

National Examinations December 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. 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 transport layer protocols.

- (5 marks) a. Suppose you are designing an application for downloading executable files over the internet. Would TCP or UDP be more appropriate? Briefly explain your choice.
- (5 marks) b. Using an example, illustrate why end-to-end congestion control is necessary in large wired networks, where links have different capacities.
- (5 marks) c. In a wired network, packet loss is usually caused by congestion, but in a wireless network, packet loss is often caused by momentary fading. Why is TCP suboptimal in a wireless network?
- (5 marks) d. Using TCP, suppose the initial window size is 1, and the congestion threshold is 64. Assuming all packets are acknowledged, give an example showing how the window size evolves up to and beyond the threshold.
- (5 marks) e. Repeat part b, assuming a packet in the fourth window is not acknowledged, and TCP enters slow start. In your example, illustrate all relevant features of TCP.

**(25 marks) Question 2.** 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. If the PRB lasts 0.5 ms, what is the peak data rate of a PRB (in bits/s)?
- (5 marks) d. LTE systems commonly use frequency division duplexing (FDD). Briefly explain how this works.

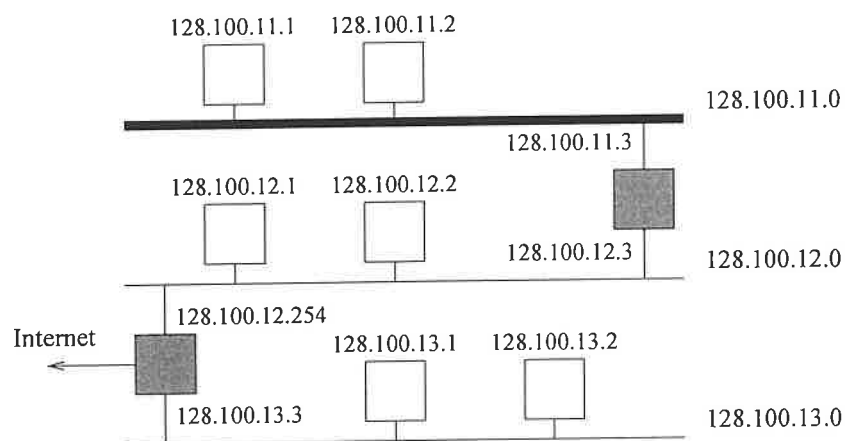
**(25 marks) Question 3.** This question concerns IP packet routing.

(5 marks) a. How many possible IP addresses are there in IPv6? (Ignore any reserved or special addresses and give the total possible number.)

(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 128.100.13.1 with destination 128.100.11.2.

(5 marks) d. Consider the IPv4 address range (with netmask) 10.0.0.0/24. What range of addresses does this cover?



**(25 marks) Question 4.** This question concerns the WiFi and Bluetooth wireless protocols.

(10 marks) a. Frequency hopping spread spectrum is used to share the medium among devices in a Bluetooth piconet. Using an example, explain how this works.

(5 marks) b. Bluetooth allows frequency hopping with 79 subcarriers. If two Bluetooth piconets are operating simultaneously, what is the probability that they will collide in any given frame?

(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.

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

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; credit will not be awarded unless Dijkstra's algorithm is correctly followed.

