National Examinations – December 2018

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. An approved Casio or Sharp calculator is permitted.
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 packet switching and circuit switching.

(5 marks) a. Explain the difference between packet switched networks and circuit switched networks.

(5 marks) b. Why is packet switching better for bursty, irregular traffic? Briefly explain (1-2 sentences).

(5 marks) c. Of the following standards, protocols, or methods, state whether it is most useful for packet switching or circuit switching (if there is no difference, say so). Give a one-sentence explanation for each.

i. TCP/IP
ii. Ethernet
iii. Public switched telephony
iv. FDMA

(5 marks) d. Why is circuit switching better for traffic with quality-of-service guarantees? Briefly explain (1-2 sentences).

(5 marks) e. How would you implement circuit switching in a system that uses TDMA? Briefly explain (1-2 sentences).

(25 marks) **Question 2.** This question concerns cellular telephony.

(15 marks) a. In the LTE downlink, consider an OFDM symbol

$$s(t) = \sum_{i=1}^{K} X(i) e^{j\frac{2\pi i}{T_s}t}$$

where T_s is the symbol duration, K is the number of subcarriers, and $X(i)$ is the information sent to the ith user. In the absence of noise, the following detector is used for the rth symbol:

$$d_r = \frac{1}{T_s}\int_0^{T_s} s(t) e^{-j\frac{2\pi r}{T_s}t} dt.$$

Show that $d_r = X(r)$.

(5 marks) b. 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 4-QAM constellation. If the PRB lasts 0.5 ms, what is the peak data rate of a PRB (in bits/s)?

(5 marks) c. A city of size 36 km^2 is to be covered by a digital cellular phone network. The spectrum re-use cluster size is 3 cells, and each cell has area 0.5 km^2. Assume that the cells perfectly fit the city size without overlap. If the system bandwidth is 21 MHz, and FDM is used where each user is allocated 25 kHz including guardband, how many users can simultaneously use the system throughout the city? How many can simultaneously use the system per cell?

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

(5 marks) a. Suppose you have a video streaming application over a mobile wireless link. Would you use TCP or UDP? Briefly explain your choice.

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

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

(5 marks) e. 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.

(25 marks) **Question 4.** This question concerns medium access control protocols.

(5 marks) a. In the OSI seven-layer model, what tasks are allocated to the medium access (MAC) sublayer?

(5 marks) b. In wireless networks, explain the hidden terminal problem. Explain how RTS-CTS methods can mitigate this problem.

(5 marks) c. In wireless networks, explain the exposed terminal problem. Explain how RTS-CTS methods can mitigate this problem.

(5 marks) d. Briefly explain the operation of an Aloha network. In what applications is Aloha used and why?

(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 5**. This question concerns the WiFi and Bluetooth wireless protocols.

(5 marks) a. Frequency hopping spread spectrum is used to share the medium among devices in a Bluetooth piconet. Briefly explain how this works.

(5 marks) b. Suppose two Bluetooth piconets are operating at the same time. For simplicity, assume their frequency hops are synchronized. If Bluetooth uses 79 hop carriers, each with 1 MHz of bandwidth, what is the probability that there will be a collision in a given slot?

(5 marks) c. In a WiFi network, what services are provided by each of Basic Service Set (BSS) and Extended Service Set (ESS)?

(5 marks) d. Briefly describe medium access sharing in WiFi, making specific reference to inter-frame spacing.

(5 marks) e. WiFi and Bluetooth occupy the unlicensed ISM band. Give one advantage and one disadvantage of using the ISM band.