National Examinations

May 2019

16-Elec-B4
Information Technology Networks

3 Hours Duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made.
2. This is a closed book exam. One of two calculators is permitted – any Casio or Sharp approved model.
3. There are **5 questions** on this exam. **Any 4 questions constitute a complete paper.** Only the first 4 questions as they appear in your answer book will be marked, unless you **clearly** indicate which questions you want marked **on the front of your exam booklet**.
4. Marks allocated to each question are noted in the left margin. A complete paper is worth 100 marks.

(25 marks) **Question 1.** This question concerns cellular telephony.

(10 marks)   a. In the LTE downlink, an OFDM symbol is described mathematically by

$$s(t) = \sum_{i=1}^{K} X(i)e^{j2\pi \frac{i}{T_s}t}$$

Identify and explain K, $X(i)$, and T_s.

(5 marks)   b. For the symbol in part a, briefly explain how the fast Fourier transform (FFT) can be used to modulate and demodulate the symbol.

(5 marks)   c. In LTE, the physical resource block (PRB) contains 7 OFDM symbols, described in part a, with each symbol using 12 subcarriers. Suppose each symbol is selected from a 16-QAM constellation, and suppose four symbols from the entire PRB are used as reference symbols to estimate the channel, and cannot be used for data. If the PRB lasts 0.5 ms, what is the peak data rate of a PRB (in bits/s)?

(5 marks)   d. A city of size 42 km² is to be covered by a digital cellular phone network. The spectrum re-use cluster size is 3 cells, and each cell has area 0.2 km². Assume that the cells perfectly fit the city size without overlap. If the system bandwidth is 35 MHz, and FDM is used where each user is allocated 25 kHz including guard band, how many users can simultaneously use the system? How many can simultaneously use the system per cell?

(25 marks) **Question 2.** This question concerns medium access control protocols.

(5 marks)   a. Briefly discuss the operation of CSMA/CD, making specific reference to collisions, and recovery from collisions.

(5 marks)   b. How does an ALOHA network operate differently from CSMA/CD? Are collisions possible in ALOHA?

(5 marks)   c. In a wireless network, briefly explain the hidden terminal problem. Explain how RTS-CTS-ACK control messages solve this problem.

(5 marks)   d. Briefly explain the exposed terminal problem, and explain how RTS-CTS-ACK control messages solve this problem.

(5 marks)   e. Using any medium access control scheme, what is the shortest period of time that could pass before a collision is detected? Explain.

(25 marks) **Question 3.** This question concerns transport layer protocols.

(5 marks)   a.   Why does network congestion lead to dropped packets in wired networks?

(5 marks)   b.   Using TCP, suppose the initial window size is 1, and the congestion threshold is 16. Assuming all packets are acknowledged, give an example showing how the window size evolves up to and beyond the threshold.

(5 marks)   c.   Repeat part b, assuming a packet in the second window is not acknowledged, and TCP enters slow start. In your example, illustrate all relevant features of TCP.

(5 marks)   d.   In a wired network, packet loss is usually caused by congestion, but in a wireless network, packet loss is often caused by momentary fading. Explain why "slow start" leads to poor performance in wireless networks.

(5 marks)   e.   Give an example of a service that would be best suited for UDP rather than TCP, and briefly explain why.

(25 marks) **Question 4.** This question concerns shortest-path routing.

Apply the **Bellman-Ford** algorithm to find the paths from **node H** to all other nodes in the following network, with the given edge distances. Show all work; credit will not be awarded unless the Bellman-Ford algorithm is correctly followed.
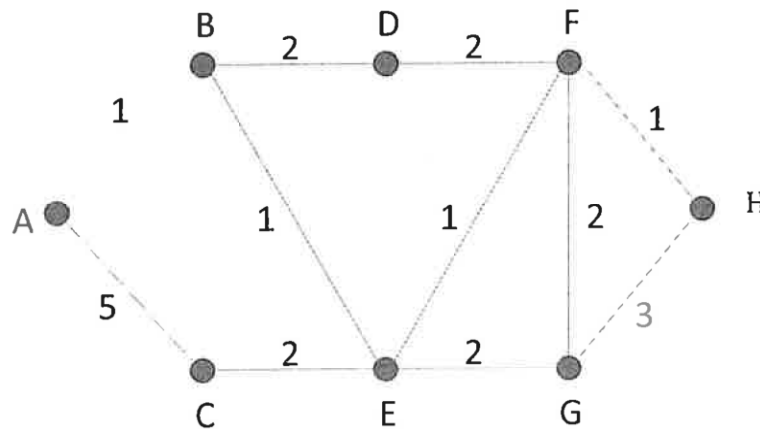
(25 marks)

Question 5. This question concerns layered architecture.

(10 marks)

a. Name each layer of the OSI seven-layer model, and describe it in one sentence. (Be brief; marks may be deducted for unnecessary detail!)

(10 marks)

b. Of the seven layers in the OSI model, name the layer (or layers, if more than one) where each of the following is used or found.

     i.   End-to-end error correction and in-order packet delivery.
     ii.   The SMTP protocol.
     iii. TCP/IP.
     iv. Ethernet.
     v.   Signal voltages.
     vi. Encryption and decryption.
     vii. Character display, such as ASCII.
     viii. The HTTP protocol.

(5 marks)

c. Why is layered architecture used in complex networks, such as the internet?