

ELEC 5200-001/6200-001 (Fall 2013)
Chapter 4 Problems
Assigned 9/25/13, due 10/2/13

Problem 1: Execution times of hardware blocks of a single cycle datapath (refer to the diagram in Figure 4.17) are as follows:

Multiplexer	2ps
Control	2ps
Register file read or write	10ps
Sign extension	1ps
Shift left by 2	1ps
Adder or ALU	20ps
Instruction or data memory	15ps

All other hardware times can be neglected.
 Find a lower bound on the cycle time for the program counter.

Problem 2: Consider the hardware times of major units (others being negligible) in a datapath as:

Memory access (read or write)	100ps
ALU	75ps
Register file (read or write)	50ps

Determine minimum clock cycle time, average CPI, and average instruction execution time for single-cycle and multi-cycle datapaths for the following program statistics: (refer to Chapter 4, 332-335 for a multi-cycle datapath discussion):

Instruction type	Percentage in a program	Average cycles used by instruction	
		Single-cycle	Multi-cycle
lw	20	1	5
sw	10	1	4
branch	10	1	2
jump	10	1	2
register	50	1	4

Problem 3:

(refer to Chapter 4, 332-335 for a multi-cycle datapath description):

- (a) Suppose operations involving register file, memory or ALU take one time unit each. Neglecting the time of all other hardware, how much time will each MIPS instruction take on a single-cycle datapath? Consider R-type, lw, sw, beq and j instructions.
- (b) What will be the execution times for MIPS instructions on a 5-cycle multi-cycle datapath using a clock period of 1 time unit?
- (c) A program contains the following mix of instructions:

Memory type	20%, equally divided between lw and sw
R-type	50%
Branch	15%
Jump	15%

What is the single-cycle CPU time to multi-cycle CPU time ratio for running this program on the two datapaths?

Problem 4: Consider two types of MIPS datapaths. The clock rates for single-cycle and multi-cycle implementations are 200MHz and 1GHz, respectively. The following subroutine is used for estimating the performances. The argument register \$a0 contains a very large positive integer (1 million or greater):

```
repeat    beq    $a0, $zero, finish
          addi   $a0, $a0, -1
          jump  repeat
finish    add    $v0, $a0, $zero
```

- Determine: (a) Average cycles per instruction (CPI) for two datapaths.
- (b) How much faster is the multicycle execution of the program (ratio of single-cycle to multicycle execution times)?

Problem 5: Sketch a schematic showing a multicycle MIPS datapath for the execution of the jump and link (jal) instruction. In your schematic you may include only those units that participate in the execution of this instruction.