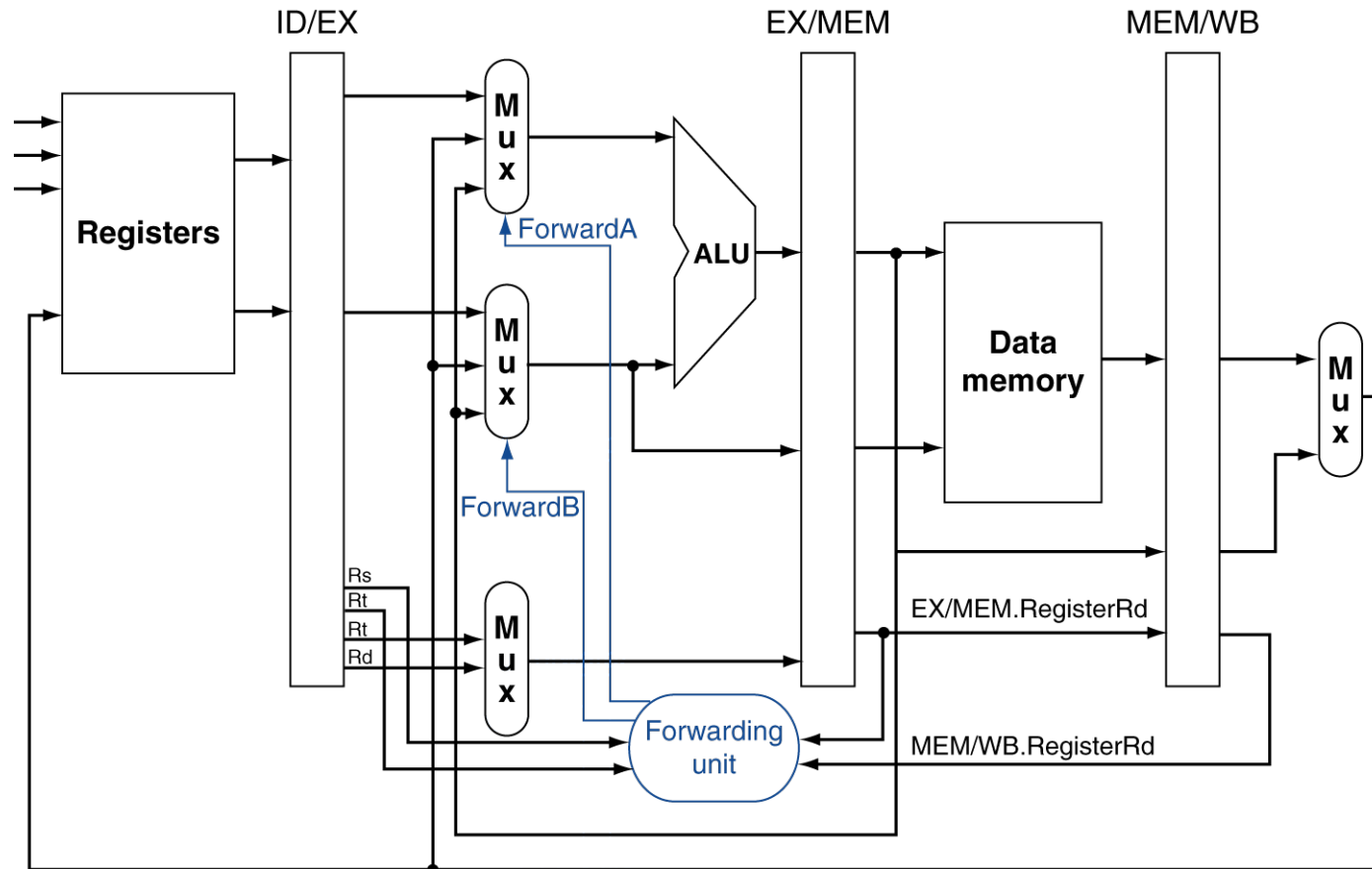


- Pass register numbers along pipeline
 - e.g., ID/EX.RegisterRs = register number for Rs sitting in ID/EX pipeline register
- ALU operand register numbers in EX stage are given by
 - ID/EX.RegisterRs, ID/EX.RegisterRt
- Data hazards when
 - 1a. EX/MEM.RegisterRd = ID/EX.RegisterRs
 - 1b. EX/MEM.RegisterRd = ID/EX.RegisterRt
 - 2a. MEM/WB.RegisterRd = ID/EX.RegisterRs
 - 2b. MEM/WB.RegisterRd = ID/EX.RegisterRt

Fwd from
EX/MEM
pipeline reg

Fwd from
MEM/WB
pipeline reg

- Only if forwarding instruction writes a register!
 - EX/MEM.RegWrite, MEM/WB.RegWrite
- And only if Rd for that instruction is not \$zero
 - EX/MEM.RegisterRd \neq 0,
MEM/WB.RegisterRd \neq 0



Forwarding replaces stale ALU inputs

■ EX hazard

- if (EX/MEM.RegWrite and (EX/MEM.RegisterRd \neq 0)
and (EX/MEM.RegisterRd = ID/EX.RegisterRs))

ForwardA = 10

- if (EX/MEM.RegWrite and (EX/MEM.RegisterRd \neq 0)
and (EX/MEM.RegisterRd = ID/EX.RegisterRt))

ForwardB = 10

■ MEM hazard

- if (MEM/WB.RegWrite and (MEM/WB.RegisterRd \neq 0)
and (MEM/WB.RegisterRd = ID/EX.RegisterRs))

ForwardA = 01

- if (MEM/WB.RegWrite and (MEM/WB.RegisterRd \neq 0)
and (MEM/WB.RegisterRd = ID/EX.RegisterRt))

ForwardB = 01

Mux control	Source	Explanation
ForwardA = 00	ID/EX	First ALU operand comes from the register file.
ForwardA = 01	MEM/WB	First ALU operand is forwarded from data memory or earlier ALU result.
ForwardA = 10	EX/MEM	First ALU operand comes from the prior ALU result.
ForwardB = 00	ID/EX	Second ALU operand comes from the register file.
ForwardB = 01	MEM/WB	Second ALU operand is forwarded from data memory or earlier ALU result.
ForwardB = 10	EX/MEM	Second ALU operand comes from the prior ALU result.

- Consider the sequence:
 - add \$1, \$1, \$2
 - add \$1, \$1, \$3
 - add \$1, \$1, \$4
- Both hazards occur
 - Want to use the most recent
- Revise MEM hazard condition
 - Only fwd if EX hazard condition isn't true

■ MEM hazard

- if (MEM/WB.RegWrite and (MEM/WB.RegisterRd \neq 0)
and not (EX/MEM.RegWrite and (EX/MEM.RegisterRd \neq 0)
and (EX/MEM.RegisterRd = ID/EX.RegisterRs))
and (MEM/WB.RegisterRd = ID/EX.RegisterRs))

ForwardA = 01

- if (MEM/WB.RegWrite and (MEM/WB.RegisterRd \neq 0)
and not (EX/MEM.RegWrite and (EX/MEM.RegisterRd \neq 0)
and (EX/MEM.RegisterRd = ID/EX.RegisterRt))
and (MEM/WB.RegisterRd = ID/EX.RegisterRt))

ForwardB = 01