CNT 4504 Computer Networks February 6, 2025

Problem Set 2

10 points for each graded problem: Total of 70 points

Turn in before class on February 18, 2025

1. This problem explores framing.
   (a) Suppose a starting and ending flag has the following form: 011110. What is the bit stuffing mechanism you would use to transparently transfer arbitrary data?
   (b) Show what your output string would look like (including flags) if the data to be sent was the following: 01011101111000000011111111111110000010.
   (c) Explain the receiver operation so that the data is correctly received, for your transformed data + flags of part b.
   (d) Consider the PPP byte stuffing method used: the 8 bit HDLC flag 0x7E is used as a flag in PPP. Any occurrence of flag or “control escape” (0x7D) in the data is replaced by “control escape” followed by the original octet XORed with 0x20. Consider the following data sequence received. What was the data sent?
   0x7D 0x5E 0xFE 0x24 0x7D 0x5D 0x7D 0x5D 0x62 0x7D 0x5E.
   Show your work. Explain briefly why there is no ambiguity in this method.

2. Consider a Stop-and-Wait protocol. Assume constant delays for all transmissions and the same delay for packets sent and ACKs sent. Assume no errors occur during transmission.
   (a) Suppose that the timeout value is set to 1/2 of what is required to receive an acknowledgement, from the time a packet is sent. Give the complete sequence of frame exchanges when the sender has 3 frames to send to the receiver.
   (b) Suppose that the timeout value is sent to 2 times the round trip time. Give the sequence of frame exchanges when 3 frames are sent but the first frame is lost.

3. Consider a Go-Back-N protocol with a sender window size of 5 and a sequence number range of 1,024, and assume the receiver sends ACKs with the number of the next sequence number expected. Suppose that at time *t*, the next in-order packet that the receiver is expecting is a packet with the sequence number 8. Assume that the channel does not reorder packets.
   (a) What are the possible sets of sequence numbers inside the sender’s window at time *t*? Justify your answer.
   (b) What are all possible values of the ACK field in all possible messages currently propagating back to the sender at time *t*? Justify your answer.

4. Consider a sequence space that uses 4 bits.
   (a) What is the maximum send window size for a Go Back N protocol? What is a send window size that might not work correctly? Give an example of incorrect operation.
   (b)What is the maximum send window size for a Selective Repeat protocol with receive window size 5? With this receive window size, choose a send window size that might not work correctly, and give an example of incorrect operation.

5. *This problem will not be graded. It will be useful for you to try to solve it. However, it will be covered in the solution set.*
Explain the following with short answers.
(a) In HDLC how does a station know whether a received frame with the fifth bit set to 1 is a P for an F bit?
(b) HDLC specifies that the N(R) in a SREJ frame requests the retransmission of frame N(R) and also acknowledges all frames up to N(R) - 1. Explain why only one SREJ frame can be outstanding at a given time.
(c) Briefly describe 3 aspects of PPP that are similar to HDLC and 3 aspects in which they differ.

6. Consider two stations in an Ethernet, called A and B; each has a very large file to send to some other stations. Assume their upper layer protocols started the file transfer at the same time, but found the channel was busy. Also assume that there is no other station in the Ethernet wanting to send.
(a) What will happen when the channel becomes free? Please explain your answer in one sentence.
(b) If collision happens, both stations use binary exponential back off. What is the probability that A gets to send successfully at slot 0 after the collision? What is the probability that B gets to send successfully at slot 0 after the collision? What is the probability that A and B collide at slot 0 after the first collision? What is the probability that A and B collide at slot 1 after the first collision?
(c) Suppose A and B collided for *i-1* times after the first collision. What the probability they still collide at round *i*?
(d) What is the probability that the contention ends at round *k* (one station gets to send successfully in that round)?

7. *This problem will not be graded. It will be useful for you to try to solve it. However, it will be covered in the solution set.*
Read about Huffman codes. Below in Table A are the probabilities of letters in the English language. Give a Huffman code for the letters in the second column (J – R) only. What would your codewords be for the strings “nopor” and “kloq” respectively?

Letter	**Probability**	**Letter**	**Probability**	**Letter**	**Probability**
A	0.08149	J	0.00132	S	0.06099
B	0.01439	K	0.00420	T	0.10465
C	0.02757	L	0.03388	U	0.02458
D	0.03787	M	0.02535	V	0.00919
E	0.13101	N	0.07096	W	0.01538
F	0.02923	O	0.07993	X	0.00166
G	0.01993	P	0.01981	Y	0.01982
H	0.05257	Q	0.00121	Z	0.00077
I	0.06344	R	0.06880		

TABLE A

8. In a multiple access system, *8* stations compete for the time slots of a common channel. The duration of a given slot is *2 seconds*. In any given time slot, every station attempts to transmit with probability $p = 1/4$, independent of the others. What is the expected time until some station transmits successfully? Suppose you can choose another probability p for each station to use. What is the optimal p to use and what is then the expected time until a successful transmission for some station.

9. *This problem will not be graded. It will be useful for you to try to solve it. However, it will be covered in the solution set.*
We transmit a large message of 6×10^8 bits over three hops. Suppose the transmission line in each hop has a bit error rate of 10^{-6} and retransmission is done hop by hop for the message until it is successfully transmitted. What is the average number of bits that are transmitted using message switching over the three hops for this message? Suppose the message is broken up into thirty packets of equal size. What is the average number of bits now transmitted over the three hops? (Hint: you can use the approximation $(1 - p)^{n} \approx e^{-pn}$ for p small and n large to make calculations easier.)

10. Six stations (S1 – S6) are connected to an extended LAN through transparent bridges B1 and B2 as shown below. Initially, the forwarding tables are empty. Suppose the following stations transmit frames: S1 transmits to S2, S3 and S6; S3 transmits to S5 and S1; S4 transmits to S3; and S5 transmits to S2. Show the forwarding tables for B1 and B2 with appropriate entries after the frames have been completely transmitted.