

# Computer Systems Exam

2 June 2015

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**This is a closed book exam: no documentation is allowed. No calculator or other tools are allowed either. Please make sure that your handwriting is readable and please keep the answers brief and to the point. Whenever a question states that the answer must be a single sentence, any subsequent sentences will be ignored for grading.**

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Q1. **(0.6 pt)** You want to run a program in language L1. Consider the following designs:

- (a) Language L1 is executed directly on the hardware.
- (b) Language L1 is compiled to a simpler language L0, which is executed directly on the hardware.
- (c) Language L1 is interpreted using a simpler language L0, which is executed directly on the hardware.

Indicate which design(s) has/have:

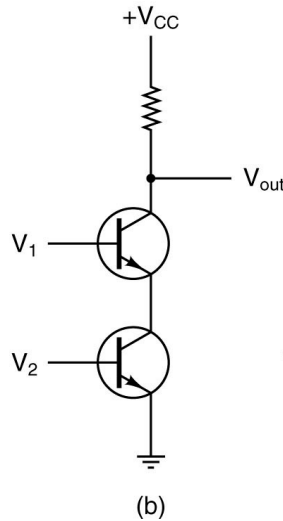
- The best performance
- The worst performance
- The lowest production cost
- The highest production cost
- The most flexibility
- The least flexibility

For each of the six explain why (one sentence each). It is possible for multiple approaches to be equally good or bad.

Q2. **(0.6 pt)** In June 2014, a CPU was released with the following characteristics: 4 cores, 4.0 GHz clock frequency, 1 MB of L2 cache, 8 MB of L3 cache, 1.4 billion transistors, 88 W power usage, \$ 339 initial price. Formulate Moore's law (one sentence) and specify what prediction(s) it makes about this chip's successor in December 2018. Provide explicit numbers and include only predictions that follow *directly* from Moore's law itself, that is, do not infer indirect predictions.

Q3. **(0.6 pt)** A memory hierarchy is used in almost all computer systems because of a trade-off between two important characteristics that differ between different types of memory hardware. Which two characteristics are these? Give four layers in the memory hierarchy and indicate the order from best to worst on both characteristics.

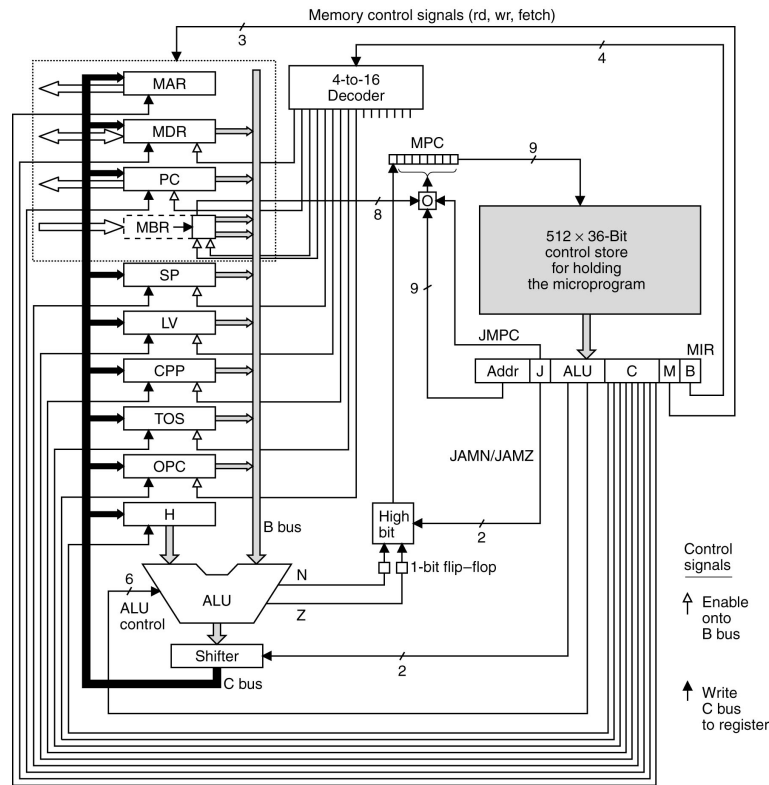
- Q4. (0.5 pt) What is the name of the gate shown below? Provide a truth table for the gate.



- Q5. (1.0 pt) A NOR-based 1 bit memory cell (SR-latch) has inputs  $S$  and  $R$  and outputs  $Q$  and  $\bar{Q}$ . What is the purpose of each input and output (one sentence each)? Draw the circuit that implements the memory cell.
- Q6. (0.6 pt) How does the timing of transactions differ between synchronous and asynchronous buses (one sentence)? Depending on the characteristics of the devices attached to the bus, one of the two designs tends to perform much better. In which situation does one of the designs clearly perform better than the other (one sentence)? Which of the two designs is faster in that case and why (one sentence)?
- Q7. (0.9 pt) Convert the following Java statement into IJVM assembly instructions. All variables are integers. The `sqrt` function takes one integer as a parameter and returns an integer.

```
z = sqrt(x * x + y * y);
```

- Q8. (1.0 pt) In the Mic-1 micro-architecture (shown in the picture), which of the following microinstructions are correct and which are impossible? Assume that any labels referenced exist.



```

1  H = H * OPC; read
2  LV = H + 3
3  MBR = TOS - H
4  MAR = SP = SP + 1; read
5  H = 0; fetch; goto (MBR)
6  H = OPC = (H OR TOS) << 8
7  PC = PC + 1; goto (PC)
8  MDR = OPC = -H; read
9  H = TOS + OPC
10 Z = OPC - H; if (Z) goto T; else goto F

```

Q9. (1.0 pt) The instruction `MOV R1, x` copies the value specified by `x` into the register R1. Give five examples of possible expressions for `x` that use different addressing modes. Use the assembly notation from the slides and the book. Assume the existence of a register R2 with value 50 and a symbol A with address 1000. Specify what values they load into R1, giving the address in case of memory references and the value itself otherwise (one sentence each).

Q10. (0.5 pt) There are two processes running on an operating system, which runs on a computer with a single CPU that has just one core. Process A copies data from one disk to another by alternately reading a large block of data from disk 1 and then writing it to disk 2. Process B determines whether a very large number is prime by dividing it by all smaller numbers in a loop. Either process would take approximately 10 minutes to run to completion when they have the machine to themselves. Both processes are started simultaneously.

Explain what scheduling policy would be optimal in this case. Explain approximately how long it would take until both processes have finished using this policy.

- Q11. **(0.8 pt)** A hard disk has 100 tracks numbered 0 (innermost) to 99 (outermost). The seek time is proportional to the number of tracks skipped. The seek time is 0.1 ms per track. There is also a reset function that moves the disk head from track 99 to track 0 in 0.1 ms. For our purposes, everything else happens instantaneously.

The disk head is at track 60 and the operating system gets the following disk requests:

- track 30
- track 90
- track 10
- track 50
- track 40

Compute the total seek time with each the following disk scheduling algorithms:

- First-Come-First-Served
- Shortest-Seek-Time-First
- Scan and Look
- Circular Scan and Look

- Q12. **(0.5 pt)** A 32-bit CPU has 4 KB pages. The page table uses 4 bytes for each entry. How large is the page table? Keep in mind that we use the convention that  $1 \text{ GB} = 2^{10} \text{ MB} = 2^{20} \text{ KB} = 2^{30} \text{ bytes}$ . Name one optimization that could be used to reduce the size of the page table (one sentence).
- Q13. **(0.6 pt)** Most file systems store a list of block numbers for each file. A simpler approach would be to use contiguous blocks, so that we only need to store where the file starts and how many blocks it occupies. Name two limitations of this approach that cause it to not be generally applicable (one sentence each). In which specific situation would this approach work well (one sentence)?
- Q14. **(0.8 pt)** An object file consists of a number of parts that are generated by the assembler and used by the linker to be able to generate the final binary. Typically, an object file starts with headers providing identification info and ends with a checksum. Name four parts that you expect to find in between these two.

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