

CS230 DLDCA Mid-Sem, Tue 17 Sep 2024, 13.30-15.30pm, Max. Marks: 30

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.

1. [1 x 2 = 2 marks] Short answer questions:

- a) Mention any two advantages of dynamic linking.
 - b) In a MIPS32 program, a beq instruction is at location 80,000 (decimal value of byte address). In its machine code, the immediate value is -200 (decimal value again). What is the branch target address (which is executed when branch is taken)?
- 2. [2 marks]** Prove that $f(x,y,z) = xy+yz+zx$ is self-dual using algebraic manipulations (i.e., Boolean Algebra rules and theorems) only. Show all your steps.

3. **[1 x 4 = 4 marks]** MIPS32 program P.exe is generated from assembly files p1.s & p2.s, it has no other external library. MIPS32 program Q.exe is generated from 2 assembly files q1.s and q2.s as well as a statically linked external library lib1.o. There is no dynamically linked library. Answer the following.
- a) In P.exe, suppose registers \$at (\$1) and \$t0 (\$8) are exchanged in all instructions in which they appear, in the machine code. Would P.exe continue to work? Justify.
- b) Answer the same as above with justification, for Q.exe.
- c) In P.exe, suppose registers \$s0 (\$16) and \$ra (\$31) are exchanged in all instructions in which they appear, in the machine code. Would P.exe continue to work? Justify.
- d) Answer the same as above with justification, for Q.exe.
4. **[2 marks] Design decision using computer performance:** Suppose that the MIPS32 designers are considering the inclusion of an instruction called add3, which adds 3 registers instead of two added by the current add instruction. Using simulation on a benchmark program, they found that when add3 is used, 5% of the executed instructions use add3. The designers also determined that, with inclusion of add3, the clock cycle length of a single cycle implementation increases from 500ps to 550ps. (1 pico-second = 10^{-12} seconds). Is the inclusion of add3 beneficial?

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5. **[3+2=5 marks]** A new flip-flop, called MN flip-flop, is constructed from a JK flip-flop as follows:

$$J = M; K = N \oplus M$$

a) Derive the characteristic table and excitation table for this new flip-flop

b) Construct a D flip-flop from this new flip-flop

6. **[1+2+2=5 marks]** Construct a counter for the following sequence using T flip-flops:

000 \rightarrow 100 \rightarrow 111 \rightarrow 010 \rightarrow 011

a) Draw the state-table.

b) Construct the present-state next-state table with T-flip-flop as the memory element.

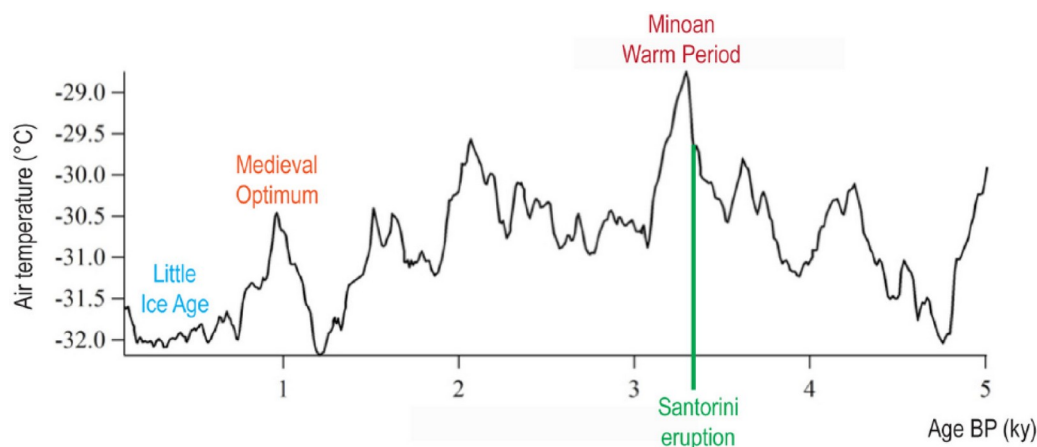
c) Derive the inputs of the T flip-flops.

7. **[2+4+2+2=10 marks]** Consider the single cycle implementation for the ISA subset {add, sub, and, or, lw, sw, beq} (as in the videos). We are now going to add support for a new instruction (this is not really a MIPS instruction though) called `sw0_inc`. This instruction is the same as `sw` except for two differences: it always uses offset as 0, and it has the side effect of incrementing the value of the base register by a given 16-bit immediate operand.
- a) What instruction format can `sw0_inc` use? Draw it, along with brief justification.
- b) Draw *only* the datapath changes from the original datapath for the ISA subset. Your changes should be *minimal*, adding only muxes as necessary: *avoid* additional ALU/adder or changes to the register file or memory components (it is of course ok to change the possible *inputs* to these components).

- c) Draw *only* the control signal changes from the original ISA subset, i.e. show additional row(s)/column(s) in the truth table.

- d) Can a `lw0_inc` instruction be similarly implemented without any change to the main components? Why or why not?

8. **[Optional, up to 10HP]** The following graph is the estimated Greenland temperature, from the GISP2 (Greenland Ice Sheet Project 2) data, from a 2018 publication. The x-axis is in units of kilo-years Before Present (BP), where BP=0 is taken as 1950AD. As additional data (not in graph), the global average warming since 1950 is about 0.75 °C.



- a) How much warmer/colder was Greenland during the Medieval Warm Period (1000AD) compared to today? _____
- b) How much warmer/colder was Greenland during the Roman Warm Period (0 AD) compared to today? _____
- c) How much warmer/colder was Greenland during the Minoan Warm Period (1300 BC) compared to today? _____
- d) Connect the theme of the various house-point questions so far with a point made in the first lecture