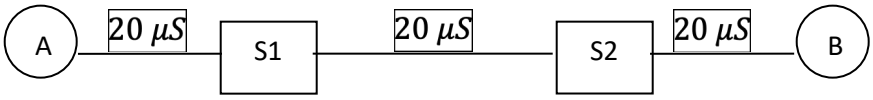
Name _____ Class: CPE348-01

1) (8 pts) A message **M = 1001011101** is to be transmitted from node A to node B using CRC coding. The CRC generator polynomial is $G(x) = x^4 + x^2 + 1$.

a) (4pts) What is the transmitted code word? Perform the polynomial long division to find this result

b) (4pts) Assume node B receives the following code word: **11100100101**. By using the CRC, does node B detect any bit errors introduced by the link? Check using the generator polynomial above.

2) (14 pts) Consider the hypothetical **20Mbps (20,000,000 bps) network** shown



The propagation delay between any two hosts (A, B or a switch) is 20us. The frame to transmit from node A to node B consists of **4,000 bits**. Each switch can start retransmission of a frame 10us **after receiving the last bit** of a frame.

a) (4pts) What is the time necessary to transmit the data as a 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)?

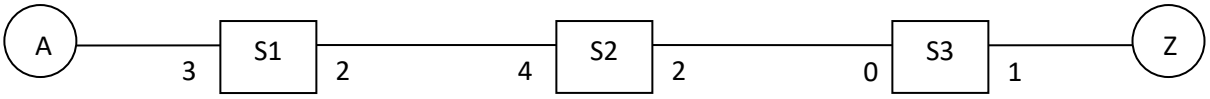
b) (3pts) What is the effective data throughput rate for this one frame from A to B (number of bits sent divided by time to send the bits) in bits per second(bps) for the network as analyzed in part a?

c) (4pts) If the original frame is split into 2 frames so that each frame to be transmitted consists of **2000 bits**, what is the time necessary to transmit both frames from A to B? Node A will transmit the second frame 5us after finishing the transmission of the first frame.

d) (3pts) For the two frames sent from A to B in part c, what is the effective data throughput rate in bits per second(bps) for the network as analyzed in part c?

3) (12 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.

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	1
S1	3	2
S2	2	8
S2	4	5
S3	0	2
S3	1	3

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 4 for Host A and a next VCI of 7 for Host Z**

Virtual Circuit Table for Switch 1 (S1)

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

Virtual Circuit Table for Switch 2 (S2)

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

Virtual Circuit Table for Switch 3 (S3)

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

4) (16 pts) Answer the following short answer questions.

a) (4pts) Explain the hidden node problem in a wireless network? How to overcome it?

b) (3pts) Suppose a sliding window algorithm is implemented using a SWS=4 and a RWS = 3, will 6 sequence numbers (i.e. 0,1,2,3,4,5) be sufficient to correctly distinguish all packets that are received? Explain your answer. (for example, an old sequence number of 0 is not mistaken for a new sequence number of 0)

c) (3pts) What is the difference between flow control and congestion control?

d) (3pts) What are the 5-tupe elements in any cryptography system?

e) (3pts) What is the protocol that handles inter-domain (that is between autonomous systems) routing?

5) (12 pts) Answer the following questions on Transport-Layer basics.

a) **(**6pts) Draw the three-way handshake used to establish a TCP connection. Show all SYN and ACK packets. Also show all sequence and acknowledgement numbers (as a variable) associated with the SYN and ACK packets.

b) (6pts) **You are designing a** reliable byte stream transport layer protocol (not TCP) to operate over a $100x10^6$ bps network and it is using a sliding window for flow control. The maximum segment lifetime for the network is 15 seconds. For this protocol, each sequence number represents 64 bytes of data.

What is the minimum number of bits necessary for the Sequence Number field of your protocol header? Provide this minimum number as a whole number (round up your answer to the next whole number. i.e. if you calculate 25.67 bits necessary, then the answer is 26)

6) (8 pts) A router has the following (CIDR) entries in its routing table

Address/mask	Next Hop
160.80.64.0/18	Interface 0
160.80.128.0/18	Interface 1
160.80.192.0/18	Interface 2
160.80.32.0/19	Router 1
160.80.160.0/19	Router 2
Default	Router 3

What is the next hop that the router selects when it receives IP packets with the addresses shown below? **Show all of your work or explain how you determined the next hop.**

a) **160.80.172.25** **Next Hop _____**

d) **160.80.68.178** **Next Hop _____**

7) (15 pts) Link State: The Link State Routing Algorithm (or Dijkstra's algorithm) is to be **performed for node C**. The link state packets sent by the nodes in the network are shown below. Cost is measured in **throughput!** When finished, provide the routing table for node C. Link state packets are in the form of **(destination, cost, next hop). Use the link state packet form for completing the information below. For a cost tie in the tentative column, chose the lower letter node first. (Hint: shortest path is the one that gives largest throughput.)**

Node A	Node B	Node C	Node D	Node E	Node F
B,5,B	A,5,A	B,2,B	C,2,C	D,4,D	B,3,B
	C,2,C	D,2,D	E,4,E	F,2,F	C,1,C
	F,3,F	F,1,F			E,2,E

Confirmed **Tentative**

(C, 0, -)

_____

(C, 0, -),

_____

(C, 0, -),

_____

(C, 0, -),

_____

(C, 0, -),

_____

(C, 0, -),

_____

Node C Routing Table		
Destination	Cost	NextHop
A		
B		
D		
E		
F		

8) (15 pts) Suppose that the TCP connection between A and B goes through router R (A to R then R to B). **Bandwidth on all links is infinite** which means packets travel as a single point (it takes 0 seconds to place/receive a packet on/from the link). Packet is labeled by unique sequence numbers 0, 1, 2, 3, …, infinity.

- Packets are instantly transmitted from A to the router or from the router to A.
- It takes 1 second for a packet (data and ACK) to cross the link R to B or B to R. There is no propagation delay for the link A to R or R to A.
- The router transmits one packet to B every second and upon receipt of a packet, B immediately starts transmission of an ACK back to the router.
- At any time instant, host A processes information in the following order: first process any ACKs, then process any timeouts and then send more packets if possible**. The whole processing takes 1 second.**
- ACK does **not** occupy the buffer space of the router.
- The router has enough **buffer space to hold two data packets including the one it is transmitting (so, total of only 2 data packets at the router).** When congestion occurs, the packets of higher sequence numbers will be dropped first.
- Host A is using an algorithm that **increments its congestion window by 1 packet for each ACK received**. Host A sets its sending window size equal to the congestion window size.
- The initial congestion window is 1 packet.
- **The timeout time is 4 seconds**. When a timeout occurs, the congestion window is reset to 1.

If the first packet (P0) sent by Host A occurs at time t=1 second,

a) (5pts) at what time does a timeout of a packet first occur? What is that packet?

b) (5pts) at what time does the congestion first occur?

c) (5pts) What is the congestion window value (value before being reduced to 1) when this timeout occurs? (according to rules above, if an ACK has been received at the same time the timeout occurs, the window is firstly incremented then dropped to 1.)

*** Draw transmission diagram for partial credits** (Hint: You should get all the answers by t=13.)

Extra Space for 8)