Name ________________________________ **Class: 448**

All answers must have supporting work. Any answer without support will receive no credit

1) (4 pts) Answer the following short answer questions.

a) Explain the stop and wait ARQ (automatic repeat request) protocol.

b) What happens in the ARQ protocol when an ACK is lost?

c) How many bytes make up an IPv4 header address? ____________________________

d) How many bytes make up a MAC address? ____________________________________

2) (4 pts total) Answer the following short answer questions.

a))**(1 pt)** What are the four lowest layers of the OSI Network architecture? Which layers are necessary for intermediate nodes (nodes that forward packets) in a network?

b)**(1 pt)** What is the goal of the spanning tree algorithm? (i.e. what is the purpose for running the spanning tree algorithm?)

c)**(2 pts)** What is the 8 bit ip-checksum (perform the ip checksum 8 bits at a time instead of 16) for the following 4 bytes of hexadecimal data? **<u>Data:</u> 5A 9F 73 83**

3) (4 pts) A message **M = 101101** is to be transmitted from node A to node B using CRC coding. The CRC generator polynomial is $G(x) = x^4 + x^2 + 1$ (bit sequence **10101**)

a) What is the transmitted code word? Perform the polynomial long division to find this result

b) Assume node B receives the following code word: **1011001101**. By using CRC, does node B detect any bit errors introduced by the link? **Use the generator polynomial from part a.**

4) (10 pts) A **hypothetical network** has an end to end length of 1500 meters with a propagation speed of 2.5×10^8 m/s. The bandwidth of the link is 5 Mbps (5,000,000 bps). The maximum frame size for transmission on this network is 500 bits.

a) What is the transmission time for a maximum sized frame on the network?

b) What is the **one way** (from one end to the other) propagation delay for the network?

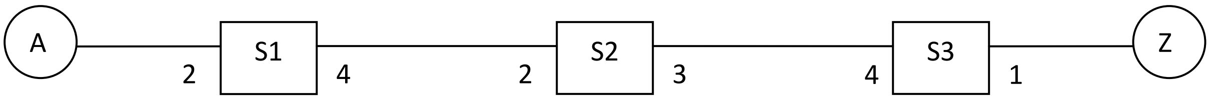
c) How long does it take to transmit a maximum sized frame from one end of the network to the other?(This time is the time from when the first bit is transmitted to the last bit received)

d) Assume CSMA/CD (carrier sense multiple access with collision detection) is used on this network. What is the minimum number of bits in a frame that can be used such that a transmitting node is guaranteed of detecting a collision?

e) For this network, is the maximum frame size sufficient for CSMA/CD? Explain

5) (6 pts) Consider the following virtual circuit network and the table showing the next Virtual Circuit Identifier (VCI) to use for each interface. The outgoing and incoming VCI's can be the same for a given interface/port (i.e. interface 3 on a switch can have a VCI of 5 for incoming packets and a VCI of 5 for outgoing packets). An interface is the same as port, and only the interfaces of interest for each switch are shown (i.e. interfaces 2 and 3 on switch 2).

Note: the network does not show all of the interfaces available on all switches, and it does not show all of the other nodes in the network. Lastly, each interface has its own set of virtual circuit identifiers (i.e each interface on a switch has its own VCI's 0, 1, 2, etc.)



The next VCI to use for interfaces on the switches

Switch	Incoming Interface	Next VCI to Use
S1	2	4
S1	4	2
S2	2	3
S2	3	5
S3	4	6
S3	1	1

Host A starts a connection to Host Z by sending a **setup message**. A short while later (after connection from A to Z has been established), Host Z starts a connection with Host A by sending a setup message. Use the table above to complete the switch tables below **to show the new entries created** during these virtual circuit setups. Assume that all previous connections remain active during the setups. **Use a next VCI of 7 for Host A and a next VCI of 8 for Host Z**

Virtual Circuit Table for Switch 1 (S1)

Setup message creating entry	Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
A to Z				
Z to A				

Virtual Circuit Table for Switch 2 (S2)

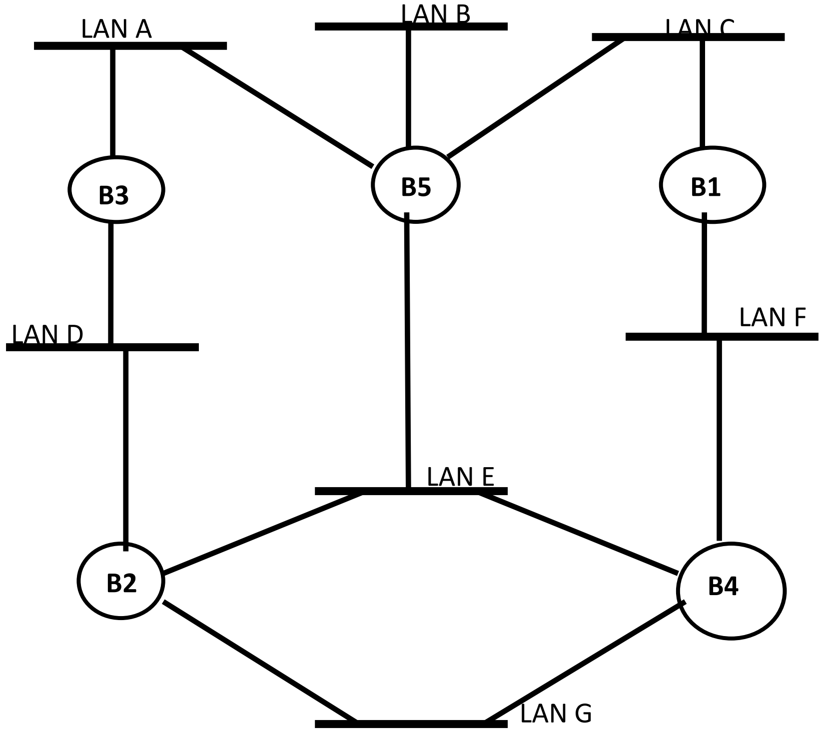
Setup message creating entry	Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
A to Z				
Z to A				

Virtual Circuit Table for Switch 3 (S3)

Setup message creating entry	Incoming Interface	Incoming VCI	Outgoing Interface	Outgoing VCI
A to Z				
Z to A				

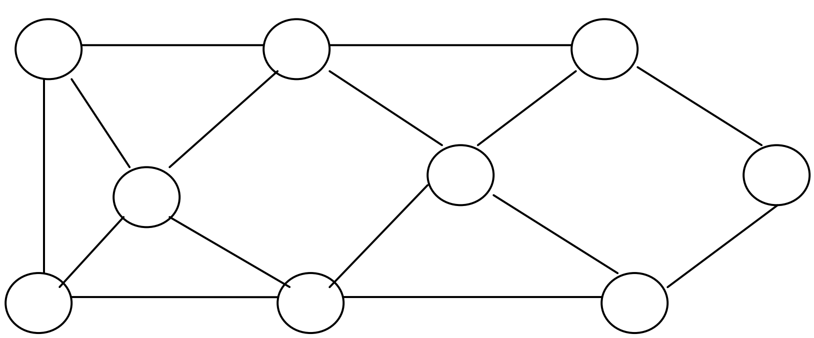
6) Spanning Trees

a) (3 pts) The spanning tree algorithm is performed on the following network. In the space provided, indicate the designated bridge for each LAN shown.

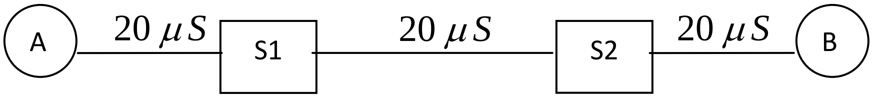


LAN	Designated Bridge
A	
B	
C	
D	
E	
F	
G	

b) (3 pts) Consider the following graph (loops are present). Create a possible spanning tree for this graph by placing X's on the links that will not be used to forward frames. Note: there are several possible answers for this problem. You just need to provide one.



7) (16 pts) Consider the hypothetical **10 Mbps (10,000,000 bps) network** shown. Sizes given are frame sizes in number of bits (frames consist of header and data)



The propagation delay between any two hosts (A, B or a switch) is $20\,\mu s$. A frame to transmit from node A to node B consists of **2,000 bits**. Each switch(S1 and S2) is a store and forward switch that starts retransmission of a packet $10\,\mu s$ **after receiving the _<u>FIRST</u>_ bit** of a frame **(provided that it is not already transmitting a previous frame).**

a) What is the time necessary to transmit the single frame from A to B (time from the first bit of the frame transmitted by node A until last bit of the frame is received at node B)?

b) What is the effective data throughput rate for this one frame from A to B (number of bits sent divided by time to send the bits) in bits per second(bps) for the network analyzed in part a? (answer is less than 10 Mbps)

Continued on Next Page

7 cont) c) If the frame in part a is split into 2 frames so that each frame to be transmitted consists of **1000 bits**, what is the time necessary to transmit the 2 frames from node A to node B? Node A will transmit the frames one right after the other.

d) Using all three frames from A to B, what is the effective data throughput rate in bits per second(bps) for the network analyzed in part c?

e) For this network is there an increase in the effective data throughput when the frame is split into 2 parts? Explain your answer.

Extra Credit) (4 pts) a particular ARQ protocol is being implemented with a sending and receiving window size of 3 frames **(SWS = RWS = 3)**. Frames are sequenced using numbers 1, 2, 3, etc. Acknowledgments are sent for each frame that is received in order. If a higher sequence numbered frame is received out of order, a NAK is sent back with the sequence number of the next expected frame. Also, once the missing frame is received an ACK is sent for all consecutive frames that have not been acknowledged so far. For example, frames 1, 2 and 3 are sent, and frame 1 is received (ACK1 sent back), frame 2 is delayed and frame 3 is received. Upon receiving Frame 3, the receiver sends a NAK2. When frame 2 arrives later ACK3 is transmitted (acknowledges frames 2 and 3 being received).

Complete the timeline for this protocol given the following information:

- Sender has 5 frames only to send with sequence numbers 1 through 5.
- **During transmissions, Frame2 is lost 🡸**

- Bandwidth is infinite, so transmit time of frames is instantaneous (Frames are transmitted and received instantly – though they still have a propagation time)
- The sender (when allowed by SWS) will transmit one frame every ¼ of a RTT – transmission time is instantaneous, but the sender can perform one transmission only every ¼ of a RTT

- A frame experiencing no delay is received ½ of a RTT after transmission starts (propagation delay only) (Frame 1 and ACK 1 are shown) and processing time is instantaneous.
- At a specific time, frames, NAKs or ACKs are received and processed(instantly) before a transmission decision occurs
    - o receiver receives a frame and then sends an ACK or a NAK if required
    - o sender receives an ACK or NAK and then determines if a timeout has occurred; it then determines the next frame to transmit (provided the SWS has not been exhausted)

- If the receiver receives a frame that it has already acknowledged, the receiver repeats its most recent acknowledgment. For example, the last ACK sent by the receiver is ACK6. If frame 5 is received again, ACK6 is repeated.
- If the receiver receives a higher sequence frame out of order, the receiver transmits a NAK with the sequence number of the next frame expected. For example, frame 4 was the last frame ACKed (ACK4) and frame 7 is received. The receiver sends a NAK5 indicating that it is waiting for frame 5, but has received a different frame
- **The sender will retransmit a frame before timeout occurs if 2 NAKs for that frame are received**

- **The timeout period is 2.5 Round Trip Times (2.5 RTT)**
- **Timing diagram is on the next page.**
- **Show all transmissions (frames, ACKs and NAKs) that will occur when transmitting these five frames under the conditions stated above**

Name ____

Extra Credit continued)