EE334 Computer Architecture
Homework Assignment 6

Name: SOL.

Due: (9:10AM) March 28, 2012

Problem 1. In this problem a sequence of instructions are executed in a 5-stage pipelined datapath. The processor has forwarding and hazard detection units. The instruction sequence is shown below in Table 1. Please answer the following questions:

a) Identify data dependencies (please show these dependencies in the table).
b) Show the first five cycles of the instruction sequence execution (use Table 1).
c) Specify the signals that are asserted in each cycle by the hazard detection and forwarding units, for this question use Table 2. (Figure 4.60 from textbook shows the datapath with the units).

Table 1. Instruction sequence and clock cycle.

Instruction sequence	Clock 1	2	3	4	5
LW R2,0(R1)	IF	ID	EX	MEM	WB
AND R1,R2,R1		IF	ID	S	EX
LW R3,0(R2)			IF	S	ID
LW R1,0(R1)					IF
SW R1,0(R2)					

Table 2. Hazard detection and Forwarding units and clock cycle.

Unit	Signals	Clock 1	2	3	4	5
Hazard detection	PCWrite	**1**	1	1	0	1
	IF/IDWrite	**1**	1	1	0	1
	ID/EXZero	**0**	0	0	1	0
Forwarding	ALUin1	**X X**	X X	00	X X	10
	ALUin2	**X X**	X X	00	X X	00

Problem 2. Assume that instructions executed by the pipelined processor are broken down as follows:

R-type	BEQ	LW	SW
40%	10%	30%	10%

← These %'s should be 100%

In this program we have that 45% of the load word (LW) instructions are followed by another instruction that needs the data that is being read from memory. For this problem, assume that forwarding is used and a perfect branch prediction. Please determine the CPI (cycles per instruction) for this machine.

$$CPI = \underset{\text{CPI ideal}}{1} + \underset{\text{load}}{0.3} \times \underset{\text{depend.}}{0.45} \times \underset{\text{penalty}}{1} = 1.135$$

[other way to compute CPI]

$$CPI = .4\times1 + .1\times1 + .3(.45\times2 + .55\times1) + 0.1\times1$$
$$= 1.035$$

{instructor removed jumps and did not add higher %'s}

Problem 3. (This is problem 4.23 from the textbook)

Exercise 4.23

The importance of having a good branch predictor depends on how often conditional branches are executed. Together with branch predictor accuracy, this will determine how much time is spent stalling due to mispredicted branches. In this exercise, assume that the breakdown of dynamic instructions into various instruction categories is as follows:

	R-Type	BEQ	JMP	LW	SW
	40%	25%	5%	25%	5%
[redacted]					

Also, assume the following branch predictor accuracies:

	Always-Taken	Always-Not-Taken	2-Bit
	45%	55%	85%
[redacted]			

4.23.1 [10] <4.8> Stall cycles due to mispredicted branches increase the CPI. What is the extra CPI due to mispredicted branches with the always-taken predictor? Assume that branch outcomes are determined in the EX stage, that there are no data hazards, and that no delay slots are used.

4.23.2 [10] <4.8> Repeat 4.23.1 for the "always-not-taken" predictor.

4.23.3 [10] <4.8> Repeat 4.23.1 for the 2-bit predictor.

Branch IF | ID | EX |

— —

IF ← right inst.

always taken

$$CPI = \underbrace{1}_{CPI_{ideal}} + 0.25\times(1-0.45)\times 2 = 1.275$$

always not taken

$$CPI = 1 + 0.25\times(1-0.55)\times 2 = 1.225$$

2-bit predictor

$$CPI = 1 + 0.25\,(1-0.85)\times 2 = 1.075$$