A36920

Calculators may be used in this examination provided they are not capable of being used to store alphabetical information other than hexadecimal numbers



UNIVERSITY OF BIRMINGHAM

School of Computer Science

Fourth Year Undergraduate/Postgraduate

06-34221

LM Computer Systems

Main Summer Examinations 2025

Time allowed: 2 hours

[Answer all questions]

Note

Answer ALL questions.

Question 1 – Fundamentals of Hardware and Software [34 Marks]

(a) A sensor installed in a home environment transmits temperature values in a 16-bit fixed-point format, where the first 6 bits are used for the integer part and the remaining 10 bits are used for the fractional part.

(i) Represent the temperature value 13.625_{10} in this format **[6 marks]**

(ii) What is the smallest positive decimal value that can be represented using the above format? Show your working. **[4 marks]**

(iii) Explain a key difference between using fixed-point vs floating-point representation for such a temperature sensor. Which would be more suitable and why? **[4 marks]**

(b) The von Neumann architecture uses a single memory for both data and instructions, which leads to a well-known performance issue. Explain what this issue is and how it limits the CPU performance. Also, discuss how modern processors address this bottleneck using caches and Harvard-like optimizations. **[10 marks]**

(c) A developer writes a Java program and compiles it into Java bytecode. This bytecode is then executed on a JVM (Java Virtual Machine). Explain the role of the JVM in making Java portable. Compare JVM interpretation vs. JIT (Just-In-Time) compilation in terms of performance. **[10 marks]**

Question 2 – Operating Systems & Algorithms [33 Marks]

The following MIPS assembly code is intended to implement a non-preemptive Shortest-Job First (SJF) Scheduling algorithm:

```
# Registers:
# $t0 = current process burst time
# $t1 = minimum burst time
# $t2 = index of the selected process
# $t3 = loop counter
# $t4 = total number of processes

    li $t4, 5                 # Number of processes
    li $t3, 0                 # Loop counter (i = 0)
    li $t1, 9999              # Set min burst time to a high value

loop:
    ble $t3, $t4, done        # Exit if all processes are checked
    lw $t1, burst($t3)        # Load current process burst time.
    blt $t0, $t1, update_min  # If burst[i] < min_burst, update min
    j next

update_min:
    move $t1, $t0             # Update min burst time
    move $t2, $t3             # Store process index

next:
    addi $t3, 0, 1            # i++
    j loop

done:
# $t2 now holds the index of the process with the shortest burst time
```

A MIPS cheat-sheet can be found below:

Instuction	Description
li a, n	put a constant value (n) into a register (a).
beq a, b, label	if a is equal to b, goes to label.
blt, a, b, label	if a is less than b, goes to label.
ble, a, b, label	if a is less than or equal to b, goes to label.
bgt a, b, label	if a is greater than b, goes to label.
j label	goes to the instruction at label.
move a, b	copy value from register b to register a.
lw reg, addr	load the 4 bytes at addr as a 32-bit value into reg.
sw reg, addr	stores the value of reg into memory as 4 bytes starting at addr.
addi a, b, c	adds signed numbers (a=b+c).
sub a, b, c	subtracts signed numbers (a=b-c).

(a) Some of the lines (up to three, excluding line 8 mentioned below) in the above implementation have bugs. Please identify which lines are incorrect and justify *why* they are incorrect. For example, line 8 (`li $t4, 5`) is incorrect because the total number of process should be 4 instead of 5. **[16 marks]**

A system has four processes with the following CPU burst times:

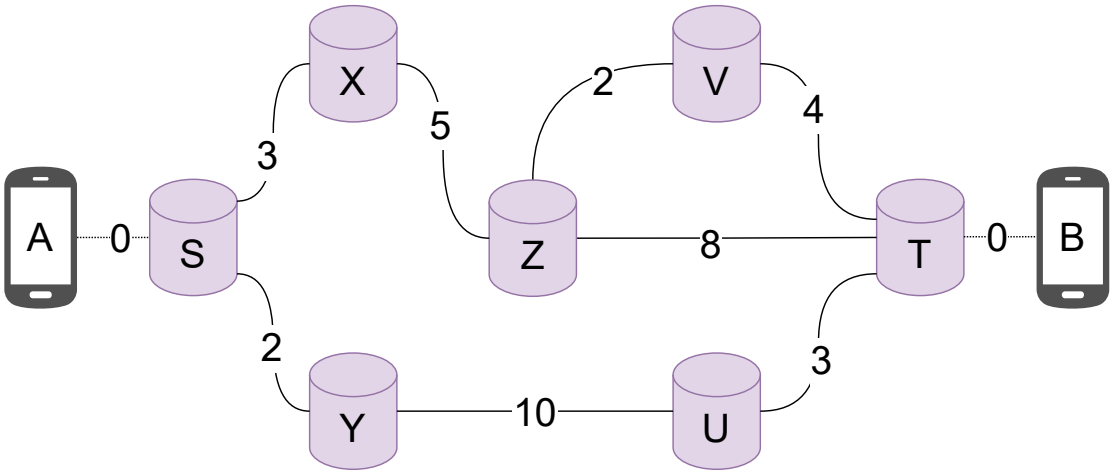
Process	Arrival Time (ms)	Burst Time (ms)
P1	0	7
P2	5	3
P3	2	5
P4	3	3

(b) Based on the process information provided in the above table, use the *Shortest Remaining Time First (SRTF)* algorithm to construct a Gantt Chart and determine the average waiting time. **[9 marks]**

(c) What is the key difference between the *Shortest Job First (SJF)* and *Shortest Remaining Time First (SRTF)* algorithms? Justify whether or not you believe applying SJF to the scenario given in the above table will lead to a lower average waiting time. **[8 marks]**

Question 3 – Computer Networking [33 Marks]

Alice sends a message to Bob using the Internet – both of them are using their smartphones. The following graph is an abstraction of the network used in their communication:



(a) The nodes of the graph represent computer systems; each one is labelled. Node A represents Alice's smartphone, B represents Bob's smartphone and the others represent routers.

(i) Which systems in the graph correspond to *access networks*? **[4 marks]**

The edges of the graph represent communication links between the systems; each one has a numeric cost.

(ii) What could these costs represent? Give at least two possibilities. **[6 marks]**

(b) Alice's message to Bob consists of an HTML object. State and describe, in detail, the Application Layer protocol used in this communication. **[10 marks]**

(c) Alice's messages is routed from her router (node S) to Bob's router (node T) on the Network Layer. The routing algorithm used to find the least-cost path is Dijkstra's algorithm.

Trace the steps of the algorithm in a table with the following headers:

Step	N'	D(X),p(X)	D(Y),p(Y)	D(Z),p(Z)	D(V),p(V)	D(U),p(U)	D(T),p(T)

Using this table, conclude the least-cost path. At each step, using the above headers, your table should keep track of which nodes have been visited (N'), the current distance cost of each node (e.g. $D(X)$ for node X) and the predecessor of each node (e.g. $p(X)$ for node X). **[13 marks]**

Do not complete the attendance slip, fill in the front of the answer book or turn over the question paper until you are told to do so

Important Reminders

- Coats/outwear should be placed in the designated area.
- Unauthorised materials (e.g. notes or Tippex) must be placed in the designated area.
- Check that you do not have any unauthorised materials with you (e.g. in your pockets, pencil case).
- Mobile phones and smart watches **must** be switched off and placed in the designated area or under your desk. They must not be left on your person or in your pockets.
- You are not permitted to use a mobile phone as a clock. If you have difficulty seeing a clock, please alert an Invigilator.
- You are not permitted to have writing on your hand, arm or other body part.
- Check that you do not have writing on your hand, arm or other body part – if you do, you must inform an Invigilator immediately
- Alert an Invigilator immediately if you find any unauthorised item upon you during the examination.

Any students found with non-permitted items upon their person during the examination, or who fail to comply with Examination rules may be subject to Student Conduct procedures.