**CS 421: COMPUTER NETWORKS** **SPRING 2022**

# FINAL
**May 28, 2022**
**135 minutes**

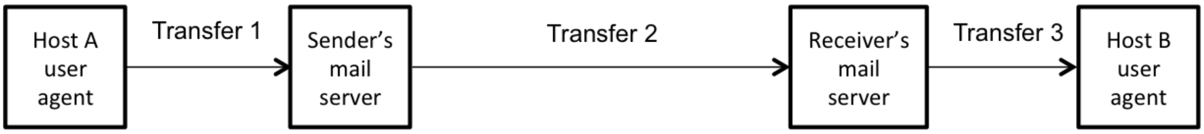
**Name:** ______________________________

**Student No:** ______________________________

| | |
|---|---|
| **Q1** | |
| **Q2** | |
| **Q3** | |
| **TOT** | |

1)

a) (6 pts) Consider the e-mail transfer given in the figure below. Mark in the table below (with **Yes or No**) whether SMTP, HTTP and IMAP protocols are currently used for each e-mail transfer marked below.




| | SMTP | HTTP | IMAP |
|---|---|---|---|
| Transfer 1 | | | |
| Transfer 2 | | | |
| Transfer 3 | | | |

b) A client and server are communicating over a connection where the client wants to download a 10 GB file. The distance between the client and server is 9,000 km and the speed of propagation is $2\text{x}10^5$ km/s. Packet size is 1000 Bytes including a 40 Byte TCP+IP header. Assume that all delays other than the propagation delay are negligible while calculating RTT.

i) (6 pts) What is the minimum window size, in Bytes, required in order to achieve a download rate of 10 Mbps at the **application layer**?

ii) (6 pts) What is the maximum throughput that can be achieved in the above file transfer if the transfer is done over FTP such that TCP window scaling is not used?

c) (6 pts) Assume a transmitter and receiver are using the Stop-and-Wait protocol. Is it possible for the receiver to consequently receive the sequence of packets with sequence numbers 1, 2, 3, 4, 8, 11, 12, 14? Why or why not? If your answer is that the sequence is possible, demonstrate a timeline of network events that leads to this sequence. If the sequence is not possible, explain why the protocol forbids it.

d) (6 pts) Answer c) if the transmitter and receiver are using the Go-Back-8 protocol instead of the Stop-and-Wait.

2)

a) (6 pts) Divide the subnetwork with CIDR prefix 139.179.192.0/19 into maximum number of subnetworks such that each subnetwork contains 1024 hosts. Express each subnetwork in CIDR format.

b) (8 pts) Suppose host A transmits a 3000 Byte IP packet (including the 20 Byte IP header) over a 2-hop path to host B. The MTU of the first link (A to router) is 1500 Bytes (IP header plus data), and the MTU of the second link (router to B) is 900 Bytes (IP header plus data). Assuming that IP header does not contain any options, indicate the length (in Bytes), more flag, and offset field values **(specify the offset values in units of 8 bytes)** of the fragment(s) transmitted over each link in the tables below.

**First link**

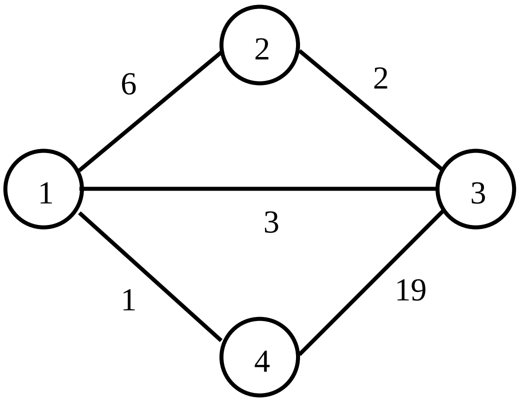
| Fragment | Length | Offset | Flag |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |

**Second link**

| Fragment | Length | Offset | Flag |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |

c) The network below uses the distance-vector routing algorithm. Assume the following:

- Links have the same cost in both directions.
- Nodes exchange their routing info once every second, in perfect synchrony and with negligible transmission delays. Specifically, at every t = i, i = 0, 1, 2, 3,..., each node sends and receives routing info instantaneously, and updates its routing table; the update is completed by time t=i+0.1.
- At time t = 0, the link costs are as shown below and the routing tables have been stabilized. At time t = 0.5, the cost of the link (1,4) becomes 32. There are no further link cost changes.
- Route advertisements are **only exchanged periodically**, i.e., there are no immediate route advertisements after a link cost change. Hence the first route advertisement after the link cost change at t = 0.5 sec occurs at t = 1.0 sec. *Note:* However, whenever a link cost change occurs, the two nodes at the endpoints of this link immediately make corresponding changes in their distance tables.




i) (10 pts) Give the evolution of the distance tables with respect to destination 4 assuming that **poisoned reverse is not used**. Specifically, give the distance table entries for destination 4 at nodes 1-3, for t = 0.1, 0.5, 1.1, 2.1, ..., **until** all distance vectors stabilize. Present your final answer in the table given below where $D^i(j)$ is the distance vector element denoting the distance from *i* to *j*.

| Time, t | $D^1(4)$ via | | | $D^2(4)$ via | | $D^3(4)$ via | | |
|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 1 | 3 | 1 | 2 | 4 |
| 0.1 | | | | | | | | |
| 0.5 | | | | | | | | |
| 1.1 | | | | | | | | |
| 2.1 | | | | | | | | |
| 3.1 | | | | | | | | |
| 4.1 | | | | | | | | |
| 5.1 | | | | | | | | |
| 6.1 | | | | | | | | |
| 7.1 | | | | | | | | |
| 8.1 | | | | | | | | |
| 9.1 | | | | | | | | |
| 10.1 | | | | | | | | |
| 11.1 | | | | | | | | |

ii) (10 pts) Redo part i.) assuming that the distance vector algorithm **uses poisoned reverse**.

| Time, t | $D^1(4)$ via | | | $D^2(4)$ via | | $D^3(4)$ via | | |
|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 1 | 3 | 1 | 2 | 4 |
| 0.1 | | | | | | | | |
| 0.5 | | | | | | | | |
| 1.1 | | | | | | | | |
| 2.1 | | | | | | | | |
| 3.1 | | | | | | | | |
| 4.1 | | | | | | | | |
| 5.1 | | | | | | | | |
| 6.1 | | | | | | | | |
| 7.1 | | | | | | | | |

iii) (4 pts) Assume that there is a packet at node 1 destined for node 4 at time t = 3.5. Using the forwarding tables valid at t = 3.5, find the paths followed by the packet for both parts i) and ii) above, i.e., with and without poisoned reverse.

3)

a) Suppose the data sequence 111001001 is transmitted using the generator sequence 110011011.

  i) (7 pts) Compute the CRC bits and the transmitted bit sequence.

  ii) (3 pts) If the 1st and 8th bits starting from the highest order (leftmost) bit in the received sequence are errored, determine whether this error can be detected by the receiver. Fully justify your answer.

b) (7 pts) The original Ethernet invented at Xerox PARC was very similar to the modern 10 Mbps Ethernet: it used the same Ethernet frame structure (with 8 Byte preamble for synchronization, 6 Byte (each) source and destination addresses, 2 Byte type field and 4 Byte CRC) and the same CSMA/CD MAC protocol as the modern 10/100 Mbps Ethernet. The length and signal propagation speeds of the original and modern Ethernet are also identical. The only difference was that the transmission rate of the original Ethernet was 3 Mbps. However, unlike the modern Ethernet, the original Ethernet did not have a minimum frame size. Was this a mistake? If not, what could be the reason that the original Ethernet did not have a minimum frame size? Justify your answer.

c) Assume that there are four nodes A, B, C and D on a 100 Mbps Ethernet. Suppose these four nodes are involved in a collision which is the second collision for A's frame, third collision for B's frame, second collision for C's frame and fifth collision for D's frame. After the collision is detected (we assume that all nodes detect the collision exactly at the same time), nodes calculate their backoff times according to the binary exponential backoff algorithm.

  i) (5 pts) What is the probability that the first transmission after the above collision will be a successful retransmission by A?

  ii) (5 pts) What is the probability that the first transmission after the above collision will be a successful retransmission by B?

  iii) (5 pts) What is the probability that the first transmission after the above collision will be another collision?