



SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE

BACHELOR OF SCIENCE HONOURS: COMPUTER SCIENCE

EXAMINATION QUESTION PAPER

MODULE CODE : HCS415

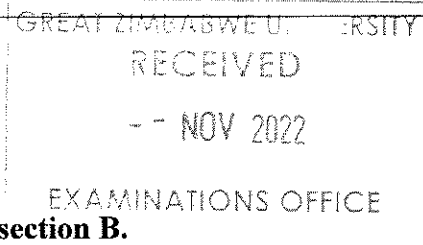
MODULE NARRATION : Advanced Data Communication and Networking

DATE : 2022

DURATION : 3 HOURS

INSTRUCTIONS TO CANDIDATES:

- 1. Each question carries 20 marks.**
- 2. Answer all questions in section A and any three (3) in section B.**



SECTION A

Question 1

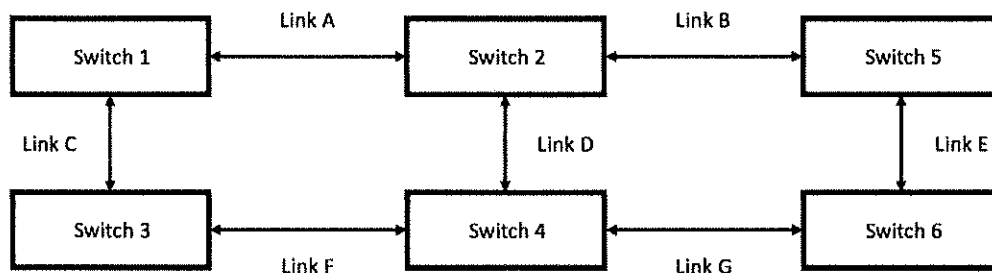


Diagram 1

Diagram 1 represents an Ethernet Layer-2 network that uses spanning-tree to compute forwarding tables. Assume all links have a link-weight of one.

[Note: Tie-breaking/leader – elections use the switch identifier from this diagram.]

- Compute the steady state routing/forwarding table for Switch 3. [4]
- Noting which switches recompute a solution, enumerate the changed forwarding tables switches of this network resulting from the complete failure and removal of link D. [9]
- Following the removal of Link D, a new link H is added between Switch 1 and 4; however this link fails frequently.

Denied access to monitor the network-traffic, outline a diagnostic strategy to identify the faulty Link H, making clear how the network-operator might use interrogation of network switch forwarding tables. [4]

- Now suppose the switches do not permit interrogation of switch forwarding tables and that the link status information is untrustworthy. Outline other techniques that might be used to identify the failed link. [3]

Question 2

The TCP transport protocol is an example of an ARQ.

- a) What is an ARQ? [1]
- b) Describe the design and operation of a simple ARQ for a lossy communication channel. [3]
- c) When and why does a simple ARQ at the transport layer have a significant negative impact upon application performance? [3]
- d) Describe what additions are required to a simple ARQ to support windowing. When and why will an ARQ which supports windowing provide better application performance than a simple ARQ? [5]
- e) Describe two situations when the performance of a windowed ARQ is no better than a simple ARQ. [4]
- f) Would the QUIC protocol, when based upon UDP rather than TCP, overcome the two situations you outlined when answering Part (e)? [4]

SECTION B

Question 3

- a) You are given that $RTT_{\text{no load}}$ is 50ms and the available bandwidth is 2,000 packets/sec. Sliding windows is used for transmission.
 - i) What window size is needed to remain at the knee of congestion? [2]
 - ii) If RTT_{actual} rises to 60ms (due to use of a larger winsize), how many packets are in queue at any one time? [3]
 - iii) What value of winsize would lead to $RTT_{\text{actual}} = 60\text{ms}$? [3]
 - iv) What value of winsize would make RTT_{actual} rise to 110ms? [2]
- b) Suppose the network is A—R1—R2—B, where the A—R1 link is infinitely fast and the R1—R2 link has a bandwidth of 1 packet/second each way, for an $RTT_{\text{no load}}$ of 2 seconds. Suppose also that A begins sending with $\text{winsize} = 6$, RTT rises to $\text{winsize}/\text{bandwidth} = 6\text{seconds}$.
 - i) Give the RTTs of the first eight packets. [5]
 - ii) How long does it take for RTT to rise to 6seconds? [5]

Question 4

- a) You are given that a router has three subqueues; i.e., $N = 3$. The outbound bandwidth is 1 size unit/ 1 time unit. At $T = 0$, packets P1, P2, P3, P4 and P5 arrive subqueue 1, each of size 1 unit. At $T = 2$ (by which point P1 and P2 will have finished transmission), packets Q1 and Q2 arrive on subqueue 2, also size 1. What finishing times will all the packets be assigned? In what order will they be transmitted? [6]
- b) Is this strategy approximately equivalent to fair queuing if we are given that all subqueues of the router are always active? [4]
- c) A WFQ router has two subqueues, each with a bandwidth of $\alpha = 50\%$. The router transmits 1 byte per ms. Initially, the subqueues are empty and $T = 0$ and the GPS virtual clock is 0. At that moment a packet P1 of size 1000bytes arrives at the first subqueue. At $T = 500$, a similarly sized packet P2 arrives at the second subqueue. Give, for each P1 and P2,
- Its finishing time under the GPS virtual clock. [3]
 - Its wallclock finishing time. [3]
 - The value of the GPS virtual clock at the moment of WFQ finishing. [4]

Question 5

- a) Describe two drawbacks of layering. Provide an example for each. [4]
- b) i) Explain the single-bit parity error-detection code using a single byte of data. How many bit errors can this code detect? [4]
- iii) Based on the single – bit parity error – detection code devise a new code to detect and correct a single 1-bit error in 4 bytes of data. How many parity bits do you require? You may assume that parity bits are error – free. [3]
- c) Consider a wireless network. For each of the following cases, state whether the packet transmission would be successful; assume no collision avoidance. Explain your answers.
- Nodes A and B are in range of each other; no other node is within range.
Node A sends a packet to B. [3]
 - Nodes A and B are in range of each other; nodes B and C are in range of each other, A and C are not in range of each other. Both A and C send a packet to B simultaneously. [2]

- iii) Nodes A and B are in range of each other; nodes B and C are in range of each other; A and C are not in range of each other. C is transmitted and A wants to send a packet to B. [2]
- iv) Nodes A and B are in range of each other; nodes B and C are in range of each other; A and C are not in range of each other. A is transmitting and B wants to send a packet to C. [2]

Question 6

Given a window size of 40, and Data[1001] is lost. Packet 1000 will be ACKed normally. Packets 1001 – 1040 will be sent, and 1002 -1040 will each trigger a duplicate ACK[1000].

- a) What actual data packets trigger the first three dupACKs? (The first ACK[1000] is triggered by Data[1000] ; don't count this one as a duplicate.) [5]
- b) After the third dupACK[1000] has been received and the lost data[1001] has been retransmitted, how many packets/ACKs should the sender estimate as in flight. When the transmitted Data[1001] arrives at the receiver, ACK[1040] will sent back. [5]
- c) What is the first Data[N] sent for which the response is ACK[N], for $N > 1000$? [5]
- d) What is the first N for which Data[N+20] is sent in response to ACK[N] (this represents the point when the connection is back to normal sliding windows, with a window size of 20)? [5]