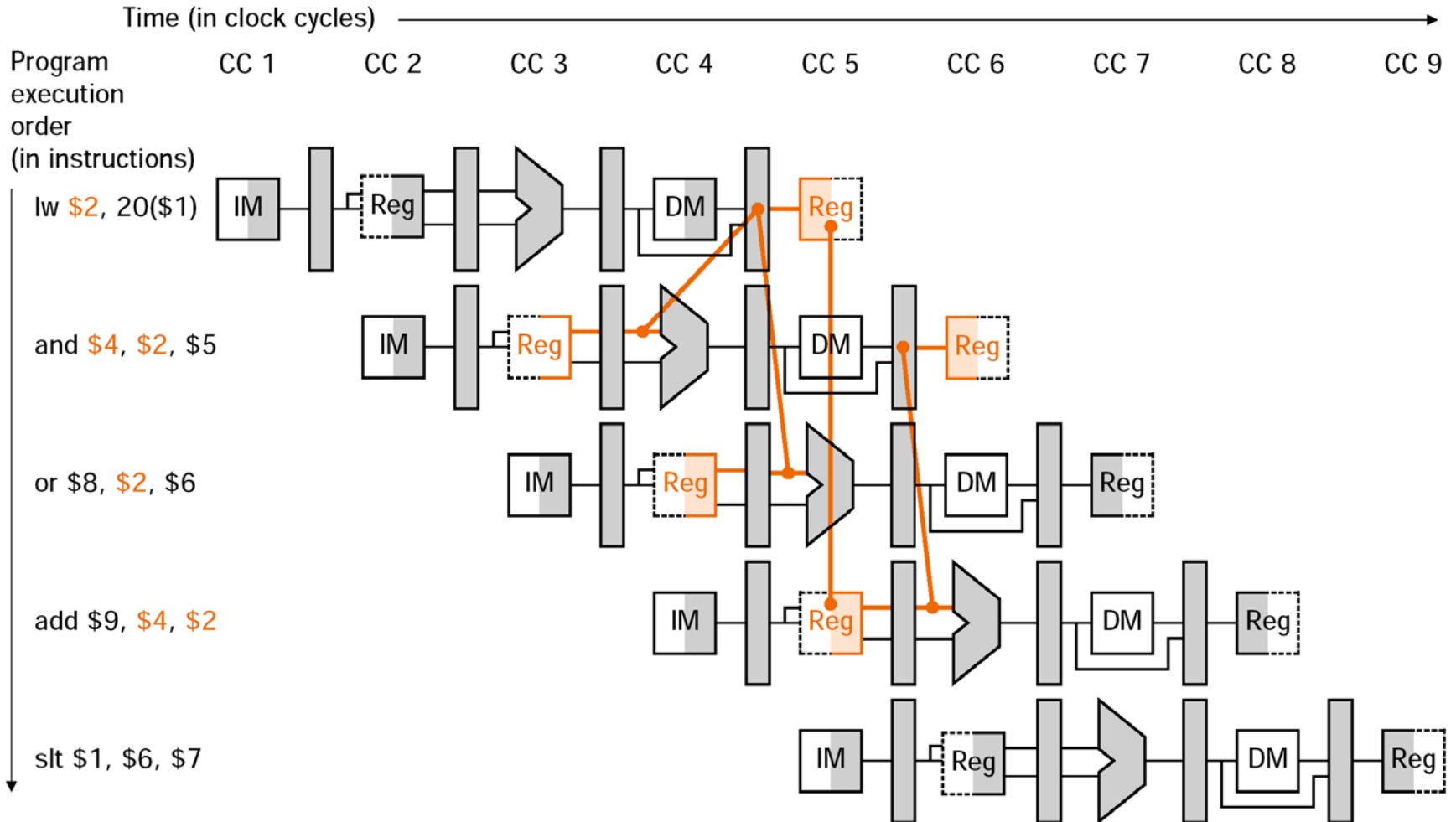
Clock 5

Forwarding Example

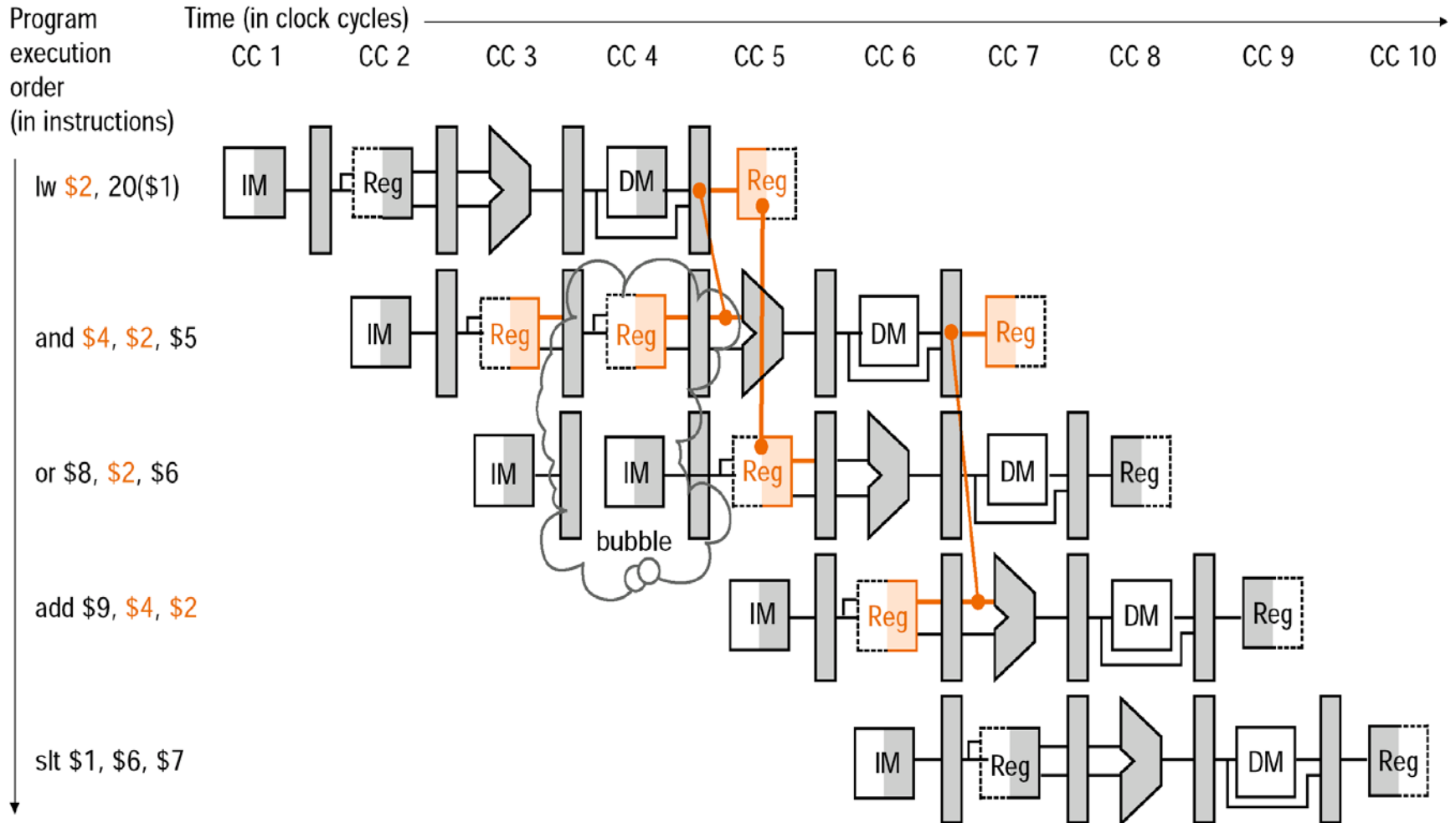


Clock 6

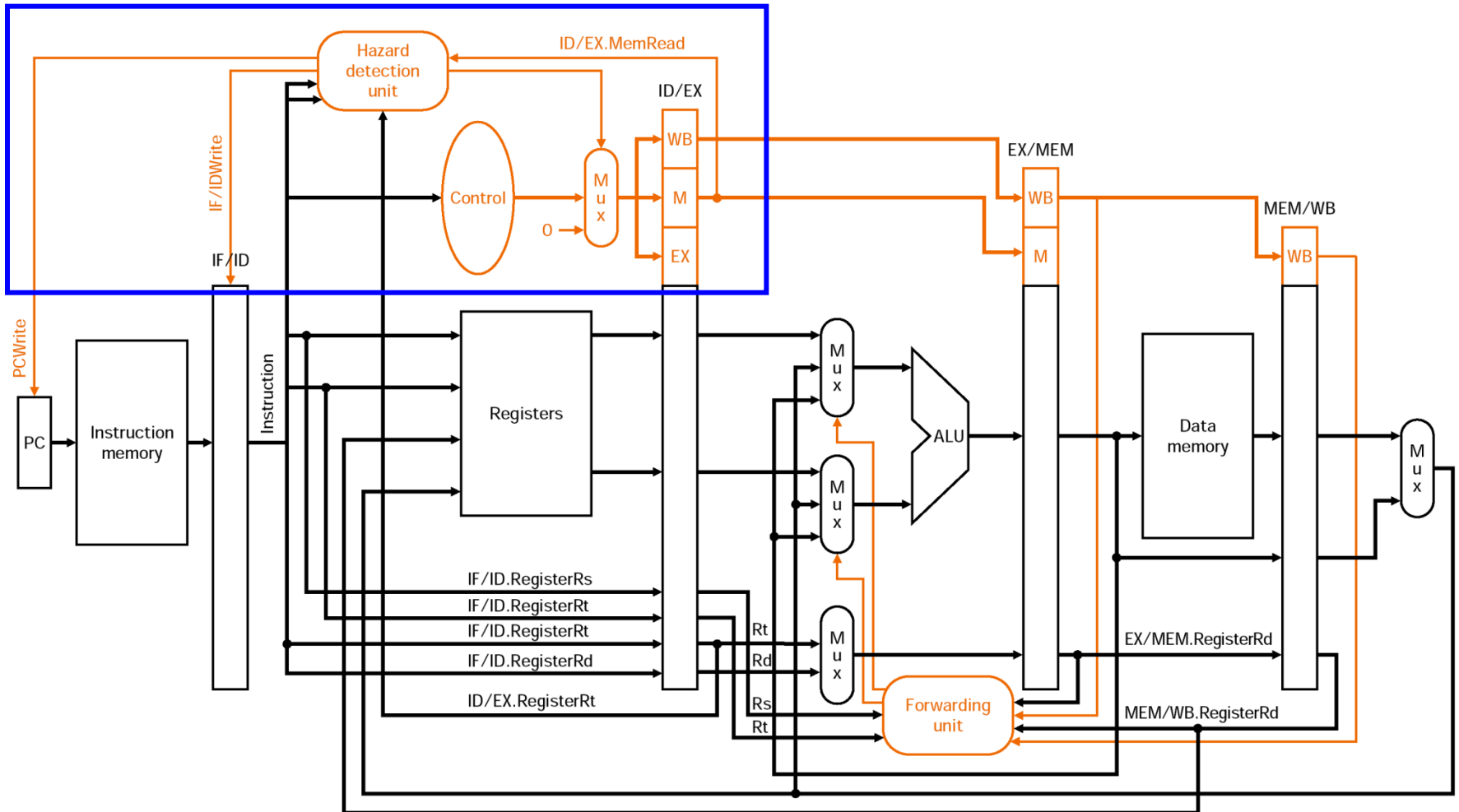
Data Hazard Requiring a Stall



Data Hazard Requiring a Stall



Stall Logic



Stall Example

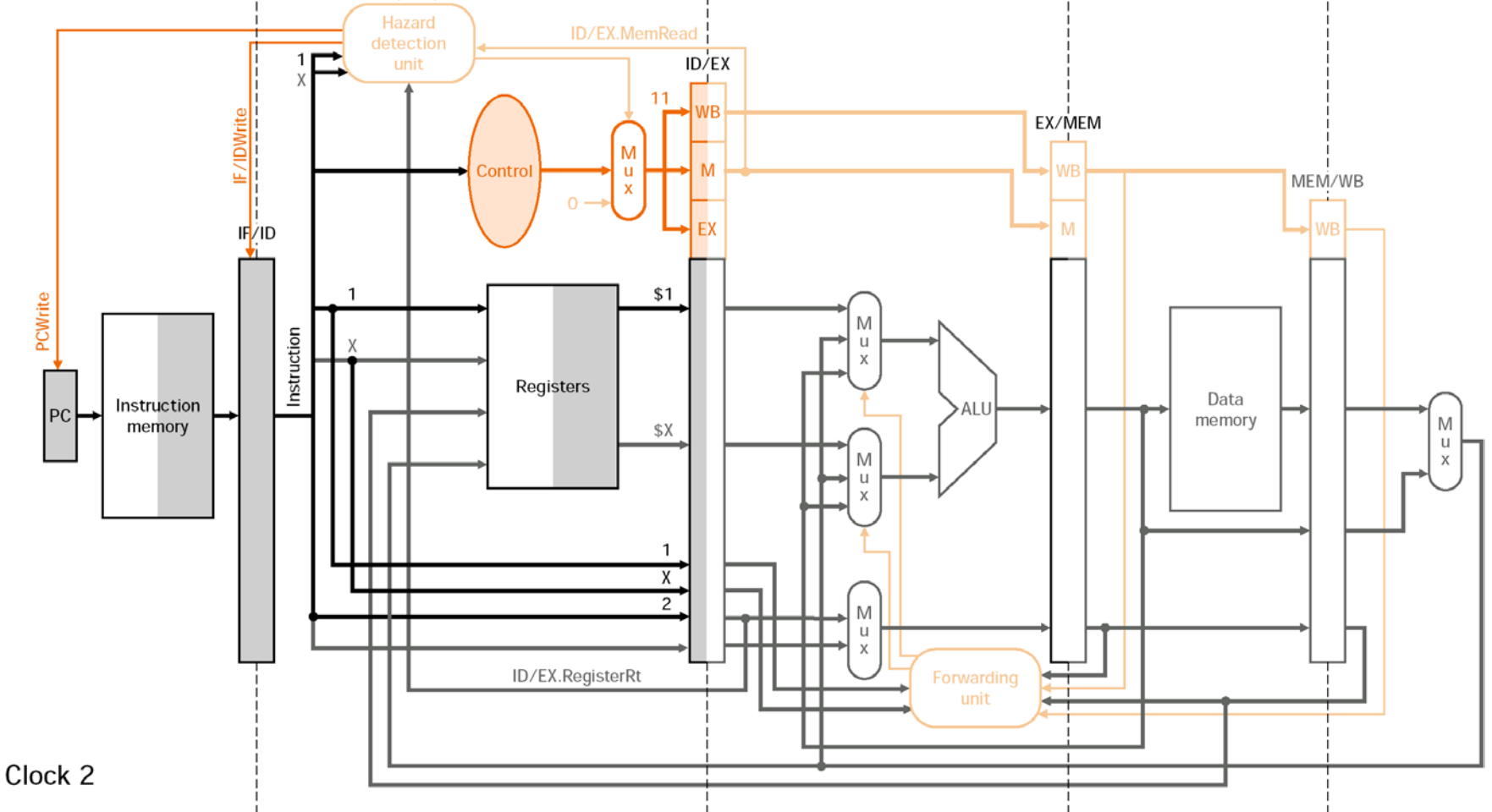
and \$4, \$2, \$5

lw \$2, 20(\$1)

before<1>

before<2>

before<3>



Clock 2

Stall Example

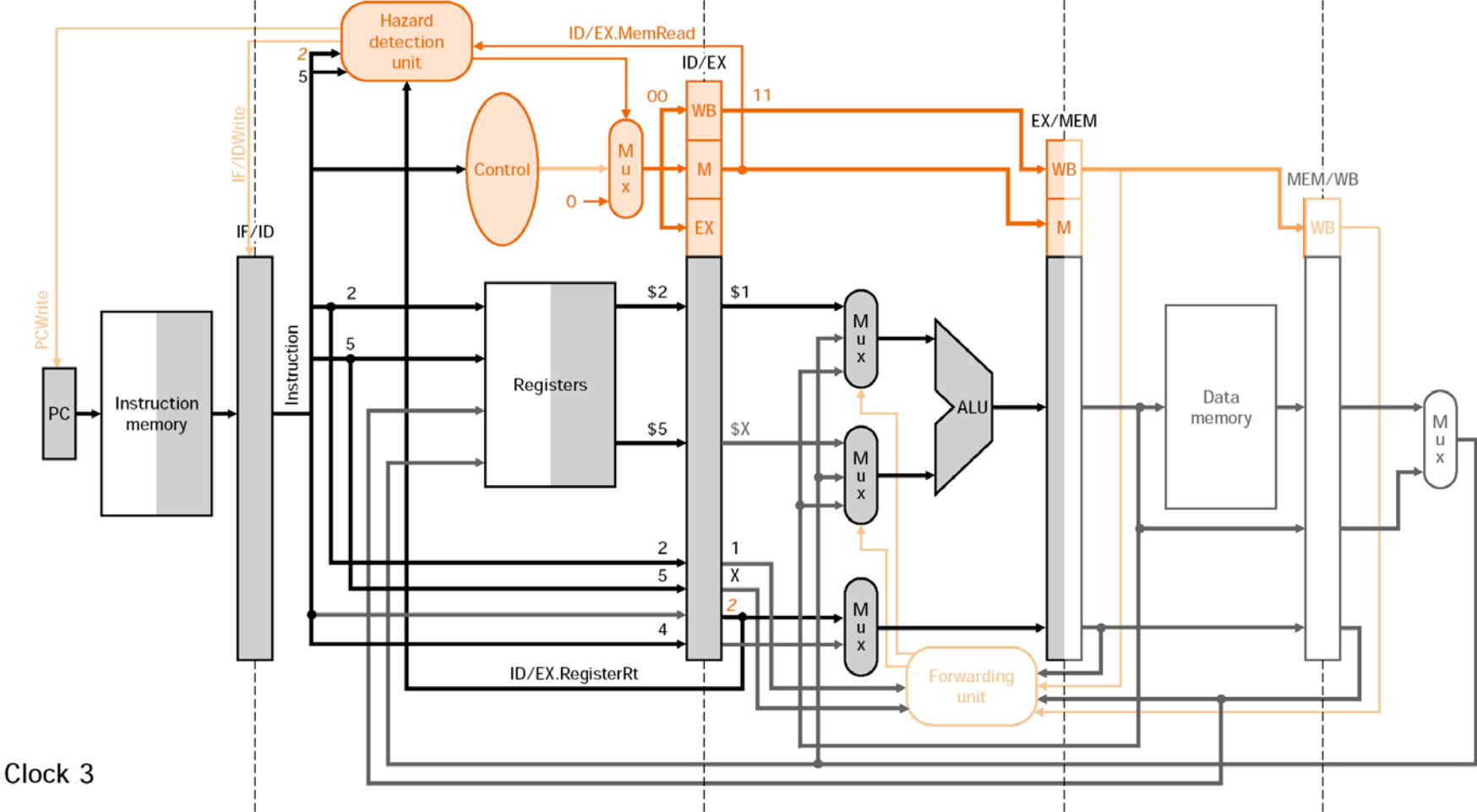
or \$4, \$4, \$2

and \$4, \$2, \$5

lw \$2, 20(\$1)

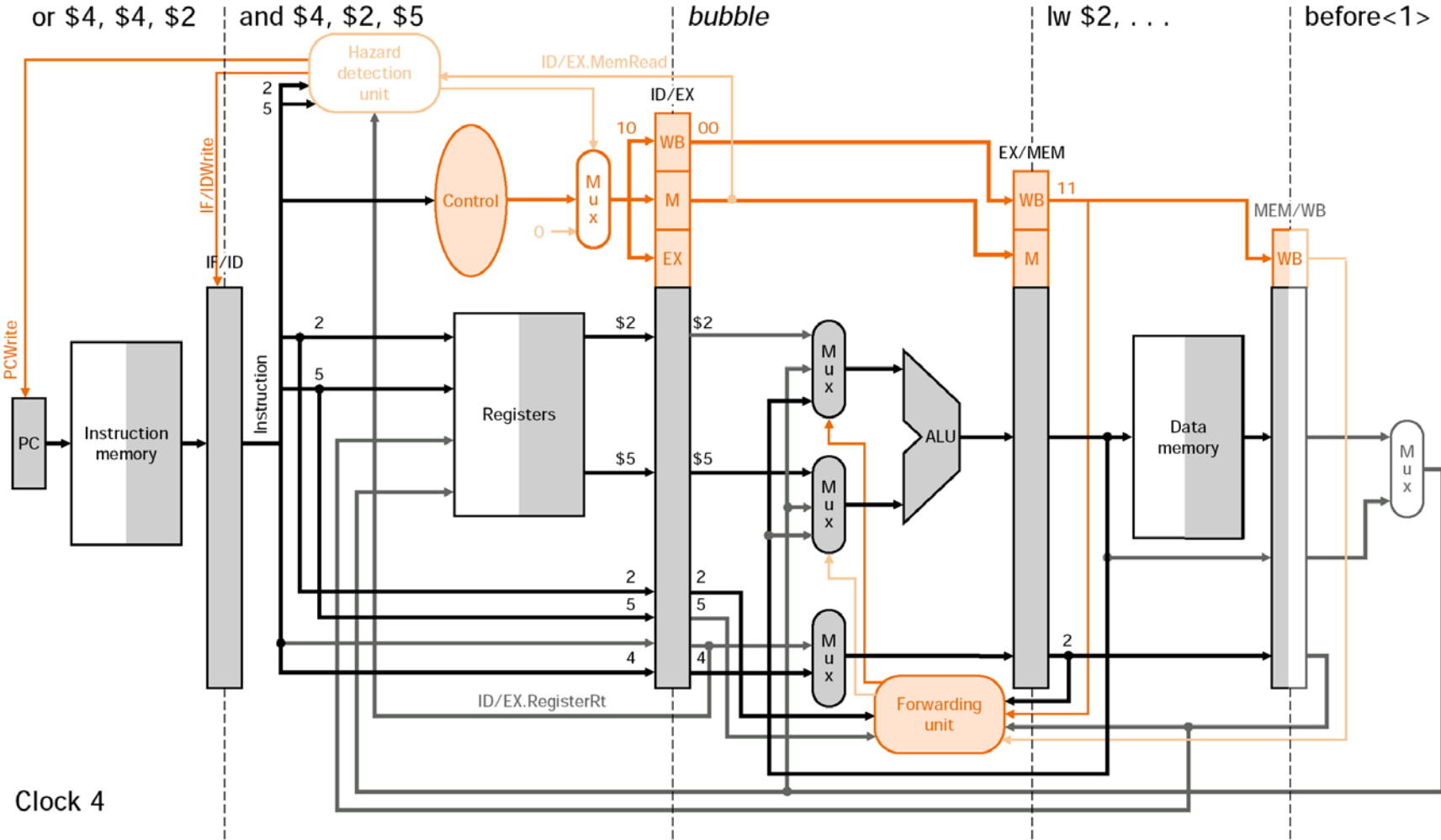
before<1>

before<2>



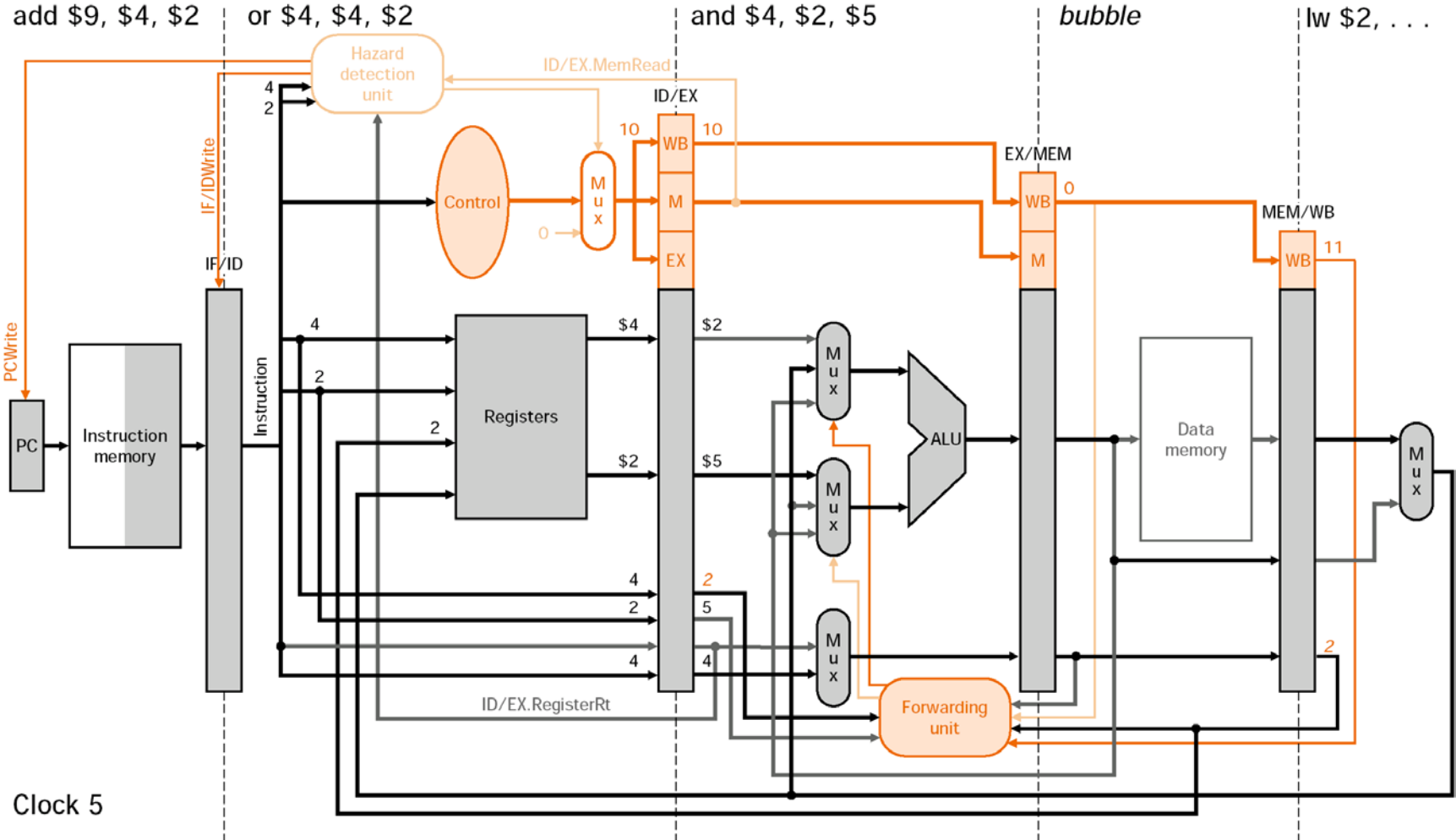
Clock 3

Stall Example



Clock 4

Stall Example



Clock 5

Stall Example

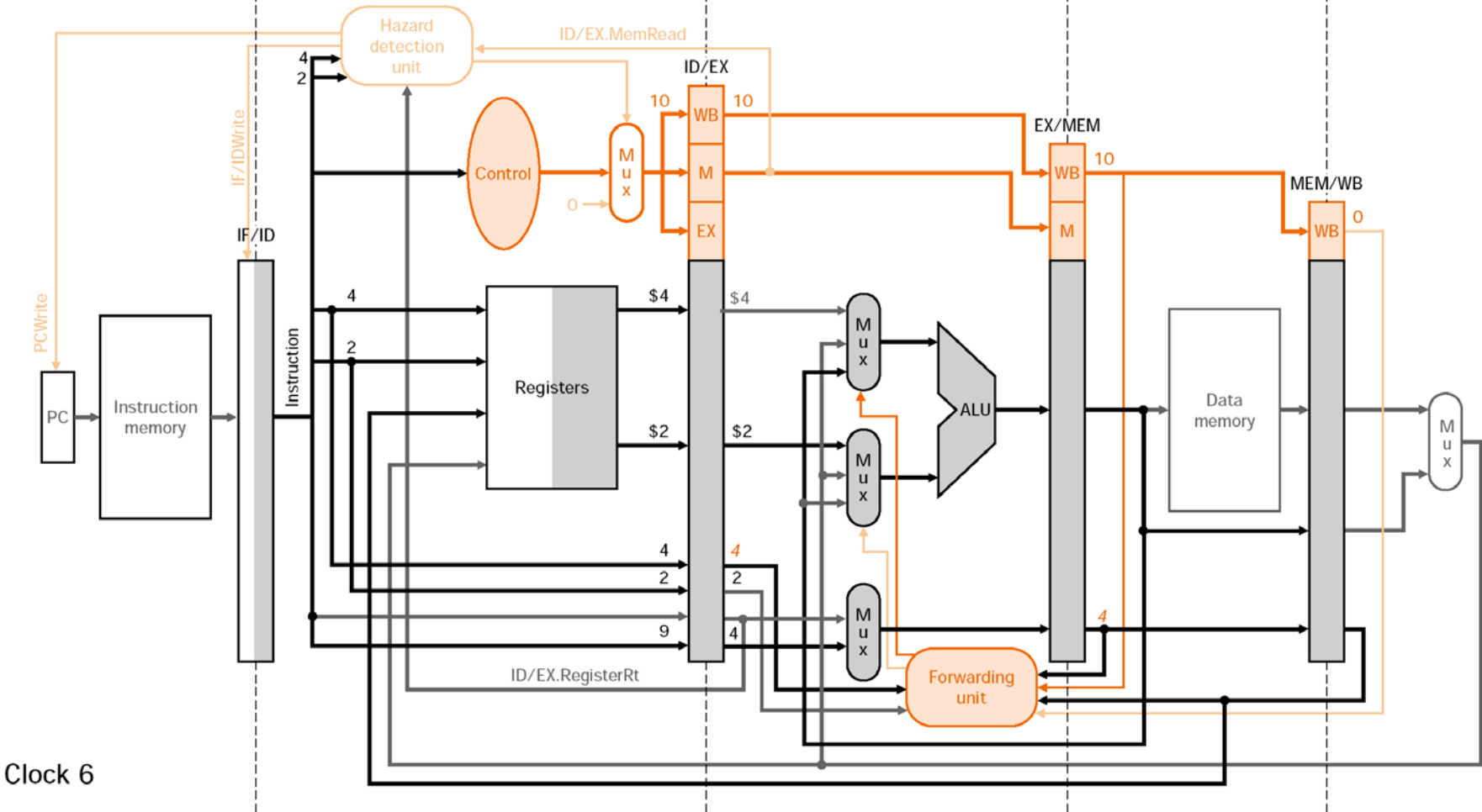
after<1>

add \$9, \$4, \$2

or \$4, \$4, \$2

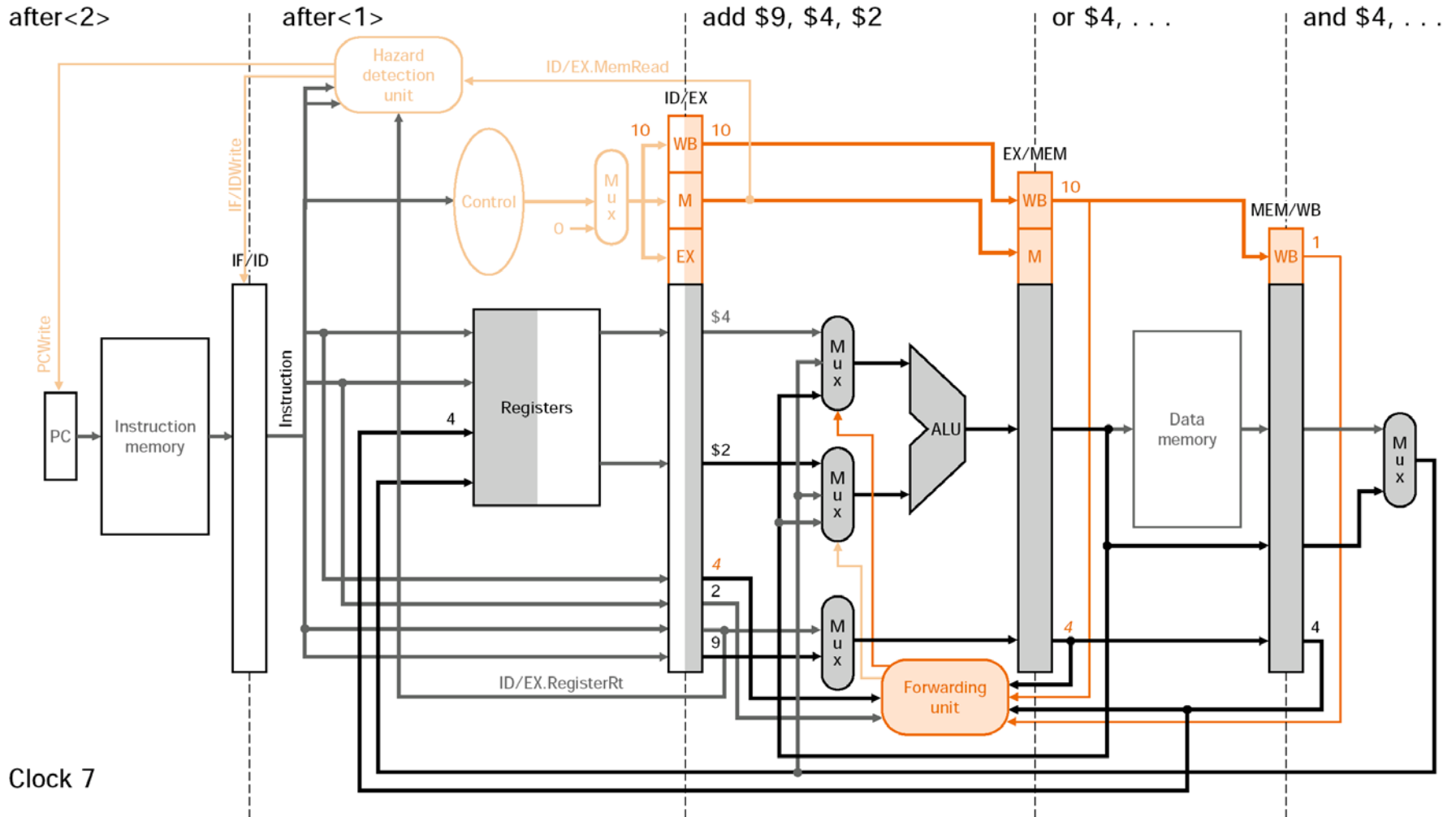
and \$4, ...

bubble



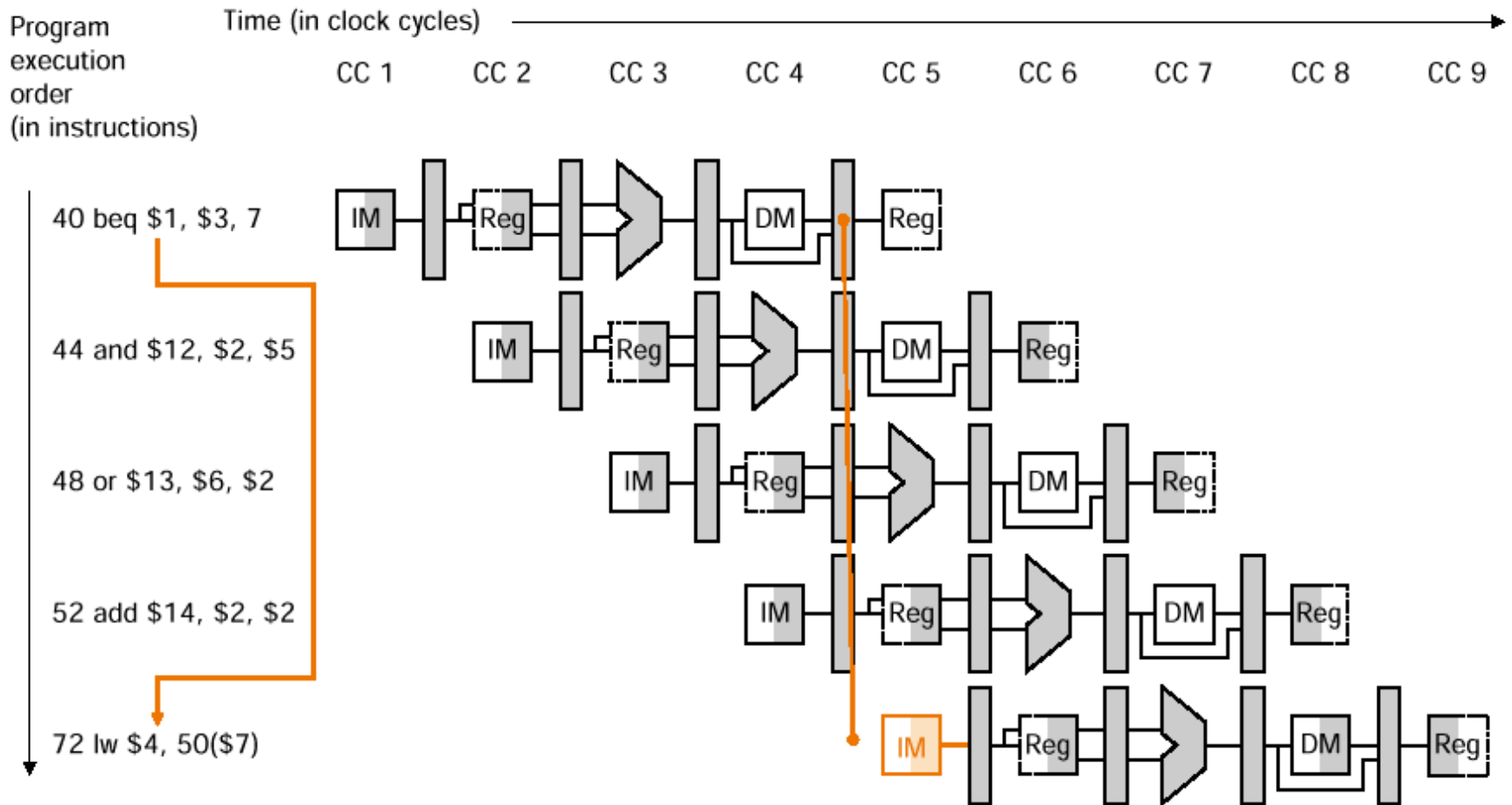
Clock 6

Stall Example

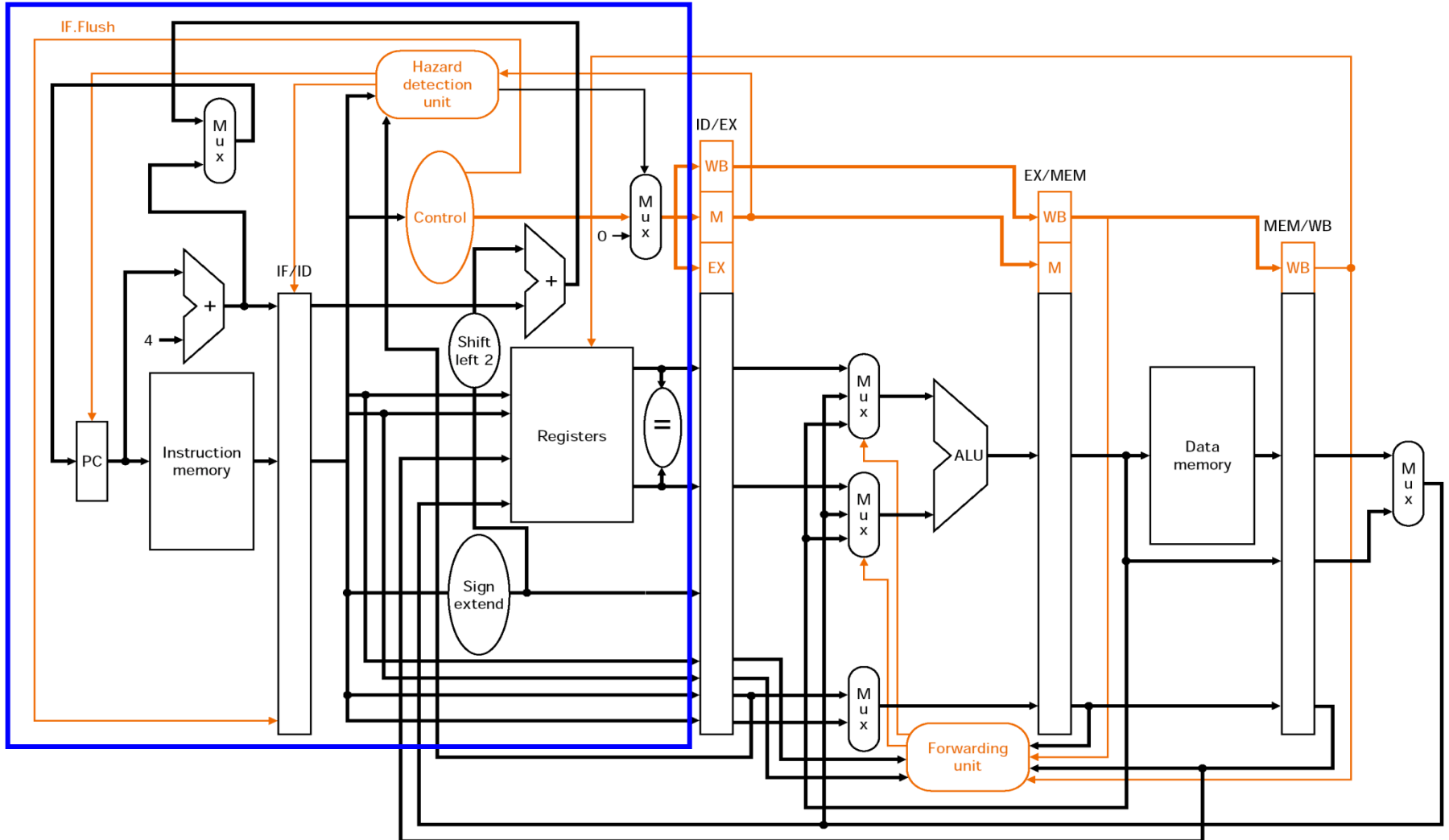


Clock 7

Control (Branch) Hazard Example



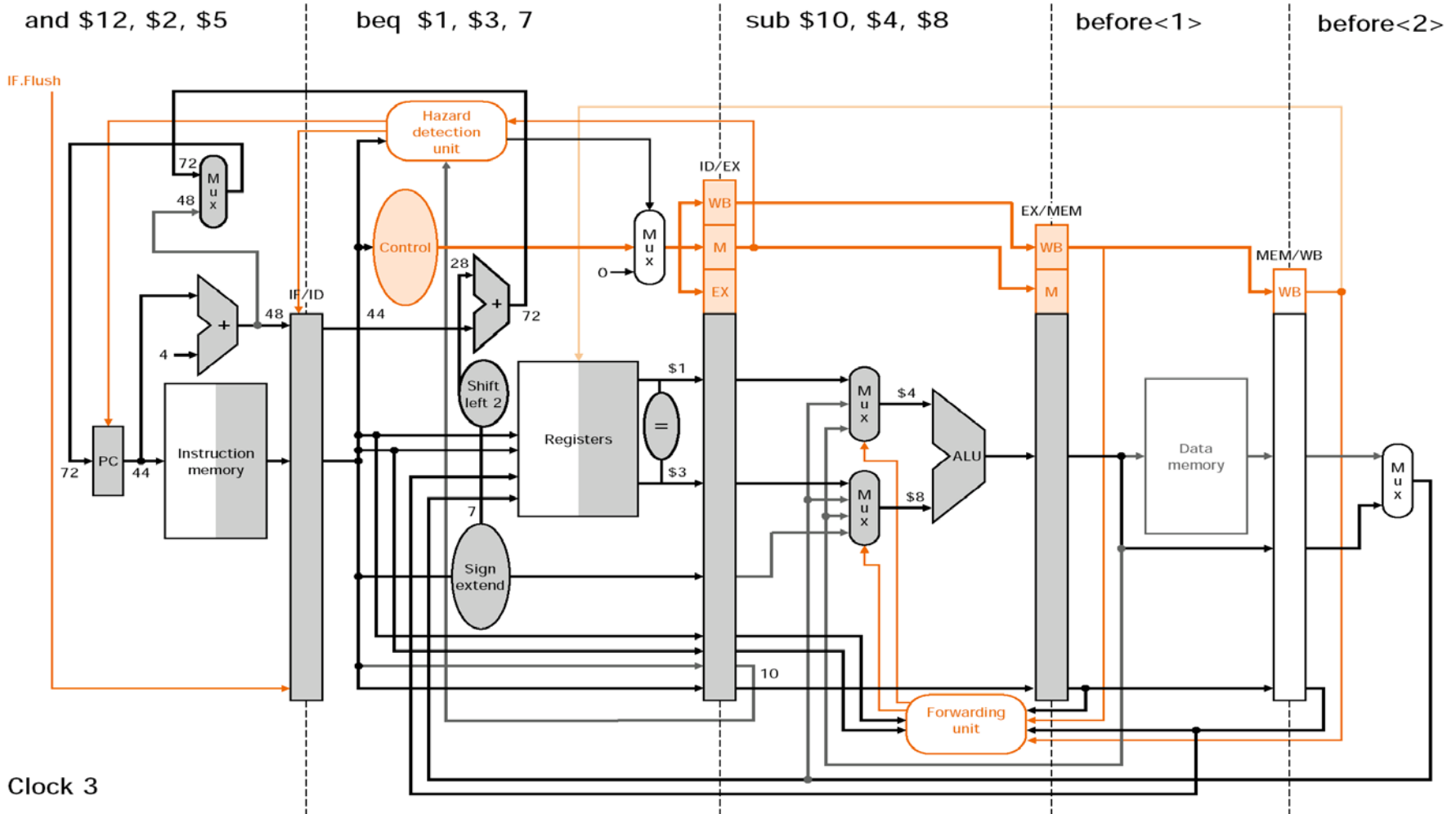
Control Hazard Logic



Control (Branch) Hazard Example

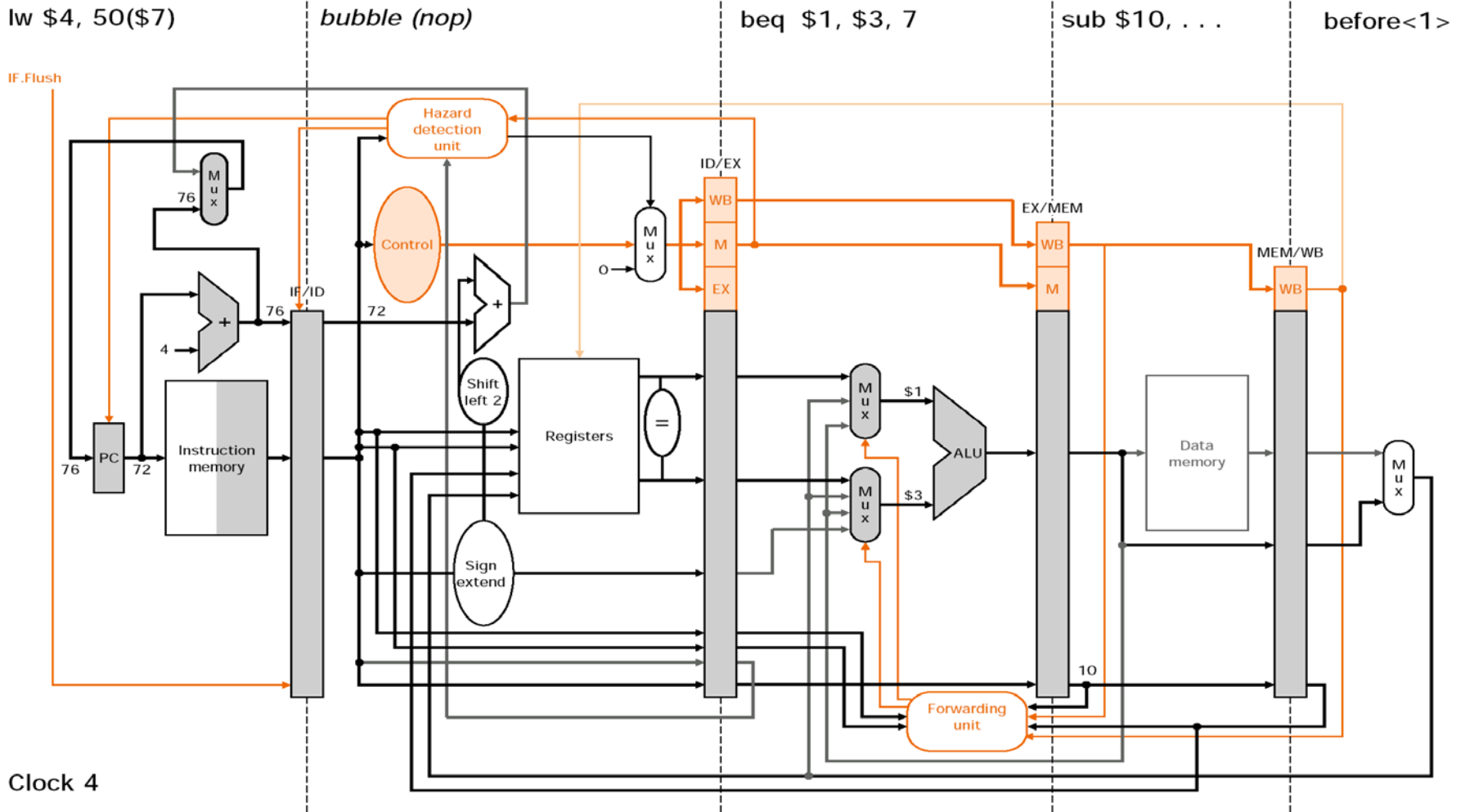
```
36  sub  $10, $4, $8
40  beq  $1,  $3, 7
44  and  $12, $2, $5
48  or   $13, $2, $6
52  add  $14, $4, $2
56  slt  $15, $6, $7
. . .
72  lw   $4, 50($7)
```

Control (Branch) Hazard Example



Clock 3

Control (Branch) Hazard Example



Clock 4