Professional Engineers of Ontario

Annual Examinations – December 2014

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 cellular telephony.

(5 marks) a. Explain, giving an example, the concept of spatial reuse of frequencies in cellular networks.

(5 marks) b. LTE networks are entirely packet switched. Briefly explain the impact of this on voice calls.

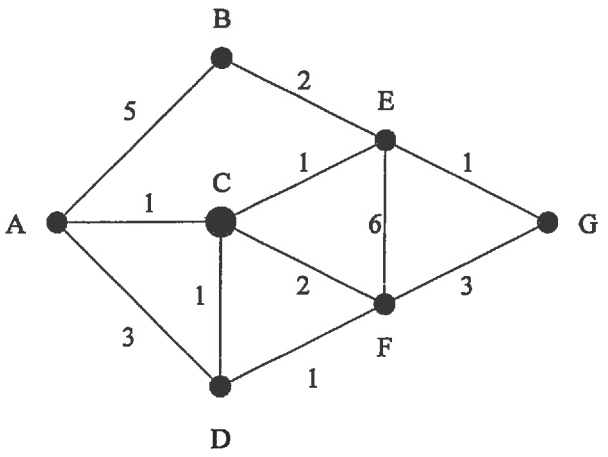
(5 marks) c. What is a MIMO wireless network? Briefly describe this method and its features.

(5 marks) d. Consider a cellular system with total available bandwidth of 49 MHz. If the system contains 70 cells, and if the cluster size is 7, how much bandwidth is allocated to each cell?

(5 marks) e. For the same system as in part (d), suppose FDMA is used, and suppose the system must accommodate at least 21,000 simultaneous users. What is the maximum bandwidth that can be given to each user?

(25 marks) Question 2. This question considers optimal routing in packet-switched networks.

Using Dijkstra's algorithm, find the shortest paths from node A to all other nodes in the network. Show all work. You may wish to explain your steps for clarity; no marks will be given unless Dijkstra's algorithm is clearly used.



(25 marks) **Question 3.** 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, making specific reference to CRC encoding with generator polynomials.

(5 marks) b. For a CRC system, let the generator polynomial be $g(x) = x^2+1$. If the information polynomial is $i(x) = x^5$, give the output of the CRC encoder.

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

(5 marks) a. 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.

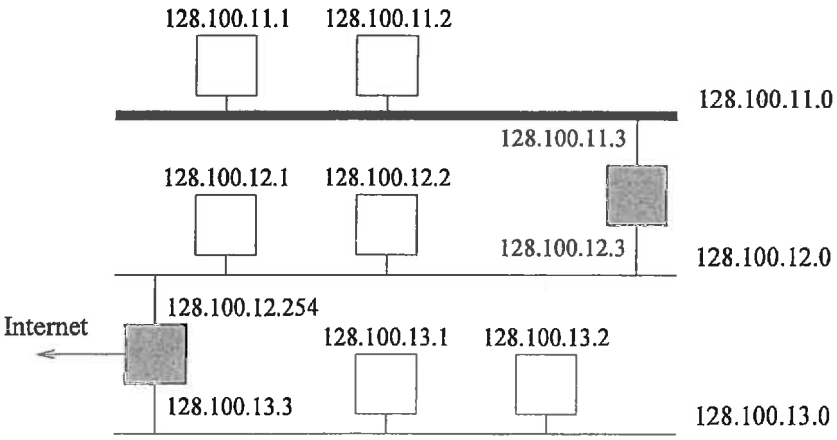
(25 marks) **Question 4.** This question concerns IP packet routing.

(5 marks) a. How many possible IP addresses are there in IPv4? (Ignore any reserved or special addresses and give the total possible number.) Briefly explain "address space exhaustion", and give one possible solution.

(10 marks) b. Consider the network of LANs in the diagram below. Dark squares are routers, and light squares are hosts. Give the IP routing tables at both routers, including netmasks and gateways.

(5 marks) c. Give, and explain, the path through the network for a packet originating at 128.100.11.2 with destination 128.100.13.1.

(5 marks) d. Give, and explain, the path through the network for a packet originating at 128.100.11.1 with destination 128.100.1.1.



(25 marks) **Question 5.** 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 64. 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 third 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.