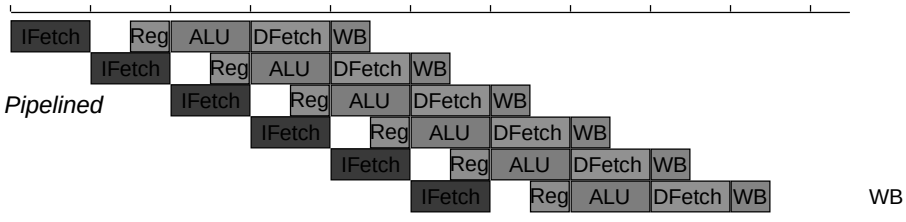
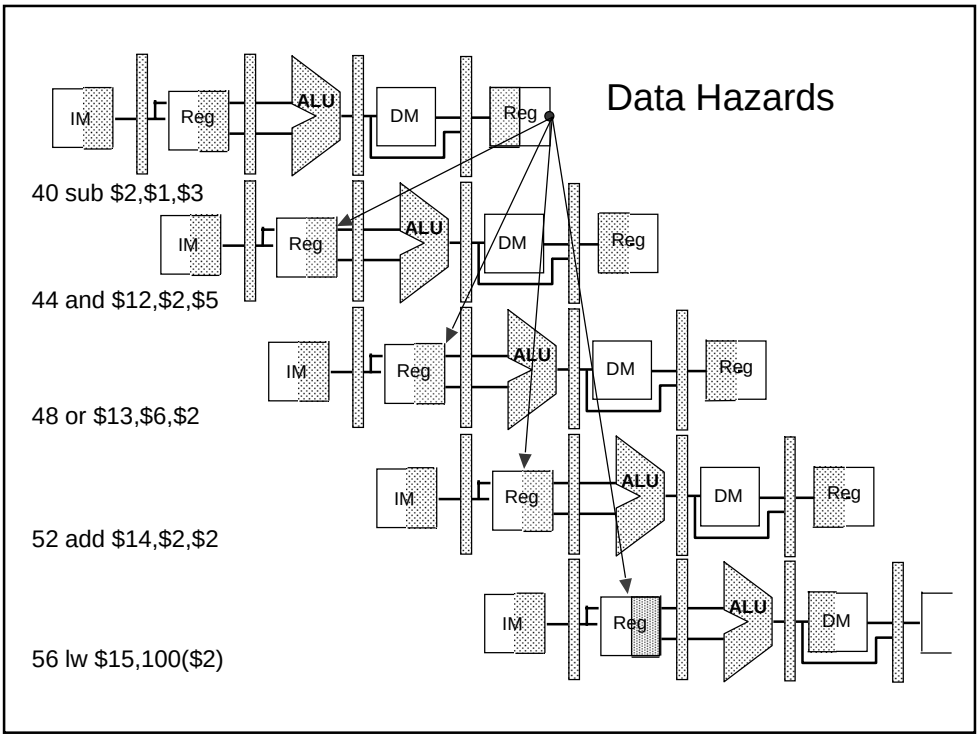
Hazard County

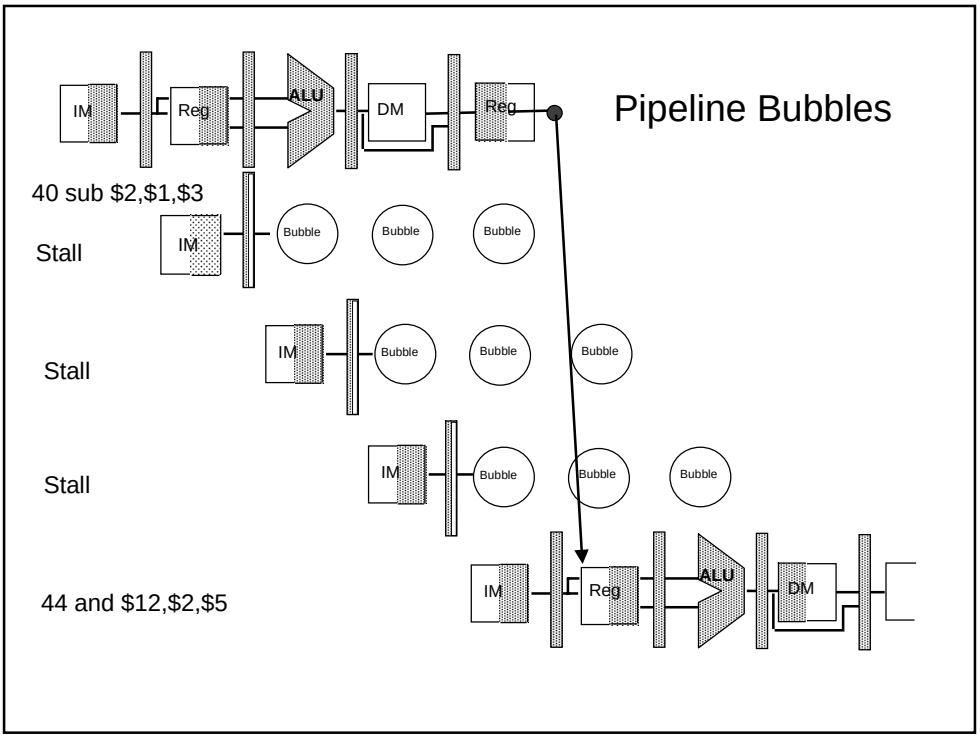
Pipelining is a good idea, but to make it work, several kinds of hazards have to be avoided, and interrupts must be handled.

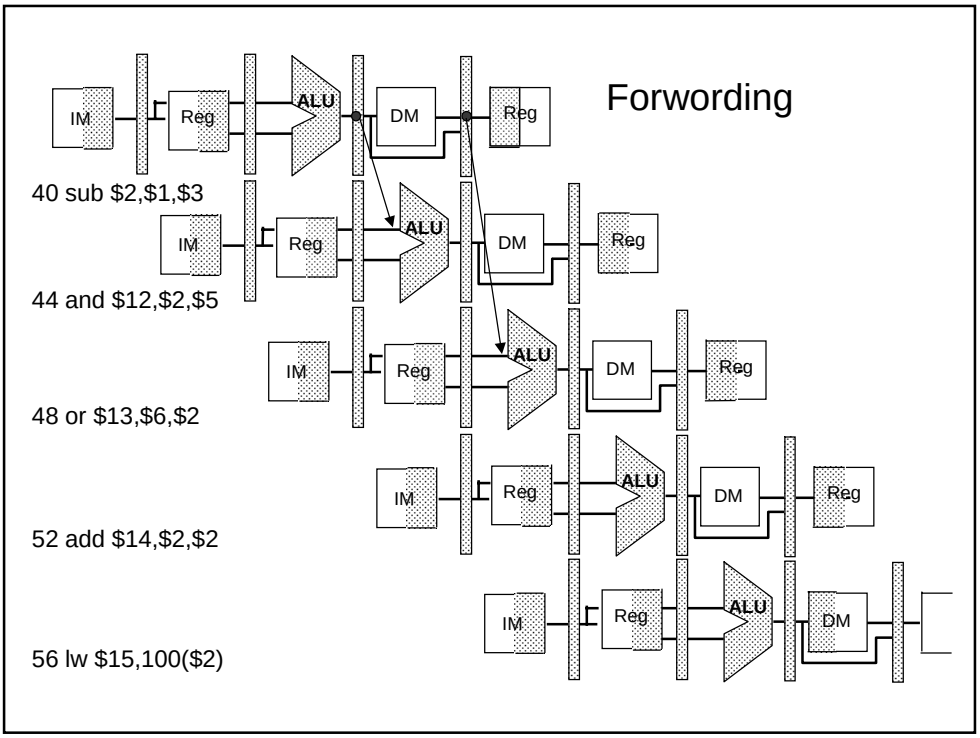
Pipelining

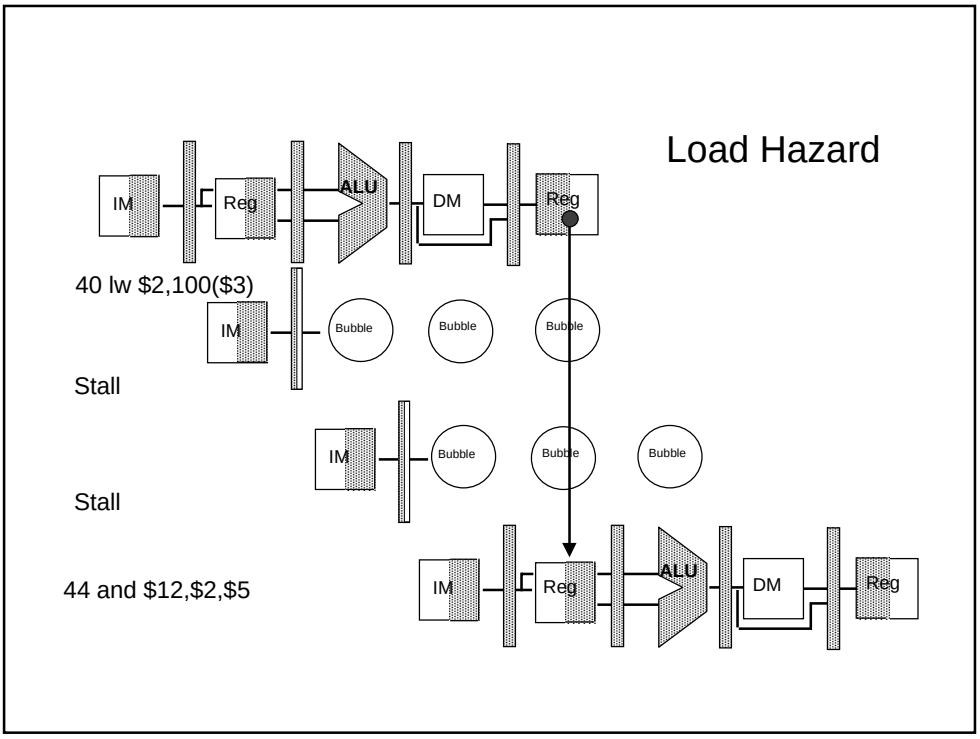
- Recall that pipelining initiates an operation on each clock cycle
- The first design goal is to assure that there are no conflicts in the use of the hardware

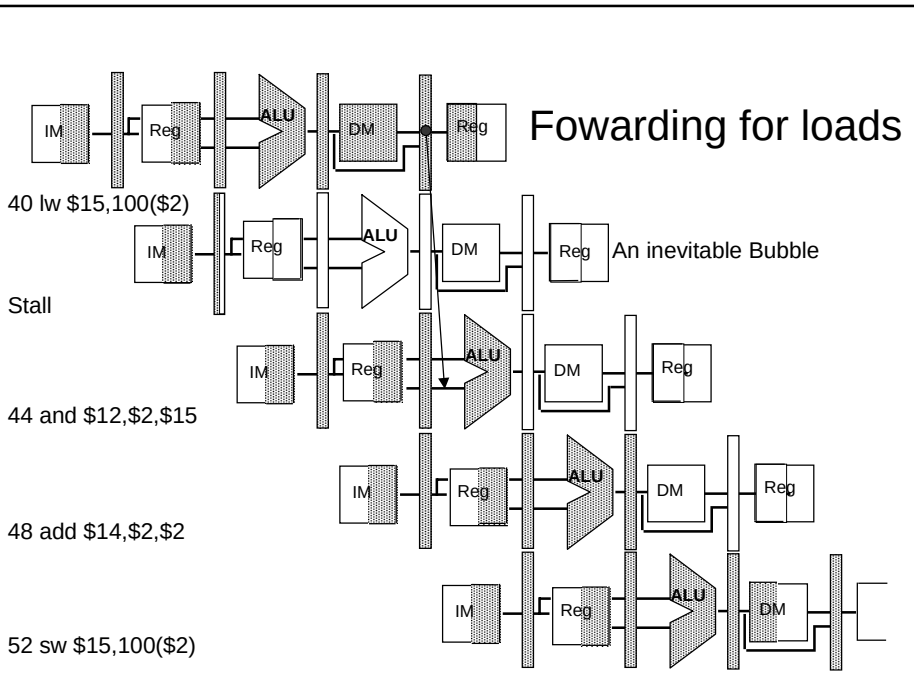



Data Hazards
IM
Reg
ALU
DM
Reg
40 sub $2,$1,$3
44 and $12,$2,$5
48 or $13,$6,$2
52 add $14,$2,$2
56 lw $15,100($2)


Pipeline Bubbles
IM
Reg
ALU
DM
Reg
40 sub $2,$1,$3
Stall
Stall
Stall
Bubble
44 and $12,$2,$5


Forwording
IM
Reg
ALU
DM
Reg
40 sub $2,$1,$3
44 and $12,$2,$5
48 or $13,$6,$2
52 add $14,$2,$2
56 lw $15,100($2)


Load Hazard
IM
Reg
ALU
DM
Reg
40 lw $2,100($3)
Bubble
Stall
Stall
44 and $12,$2,$5



Detecting Data Hazards

EX Hazard:

ID/EX.RegWrite and
((ID/EX.RegDst=0 and
ID/EX.WriteRegisterRt=IF/ID.ReadRegister1)or
(ID/EX.RegDst=1 and
ID/EX.WriteRegisterRd=IF/ID.ReadRegister1)or
(ID/EX.RegDst=0 and
ID/EX.WriteRegisterRt=IF/ID.ReadRegister2)or
(ID/EX.RegDst=1 and ID/EX.WriteRegisterRd=IF/ID.ReadRegister2))

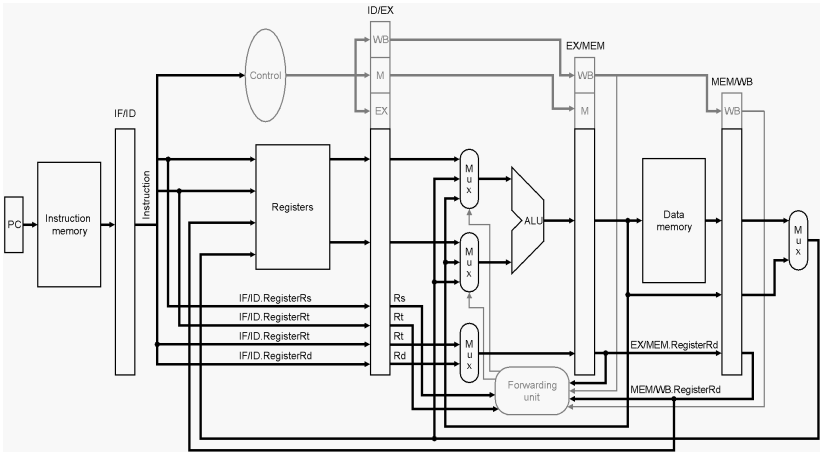
MEM Hazard:

EX/MEM.RegWrite and
((EX/MEM.WriteRegister=IF/ID.ReadRegister1)or
(EX/MEM.WriteRegister=IF/ID.ReadRegister2))

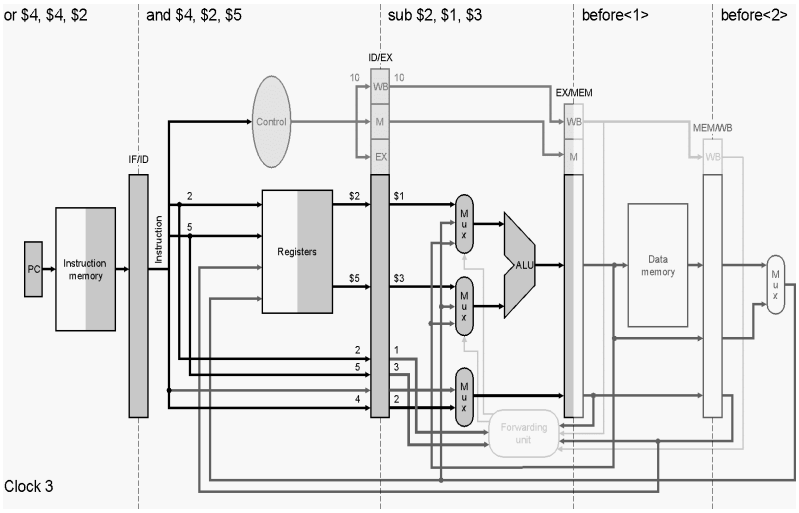
WB Hazard:

MEM/WB.RegWrite and
((MEM/WB.WriteRegister=IF/ID.ReadRegister1)or
(MEM/WB.WriteRegister=IF/ID.ReadRegister2))

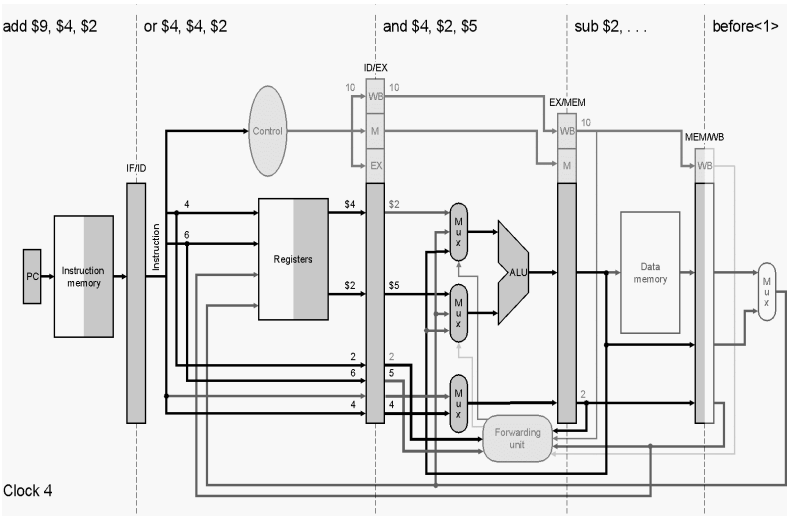
Forwarding



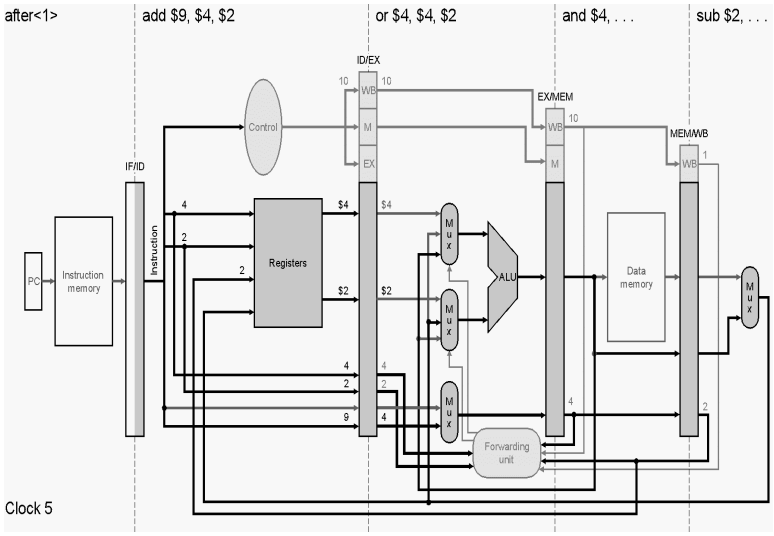
Forwarding ...



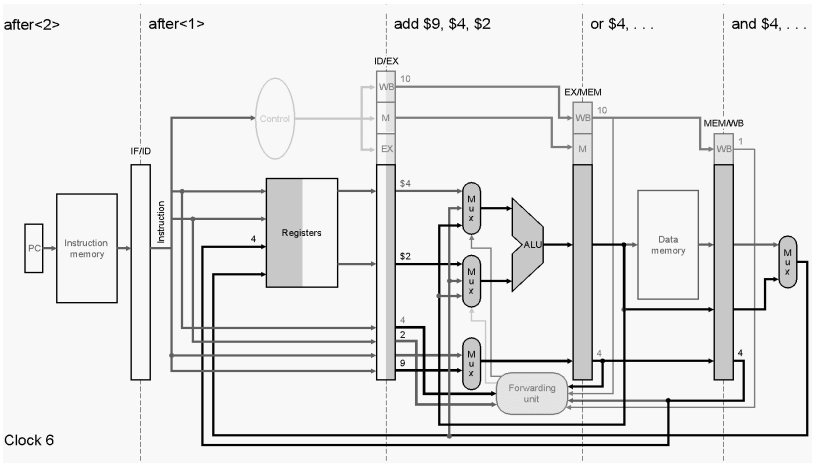
Forwarding ...



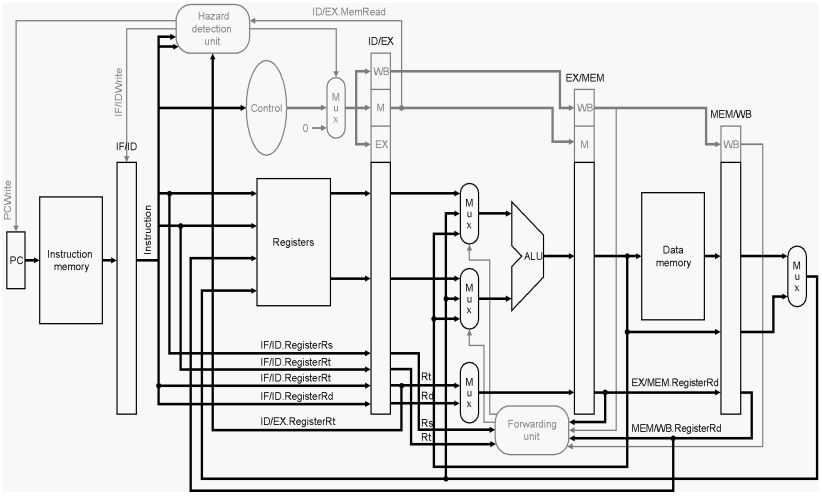
Forwarding ...



Forwarding



Hazard Detection



Load Hazards

ID/EX.RegWrite and (ID/EX.RegDst = 0) and
((ID/EX.WriteRegisterRt = IF/ID.Read.Register1) or
(ID/EX.WriteRegisterRt = IF/ID.ReadRegister2))

Consider the sequence to swap stack items

```
lw    $10, 0($29)  -- Load top item
lw    $11, 4($29)  -- Load second item
sw    $11, 0($29)  -- Replace top item
sw    $10, 4($29)  -- Replace second item
```

Which can be replace by

```
lw    $10, 0($29)  -- Load top item
lw    $11, 4($29)  -- Load second item
sw    $10, 4($29)  -- Replace second item
sw    $11, 0($29)  -- Replace top item
```