

Professional Engineers of Ontario

Annual Examinations – December 2015

07-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. A PEO-approved non-programmable 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 the WiFi and Bluetooth wireless protocols.

- (6 marks) a. Briefly describe the structure of a Bluetooth piconet, including Master, Slave, and Parked devices. How many of each type of device are allowed?
- (7 marks) b. How is the available spectrum shared among the nodes in a Bluetooth piconet using frequency hopping spread spectrum? Give a detailed example.
- (6 marks) c. In a WiFi network, what services are provided by each of Basic Service Set (BSS) and Extended Service Set (ESS)?
- (6 marks) d. Briefly describe medium access sharing in WiFi, making specific reference to inter-frame spacing.

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

- (10 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 token ring?
- (5 marks) c. In a wireless network, briefly explain the hidden terminal problem, and the exposed terminal problem. Explain how RTS-CTS-ACK control messages solve these problems.
- (5 marks) d. 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 the transport layer.

- (5 marks) a. TCP and UDP are the two most prominent transport layer protocols in use. Briefly explain the major differences between these protocols.
- (5 marks) b. Give an example of an application that is better for TCP, and one that is better for UDP.
- (10 marks) c. Using TCP, suppose the initial window size is 1, and the congestion threshold is 32. Assuming all packets are acknowledged, give an example showing how the window size evolves up to and beyond the threshold.
- (5 marks) d. Considering the same setup as in part b, suppose a packet in the third window is not acknowledged. Give the congestion window sizes for the first eight TCP windows.

(25 marks) Question 4. This question concerns cellular telephony.

- (5 marks) a. Explain, giving an example, why dividing space into “cells” increases the number of users who can simultaneously use a given wireless bandwidth.
- (5 marks) b. In LTE, the physical resource block (PRB) contains 12 subcarriers; each subcarrier is used to transmit 7 symbols. Suppose each symbol is selected from a 64-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) c. A city of size 28 km^2 is to be covered by a digital cellular phone network. The spectrum re-use cluster size is 7 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 42 MHz, and FDM is used where each user is allocated 25 kHz including guardband, how many users can simultaneously make calls in the system? How many can simultaneously make calls per cell?
- (5 marks) d. Modern wireless systems use MIMO. Give a very brief summary of this technology, and why it performs well in fading channels.
- (5 marks) e. Most cellular systems use frequency division duplexing. Briefly explain this concept.

(25 marks) **Question 5.** This question concerns shortest-path routing.

Apply Dijkstra's algorithm to find the paths from node B to all other nodes in the following network, with the given edge distances. Show all work; credit will not be awarded unless Dijkstra's algorithm is correctly followed.

