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

UNIVERSITY OF BIRMINGHAM

School of Computer Science

Computer Systems

Main Summer Examinations 2024

Time allowed: 2 hours

[Answer all questions]

Note

Answer ALL questions. Each question will be marked out of 20. The paper will be marked out of 60, which will be rescaled to a mark out of 100.

Question 1

(a) (i) Briefly, explain what is meant by an Instruction Set Architecture (ISA).

(ii) Give and justify 2 reasons why two implementations of the same ISA, running at the same clock speed, may have very different performance profiles.

(iii) Explain the factors that could affect the choice of ISA implementation for different types of applications?

[6 marks]

(b) Briefly explain and compare the concepts of compilation and interpretation of computer programs. You should make it clear what the differences are between these two approaches. Explain, clearly, the relative benefits of each of these approaches.

[6 marks]

(c) (i) Give the time complexity (using big O notation) of the following algorithm. Justify your answer.

```
x=0
for i=1 to n
   for j=1 to 5*n
      for k=1 to 8*n
         for l=1 to 100
            x=x+i+j+k+l
```

(ii) You have a choice between two algorithms that both solve the same problem. One algorithm has complexity $O(nlog(n))$, the other $O(n^2)$. You have a very small amount of data. Explain with a clear justification why it may, in some circumstances, be better to choose the algorithm which has the greater time complexity.

[8 marks]

Question 2

(a) What is the dual mode of operation in an operating system, and why is it essential for ensuring system security and stability? Discuss three key features and benefits of dual mode operation. **[4 marks]**

(b) Consider the following set of processes:

Processes	Arrival Time	Burst Time
P1	0ms	7ms
P2	3ms	5ms
P3	4ms	2ms
P4	7ms	6ms

Outline the schedule of these processes using the SRTF scheduling policy. Also, compute the Average Response and Turnaround times for the above processes. **[6 marks]**

(c) Device controllers play a crucial role in managing peripheral devices within a computer system. Briefly explain how device controllers handle tasks such as data transfer, error handling, and device status monitoring? **[4 marks]**

(d) Your friend Maria is working on a Protein String Matching project, which takes approx. 200 hours to run on her desktop machine using a single CPU. Overall, 25% of her program code is sequential and cannot be parallelised. Additionally, the program spends approx. 30% of the time doing I/O operations and the remaining 45% of code could be parallelised. She is deliberating on two choices:

(i) Running her code on a server (single core), which supports hardware optimizations and reduced latency for I/O operations from $8\mu s$ to $6\mu s$ (on average).

(ii) Writing a parallel version of the program and running it on a multicore server, which supports 8 CPUs.

From the above choices, which one would you recommend? Show your working to justify your advice. **[6 marks]**

Question 3

Alice wants to send a message to Bob. Alice and Bob communicate using the Internet, which has five layers in its protocol stack.

(a) The Transport Layer protocol used for Alice and Bob's communication is UDP. The header of a UDP message includes a 16-bit checksum value, which helps to detect errors. Alice's message, including the header, consists of the following 48-bits (represented in hexadecimal format):

DF0594C1007F

Compute the corresponding checksum value for this message. **[7 marks]**

(b) Alice's message passes from the network edge to the Internet's mesh of interconnected routers, via her access network.

(i) What kind of devices make up the network edge? **[1 mark]**

(ii) What is the 'mesh of interconnected routers' also known as? **[1 mark]**

(iii) Describe the role of routers in Alice and Bob's communication. You should *name* and *describe* at least two jobs which routers perform. **[4 marks]**

(c) Alice's message to Bob is encrypted with RSA, which is a public key encryption algorithm. A public key encryption algorithm consists of each communicator having two keys — a public key and a private key.

(i) Describe two requirements of the public and private keys used in public key encryption. **[4 marks]**

(ii) Supposing that the two prime numbers originally chosen to generate Alice's key pair are 3 and 11, compute a public and private key pair for her. **[3 marks]**

Note: In this question we use much smaller numbers than RSA would typically use.

End of Paper

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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

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- Coats/outwear should be placed in the designated area.

- Unauthorised materials (e.g. notes or Tippex) <u>must</u> be placed in the designated area.

- Check that you <u>do not</u> have any unauthorised materials with you (e.g. in your pockets, pencil case).

- Mobile phones and smart watches **<u>must</u>** 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 <u>not</u> permitted to use a mobile phone as a clock. If you have difficulty seeing a clock, please alert an Invigilator.

- You are <u>not</u> 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.