Queen Mary
University of London

Main Examination Period 2019-2020

ECS404U Computer Systems and Networks Duration: 2 hours

YOU ARE NOT PERMITTED TO READ THE CONTENTS OF THIS QUESTION PAPER UNTIL INSTRUCTED TO DO SO BY AN INVIGILATOR.

Instructions: This paper contains FOUR questions. **Answer ALL questions**.
Cross out any answers that you do not wish to be marked.

Calculators are permitted in this examination. Please state on your answer book the name and type of machine used.

Complete all rough workings in the answer book and cross through any work that is not to be assessed.

Possession of unauthorised material at any time when under examination conditions is an assessment offence and can lead to expulsion from QMUL. Check now to ensure you do not have any notes, mobile phones, smartwatches or unauthorised electronic devices on your person. If you do, raise your hand and give them to an invigilator immediately.

It is also an offence to have any writing of any kind on your person, including on your body. If you are found to have hidden unauthorised material elsewhere, including toilets and cloakrooms it will be treated as being found in your possession. Unauthorised material found on your mobile phone or other electronic device will be considered the same as being in possession of paper notes. A mobile phone that causes a disruption in the exam is also an assessment offence.

Exam papers must not be removed from the exam room.

Question:	1	2	3	4	Total
Points:	25	25	25	25	100
Score:					

Leave this table blank.

Examiners: Dr A Khouzani and Prof E Robinson

Question 1

Computer Architecture

(a) In a circuit diagram the symbol in figure 1 represents a transistor. Name the type of transistor and the different connections to it, and explain how it functions as a switch. You are not asked for a physical explanation, just an explanation in terms of the roles of the different connections. **[5 marks]**

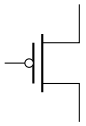

Figure 1: a transistor

(b) Figure 2 below depicts a logic gate.

(i) Detailing which transistors give open or closed circuits, explain the output at C when the input at A=0 and the input at B=1.

(ii) Identify the connective being computed by this logic gate and explain your answer.

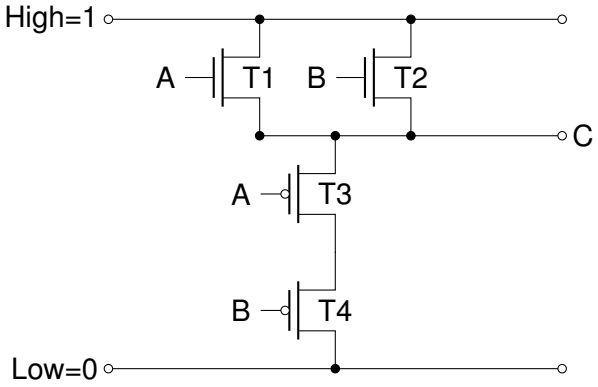

Figure 2: a logic gate

[8 marks]

(c) Figure 3 below depicts a DRAM cell.

(i) What is the function of a *capacitor*?

(ii) Explain how this cell operates to store a single bit, making clear the roles of the capacitor, transistor, word line and bit line.

(iii) Explain why the information in this cell is lost when the power to it is cut off.

Question continues on next page

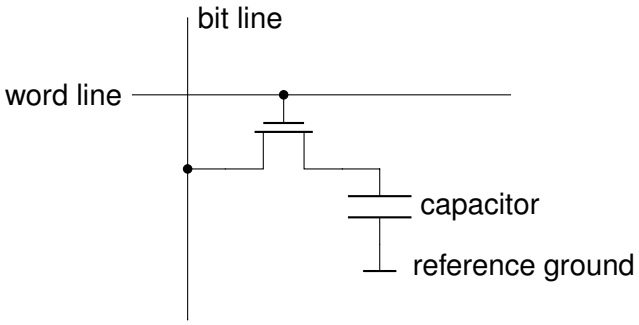

Figure 3: DRAM

[6 marks]

(d) The chip in Figure 4 has the Intel Kaby Lake architecture. Some of it marked as being L3S, which stands for Level 3 Cache.

(i) In the context of Computer Architecture, what is a cache?

(ii) Why do computer and chip designers use cache?

(iii) What is the function of this particular cache?

(iv) Why is it described as Level 3?

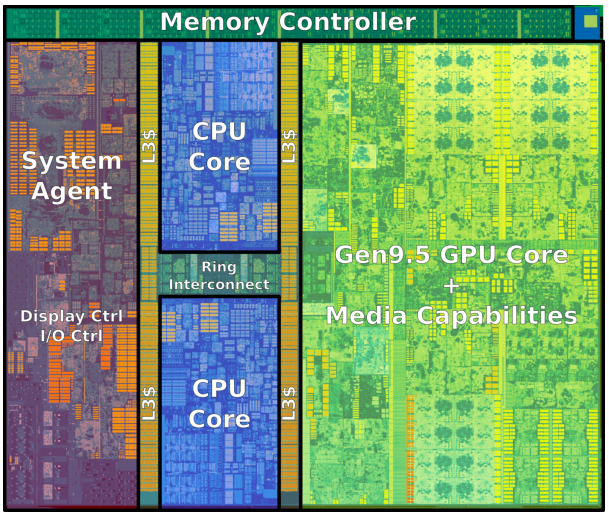

Figure 4: Intel Kaby Lake chip (Question 1-(d)).

[6 marks]

Question 2

Digital Representation

Simply giving an answer will never achieve full marks. You must always explain your methods.

(a) These bit sequences represent numbers in 8-bit 2's complement. Explain which numbers they are and how you know whether the numbers are positive or negative.

(i) 11110011

(ii) 00000110

[5 marks]

(b) (i) Show that you understand how to do long multiplication in binary by multiplying `11110011` and `00000110`.

(ii) What are the rightmost 8 bits of your answer?

(iii) What do they represent as a number in 8-bit two's complement.

[6 marks]

(c) This part is about floating point representation. The bit sequence below represents a number in 64-bit IEEE floating point format:

```
11000000 00100101 00000000 00000000 00000000 00000000 00000000 00000000
```

(i) The first bit represents the sign of the number. Is this number positive or negative?

(ii) The next 11 bits represent the exponent. In this format, we get the exponent by subtracting 1023 from the number represented by this bit sequence. What is the actual exponent?

(iii) The remaining bits give the part after the point in the significand. What is the significand in binary format and what is it as a decimal number?

(iv) Explain how these components are put together to give the final number represented, and give the number.

[6 marks]

(d) The MAC address of my device is: 2c:8a:72:bd:ef:38

(i) Explain the format being used and how it represents a bit sequence.

(ii) What is the bit sequence?

[4 marks]

(e) In ASCII, the decimal code for the character 'A' is 65, and for lower case 'a' it is 97.

(i) Put these into binary and explain why it makes sense to have the upper and lower case characters differ by 32.

(ii) Explain the limitations with ASCII that prompted the development and adoption of Unicode.

Question continues on next page

(iii) How many bytes are used to represent an ASCII character and how many bytes to represent one in UTF-8?

[4 marks]

Question 3

Instruction Set Architecture, Assembly Language

(a) Can we use compilers that are designed for different architectures interchangeably? For instance, can we use an Intel/AMD C++ compiler to compile our code to be used on a CPU with ARM or MIPS architecture? Your answer should be supported by brief reasoning.

[4 marks]

(b) Explain why "branching" in the programmes (that is, when there is a conditional jump) can cause a problem for "pipelining" and reduce its efficiency.

[5 marks]

(c) A 32-bit MIPS instruction is `0x21490023` (that is, `21490023` in HEX representation).

(i) What is the actual bit-sequence of this instruction?

(ii) The **`opcode`** of this instruction corresponds to **`ADDI`** (add-immediate). Using the following reminder about the 3 different formats of the 32-bit MIPS instructions (Figure 5) and its register names (Table 1), along with your answer to the previous part, fully identify the instruction. Namely, identify the operands of the instruction, express it in MIPS Assembly mnemonics, and briefly describe in words what operation it performs.

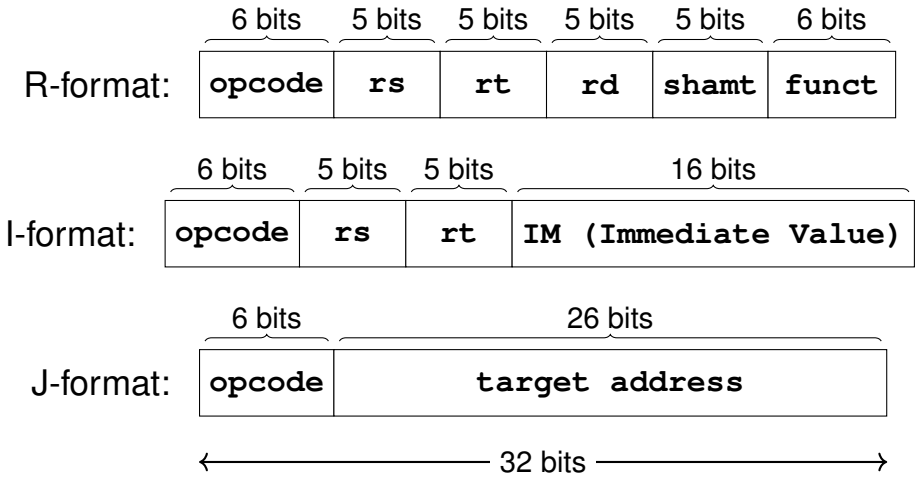

Figure 5: The 3 different formats for 32-bit MIPS instructions (Question 3(c)-ii).

[8 marks]

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Reg. No.	Reg. Name	purpose (usage)
$0	**$zero**	always holds 32 bits of zeros (no overwrite)
$1	$at	Reserved to be used by the assembler
$2 · · · $3	**$v0**, **$v1**	Return values from subroutines
$4 · · · $7	**$a0** · · · **$a3**	Arguments to subroutines
$8 · · · $15	**$t0** · · · **$t7**	General purpose (temporary registers)
$16 · · · $23	**$s0** · · · **$s7**	General purpose (save registers)
⋮		

Table 1: The naming convention for some of the 32-bit MIPS registers (Question 3(c)-ii).

(d) A programme in 32-bit MIPS Assembler is shown in the following:

```
1  .text
2  MAIN:
3      li $v0, 5    # set v0 to "5" to select the "read integer" syscall
4      syscall      # invoking the syscall to read the integer (to $v0)
5      addu $s0, $v0, $zero      # equivalent to 'move $s0, $v0'
6  START:
7      li $s1, 0
8  LOOP:
9      beq $s0, $zero, DONE
10     andi $t0, $s0, 1
11     addu $s1, $s1, $t0
12     srl $s0, $s0, 1
13     j LOOP
14 DONE:
15     addu $a0, $s1, $zero      # equivalent to 'move $a0, $s1'
16     li $v0, 1        # set v0 to "1" to select the "print interger" syscall
17     syscall          # invoking the syscall to print the integer (from $a0)
18
19     li $v0, 10   # set v0 to "10" to select the "exit" syscall
20     syscall      # invoking the syscall to exit.
```

As a reminder, the MIPS instruction `srl` is `shift right logical`. In particular, it has the format `srl rd, rt, sa`, which means the contents of the register **`rt`** are shifted right by `sa` many bits ('shift amount'), inserting zeros into the emptied bits in the left, and the resulting bit-sequence is placed in register **`rd`**. You should be quite familiar with the rest of the instructions.

(i) Suppose when prompted at the console, **we input number 11** (in decimal). Provide the trace of the values in registers **`$s0`** and **`$s1`** (as a pair) when this code is executed until it finishes. That is, write down the new values in both **`$s0`** and **`$s1`** each time either one of them changes as you step through the

Question continues on next page

programme until the programme finishes execution. You can choose to present the values either in decimal, hex, or binary, as long as you clearly specify which.

(ii) Express in a simple sentence what does this programme effectively do? (Your answer should be a sentence starting like: "this programme takes an integer value from the user and computes . . . ")

[8 marks]

Question 4

Computer Networks

(a) Suppose Alice, a QMUL student, lives in Croydon, south of London. She uses her laptop to connect to internet through wifi, both at home and on our campus. For each of the following entries, determine if it changes based on whether she is connected to internet at home or on campus (your answers should be supported by a brief explanation):

(i) The MAC address of her laptop;

(ii) The public IP address of her laptop;

(iii) The MAC address of the wifi access point that connects her to internet;

(iv) The TCP port number of her web browser.

[9 marks]

(b) 'IP header' refers to the information present at the beginning of an IP packet. Name at least 4 entries in the 'IP header', and for each of them, briefly describe what it is used for (i.e., what role does it play).

Hint 1: The IP (Internet Protocol) is right above the Link layer and right below the Transport layer in the TCP/IP protocol stack.

Hint 2: If it matters at all, you can consider either IPv4 or IPv6, but there are common entries present in both of them, based on the services that the IP layer needs to provide.

[8 marks]

(c) This part is about DNS name servers. Recall: DNS stands for Domain Name System.

(i) What service does a DNS name server provide in connection with internet communication?

(ii) Describe a way in which the use of DNS makes the internet vulnerable to attack. How can an attacker use the existence of DNS servers to compromise the integrity of internet traffic?

[8 marks]

End of questions