

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

LH Advanced Networking

Main Summer Examinations 2023

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 80, which will be rescaled to a mark out of 100.

Question 1

The TCP/IP protocol has evolved considerably since its initial specification nearly forty years ago. Several extensions were introduced to deal with the problems associated with networks with a high bandwidth-delay product, also known as “long fat networks”, and there have been a range of solutions proposed to deal with the shortage of IPv4 addresses.

- (a) Describe the problems which are caused by a high *bandwidth-delay product*. Which features in the TCP standard as originally designed make such networks problematic for high-performance networking?

Assuming the speed of light is 3×10^8 metres per second, calculate the maximum rate at which data can be sent between two computers 3000 kilometres apart using unextended TCP. **[8 marks]**

- (b) Consider an application which has been written to use UDP for single-shot “query” and “response” operations. Considering the same 3000km separation, how long will each such operation take? State any assumptions that you make.

If an application needs to reliably perform five hundred (500) such operations per second, what approaches might be used to allow this to work? **[8 marks]**

- (c) There is a global shortage of IP version 4 addresses. Explain briefly the causes of this, and suggest two possible ways to expand the number of addresses available for allocation. **[4 marks]**

Question 2

TCP is the dominant transport protocol used on today's Internet.

- (a) TCP uses the mechanism of a “sliding window” to manage reliable transmission and reception of data. The window defines the amount of unacknowledged data that is in flight.

Explain the operation of the sliding window, with reference to the operation of both the sender and the receiver's window. Your answer should include a description of how the sender processes data which applications pass down for transmission, and how the receiver processes arriving packets prior to passing data to an application.

[10 marks]

- (b) The operation of TCP relies heavily on the timely and efficient sending of acknowledgements to indicate the successful arrival of data.

Explain the operation of TCP's acknowledgement mechanism. What data is acknowledged, and when are those acknowledgements sent? When choosing an acknowledgement strategy, what are the implications for performance in terms both of efficiency and latency? Your answer should compare and contrast two alternative strategies. **[10 marks]**

Question 3

Assume a complete, undirected network with N nodes. The network must be capable of tolerating stop failures.

- (a) Define the distributed consensus problem. **[5 marks]**
- (b) Develop an algorithm that solves the distributed consensus problem in a synchronous network. State any assumptions. **[5 marks]**
- (c) Analyse the communication complexity of your algorithm. **[5 marks]**
- (d) A number of links are removed from the network, hence it is no longer complete. Propose how your algorithm could be adapted to work when the network is not complete. If no adaptation is necessary, explain why this is the case. **[5 marks]**

Question 4

- (a) Define the leader election problem. **[5 marks]**
- (b) Develop an algorithm that solves leader election in a synchronous unidirectional ring network. State any assumptions. **[5 marks]**
- (c) Analyse the time complexity of your algorithm. **[5 marks]**
- (d) The network is modified so that it permits bidirectional communication. Explain the implications of the network permitting bidirectional communication for the algorithm you have developed. You should state whether your algorithm solves the leader election problem in the modified network. **[5 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.