CS230 DLDCA End-Sem LITE, Tue 12 Nov 2024, 13.30-16.30, Max. Marks: 40

General instructions

- Write only in the space provided. Answer briefly but crisply (not lengthily or loosely).
- You are allowed to refer to your own hand-written notes only.
- Write neatly and clearly. Up to **+2 HP** for neat handwriting, neat/crisp answers.
- Answers generally have to be (briefly) explained. State any necessary assumptions.

[Q1] Short answer questions: [1x13+2=15 marks]

1. What real instruction(s) does the pseudo-instruction 'la' (load address) translate to?

2. MIPS has a convention as to which registers are caller saved versus which are callee saved. What is the need for such a convention?

3. Are RAW hazards in memory locations possible in the 5-stage MIPS pipeline? Explain.

4. Give an example of spatial locality in instruction memory access.

5. When we say that a machine is a 32-bit architecture, what does this 32-bit refer to?

6. State one use of virtual memory as a level of indirection.

7. What is the typical hit-time of TLB, in terms of number of cycles?

8. State one advantage of having a long pipeline, i.e. a large number of stages

9. State one disadvantage of having a long pipeline, i.e. a large number of stages

10. What are the three kinds of bus lines?

11. In MIPS, **`not R1, R2`** is a pseudo-instruction where R1 gets assigned the value corresponding to the bit-wise toggling of R2. Implement this pseudo-instruction using real MIPS instruction(s).

12. In the instructions **`srl`** & **`sll`**, which of the registers **`{Rs, Rt, Rd}`**, if any, are ignored (i.e. neither read and used, nor written)?

13. What does the instruction **`jalr`** do?

14. **[2 marks]** Complete the following MIPS assembly code such that when executing the instruction at L3, $s0 has the value of PC.

```
L1:  _____

L2:  _____

L3:  # here, $s0 must be PC (i.e address corresponding to L3)
```

[Q2] MIPS ISA [5 marks]

Consider the conditional move instruction MOVZ which copies a source register to a destination register only if a third register is zero. For example, the instruction

MOVZ $8, $11, $4

copies the contents of register 11 into register 8, only-if register 4 is zero (otherwise it does nothing).

1. **[1 mark]** Machine M1 is a regular MIPS machine whose assembler implements MOVZ as a pseudo-instruction. Indicate how MOVZ $a, $b, $c can be implemented using real MIPS instruction(s).

2. **[1 mark]** Your answer above would have used a branch instruction. Give the 16-bit immediate value in the machine code of this branch instruction.

3. **[2 marks]** Machine M2 extends the MIPS ISA by implementing MOVZ as a real instruction. A program P while executing on M2, has 5% of executed instructions as MOVZ. For this program, M1 and M2 have the same clock cycle length and the same CPI. Which machine executes P faster and by what factor?

4. **[1 mark]** M2's clock speed is 2.1GHz. What is M1's clock speed?

[Q3] Pipelining [8 marks]

Consider the same MOVZ instruction as above (except for the definition of MOVZ, this question is independent of the previous question). Machine M2 implements MOVZ by extending the original 5-stage MIPS pipeline implementation.

1. **[2 marks]** Suggest an appropriate instruction format for MOVZ $a, $b. $c. Provide a drawing with justification.

2. **[1 mark]** In which stage of execution does MOVZ need the RegWr (Register Write) control line? Explain briefly.

3. **[1 marks]** At the end of which stage of MOVZ's execution can the RegWr line be determined?

4. **[4 marks]** Consider data forwarding for the MOVZ instruction when the source register of the 'move' has an RAW dependence on a previous instruction (consider *only* these instances of data forwarding). Draw an appropriate pipeline timing diagram to illustrate the possible scenarios of data forwarding.

[Q4] MIPS Assembly Language [7 marks]

Fill-in-the-blanks to complete the MIPS32 assembly translation of the given C code.

```
struct Complex {
  int re, im;
}
struct Complex C1[], C2[];
int i, N, k;

// Some C code here
// which need not
// be translated

for(i = k; i < N; i++) {
  C1[i] = C2[i];
}

# Assume:
# i in $s0, k in $s1
# N in $s2
# C1 in $s3
# C1's length in $t3
# C2 in $s4
# C2's length in $t4
# Use other temporary
# regs as needed
# Assume int and
# pointers size = 1 word
```

```
# Code begins here; see assumptions given

  addi  $s0, $s1, 0

  ____________________

LOOP:
  ____________________ # if i is out of C2's range

  ____________________ # jump to OutOfBounds

  ____________________ # if i is out of C1's range

  ____________________ # jump to OutOfBounds

  sll  $t0, $s0, 3
  add  $t2, $t0, $s4 # t2 is now &C2[i]
  add  $t1, $t0, $s3 # t1 is now &C1[i]
  # Next four lines achieve C1[i]=C2[i]
  # 1 mark each for next 4 lines

  ____________________

  ____________________

  ____________________

  ____________________

  addi $s0, $s0, 1  # i++

COMPARE:

  slt $t0, $s0, $s2

  ____________________ # loop back as necessary
```

(next question is in next page)

[Q5] Majority Gate [1+1+1+2=5 marks]

Consider the following function: M (x, y, z) = xy + yz + xz. This is called a majority function/gate. This is because the function evaluates to 1(0) only if at least two of the 3 variables are 1(0). In this question, we shall be exploring the majority gates. Turns out that such majority functions have very interesting applications in nanotechnology-based circuits. Implement the following functions using only majority gates. You may use 0 or 1 as input where appropriate. You may also assume that where needed, the complemented input x' of an input variable x is also available, in addition to x itself.

1. F(x) = x ; use exactly one majority gate

2. F(x,y) = x+y ; use exactly one majority gate

3. F(x,y) = xy ; use exactly one majority gate

4. F(x,y,z) = xy' + y'z ; use exactly two majority gates

[Q6] Dharavi and the "once-in-a-century" "pandemic" [optional, 10HP]

The official claim regarding Covid is that it was a highly transmissible, deadly, "once-in-a-century" "pandemic", overwhelming hospitals everywhere. The Dharavi slum is one of the densest and poorest places on earth, with poor access to healthcare. What percentage of people in Dharavi died of Covid? (The next time you meet someone from the working class, ask them whether they found the "pandemic" deadly as claimed).