Professional Engineers of Ontario

Annual Examinations – May 2012

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. One of two calculator is permitted; a 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.
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.

(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. The GSM system uses TDM to transmit data. Eight users share a TDM frame of duration 4.615 milliseconds (ms), where each user transmits a 148-bit data frame. There is a guard time of 0.030 ms. What is the peak bit rate of the user?

(5 marks) c. GSM uses frequency-division duplexing. Explain how this works and why it is used.

(5 marks) d. 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 1 km^2. Assume that the cells perfectly fit the city size without overlap. If the system bandwidth is 49 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) e. Modern wireless systems use MIMO. Give a very brief summary of this technology, and why it performs well in fading channels.

(25 marks) **Question 2.** This question concerns the data link layer and peer-to-peer protocols.

(5 marks) a. Briefly describe how cyclic redundancy checks (CRCs) detect whether a packet contains an error.

(5 marks) b. In an error-correcting code, suppose the minimum Hamming distance between any two valid codewords is d. How many errors can be corrected?

(5 marks) c. Briefly describe the operation of ARQ, specifically describing stop-and-wait ARQ as well as go-back-n ARQ.

(5 marks) d. If propagation delay is large with respect to the packet size, which is more efficient: stop-and-wait ARQ or go-back-n ARQ? Explain.

(5 marks) e. Bluetooth networks share the medium using "frequency hopping spread spectrum". Briefly explain.

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

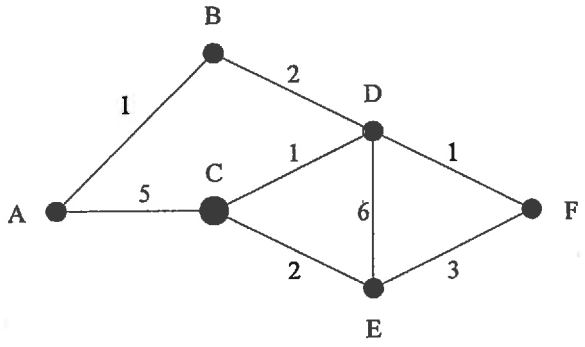
(10 marks) a. Briefly explain the operation of congestion control in the TCP protocol.

(5 marks) b. Suppose a TCP protocol is used with a congestion threshold of 32. Give the congestion window sizes for the first eight TCP windows, assuming that TCP starts with a window size of 1 and all packets are acknowledged.

(5 marks) c. Considering the same setup as in part b, suppose a packet in the fourth window is dropped (i.e. not acknowledged). Give the congestion window sizes for the first eight TCP windows, assuming that TCP enters slow start after the dropped packet, and the final value of the congestion threshold.

(5 marks) d. For a streaming application to a wireless device, which would be better: TCP or UDP? Briefly explain.

(25 marks) **Question 4.** Apply Dijkstra's algorithm to find the paths from node F to all other nodes in the following network, with the given edge distances. Show all work: no marks will be awarded unless you clearly apply Dijkstra's algorithm. (You may wish to explain your steps for clarity.)



(25 marks) **Question 5.** This question concerns layered architecture.

(5 marks) a. What is the advantage of using a layered architecture when designing networks?

(10 marks) b. Name each layer of the OSI seven-layer model, and describe it in one sentence.

(10 marks) c. 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. Link budgets.
ii. Ethernet.
iii. The HTTP protocol.
iv. Confirmation of end-to-end packet delivery across multiple hops.
v. Conversion of character codes, e.g. EBCDIC to ASCII.
vi. Line codes.
vii. Routing.
viii. The TCP/IP protocols.

Marking Scheme

1. 25 marks
    a. 5 marks
    b. 5 marks
    c. 5 marks
    d. 5 marks
    e. 5 marks
2. 25 marks
    a. 5 marks
    b. 5 marks
    c. 5 marks
    d. 5 marks
    e. 5 marks
3. 25 marks
    a. 10 marks
    b. 5 marks
    c. 5 marks
    d. 5 marks
4. 25 marks (no subdivisions)
5. 25 marks
    a. 5 marks
    b. 10 marks
    c. 10 marks