Computer Architecture and Programming Languages
Jacobs University Bremen
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Course: CO20-320241
November 27, 2018

Homework 10 - Datapath and Control

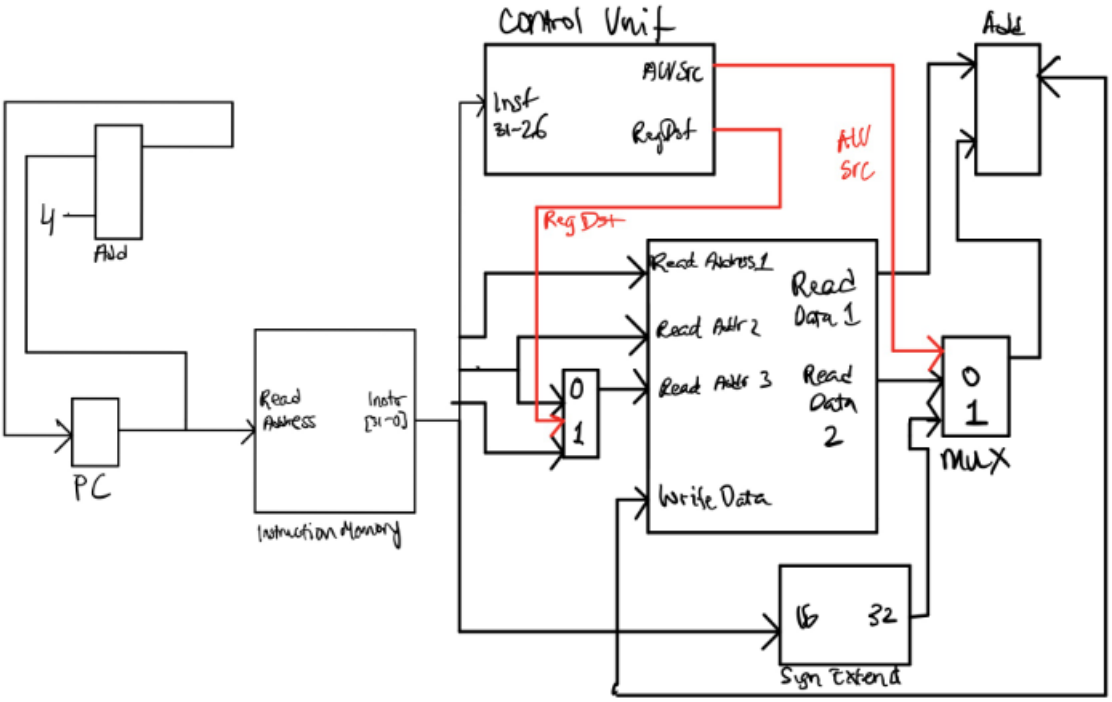
Problem 10.1

Solution:

Control lines are necessary because together with the multiplexors, it does the selection for the single cycle datapath. Control lines are determined by the opcode fields of the instruction and those instructions are being passed through the multiplexer in order to output the multiple single line inputs to one single output.

Problem 10.2

Solution:



Problem 10.3

Solution:

a) We must pick the longest path to determine the clock cycle time, therefore, all we need to do is compare the latencies between the four possible paths for the ALU instructions

1. I-mem → RegF → ALU → Mux3 → WBacktoRegF
. 450 ps 250 ps 120ps 30ps - = 850 ps
2. I-mem → RegF → Mux2 → ALU → Mux3 → WBacktoRegF
. 450 ps 250 ps 30ps 120ps 30ps - = 880 ps
3. I-mem → Mux1 → RegF (Write address)
. 450 ps 30 ps 250ps = 730 ps
4. Add → Mux4 → PCWrite
. 110 ps 30 ps - = 140 ps

The clock cycle time is 880ps from the second path.

b) 1. I-mem → RegF → ALU → D-mem
. 450 ps 250 ps 120ps 350ps = 1170 ps
2. I-mem → RegF → D-mem
. 450 ps 250 ps 350ps = 1050 ps
3. I-mem → Sign Extend → Mux2 → ALU → D-Mem
. 450 ps 20 ps 30ps 120ps 350ps = 970 ps
4. Add → Mux4 → PCWrite (update PC)
. 110 ps 30 ps - = 140 ps

The clock cycle time is 1170 ps from the first path.

c) Now, we must compare part a and b with the paths for beq and lw.
For lw:
1. I-mem → RegF → ALU → D-mem → Mux3 → WBack to RegF
. 450 ps 250 ps 120ps 350ps 30ps - = 1200 ps
2. I-mem → Mux1 → RegF(Write Address)
. 450 ps 30 ps 250ps = 730 ps
3. I-mem → Sign Extend → Mux2 → ALU → D-Mem → Mux3 → WBack to RegF
. 450 ps 20 ps 30ps 120ps 350ps 30ps = 1000 ps
4. Add → Mux4 → PCWrite (update PC)
. 110 ps 30 ps - = 140 ps

For beq:
1. I-mem → RegF → ALU → Mux4 → PCWrite (update PC)
. 450 ps 250 ps 120ps 30ps = 850 ps
2. I-mem → RegF → Mux2 → ALU → Mux4 → PCWrite (Update PC)
. 450 ps 250 ps 30ps 120ps 30ps = 880 ps
3. I-mem → Sign Extend → Shift-left-2 → Add → Mux4 → PCWrite (update PC)
. 450 ps 20 ps 30ps 120ps 30ps = 650 ps
4. Add → Mux4 → PCWrite (update PC)
. 110 ps 30 ps - = 140 ps

The clock cycle time is 1200ps from the first path of lw.