

| | PC | F | D | E | M | W | |
|--|----|---|---|---|---|---|--|
| | 0 | | | | | | |
| | 4 | | | | | | |
| | 8 | | | | | | |
| | c | | | | | | |
| | 10 | | | | | | |
| | 14 | | | | | | |
| | 18 | | | | | | |
| | 1c | | | | | | |
| | 20 | | | | | | |

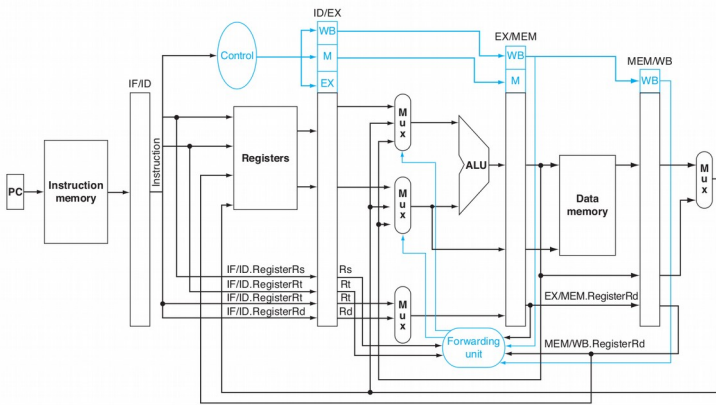


FIGURE 4.56 The datapath modified to resolve hazards via forwarding. Compared with the datapath in Figure 4.51, the additions are the multiplexers to the inputs to the ALU. This figure is a more stylized drawing, however, leaving out details from the full datapath, such as the branch hardware and the sign extension hardware.

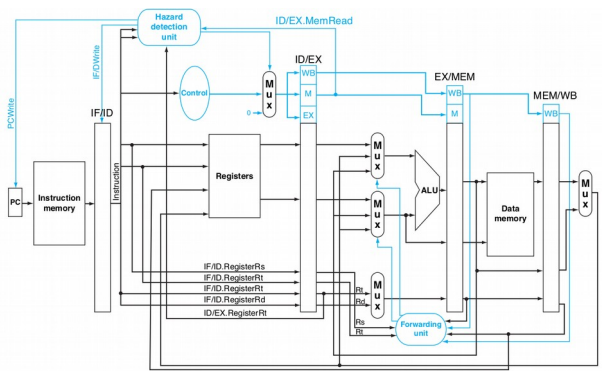
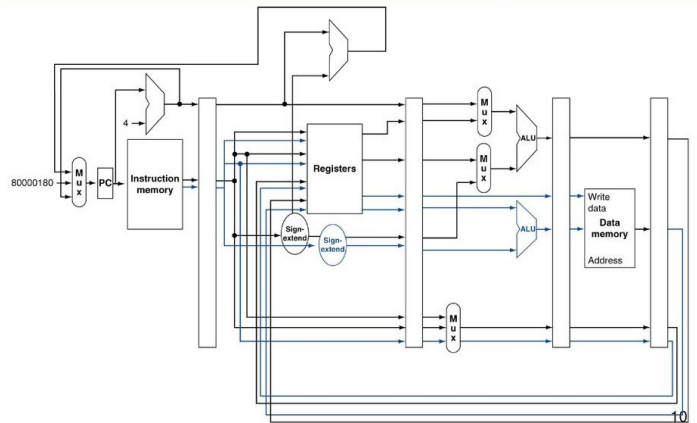
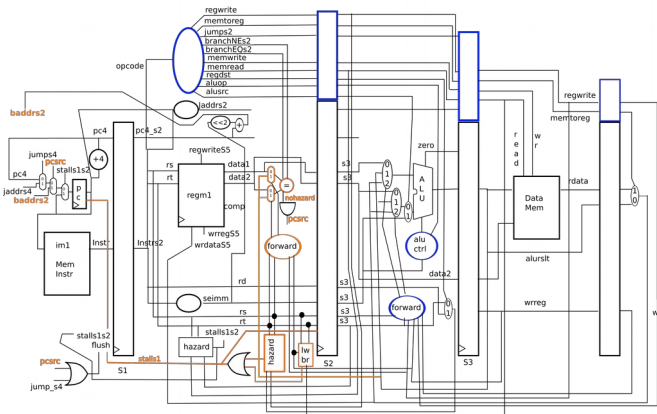


FIGURE 4.60 Pipelined control overview, showing the two multiplexers for forwarding, the hazard detection unit, and the forwarding unit. Although the ID and EX stages have been simplified—the sign-extended immediate and branch logic are missing—this drawing gives the essence of the forwarding hardware requirements.



IF: Instruction fetch ID: Instruction decode/ register file read EX: Execute/ address calculation MEM: Memory access WB: Write back

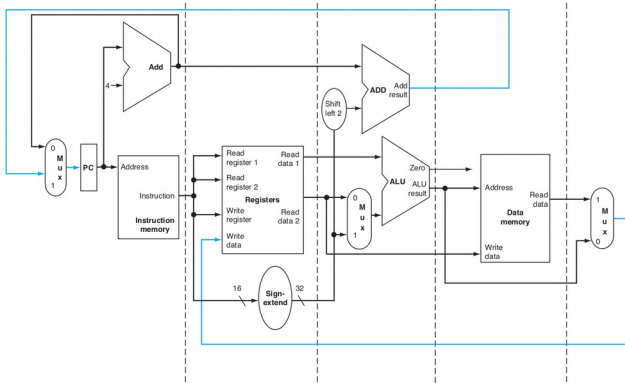


FIGURE 4.33 The single-cycle datapath from Section 4.4 (similar to Figure 4.17). Each step of the instruction can be mapped onto