

**CS 555: Computer Networks and Data Communication  
Spring 2004  
Midterm Examination  
Points: 150  
March 3, 2004 (5:45-7:00 PM)  
Time allowed: 75 minutes  
CLOSED BOOK, CLOSED NOTES, OPEN MIND  
Answer All Questions  
Solution**

Turning in this exam under your name confirms your continued support for the honor code of Old Dominion University and further indicates that you have neither received nor given assistance in completing it.

Name: \_\_\_\_\_ SSN: \_\_\_\_\_

Question #	Possible points	Obtained points
1	30	
2	30	
3	30	
4	30	
5	30	
Total	150	

**FINAL ANSWER SHOULD BE WRITTEN IN THE  
ALLOTTED TABLES.**

**SHOW ALL YOUR WORK**

**Question 1:**

(1a) A 9600-baud modem employs the constellation diagram shown in Figure 1.

- (i) How many amplitude levels and phase levels are employed here? **Three amplitude and 6 phase levels.**
- (ii) What is the data rate (in kbps) of the modem? **Total of 16 points means 4 bits/signal. So data rate = 9600 \* 4 = 38,400 bps.**

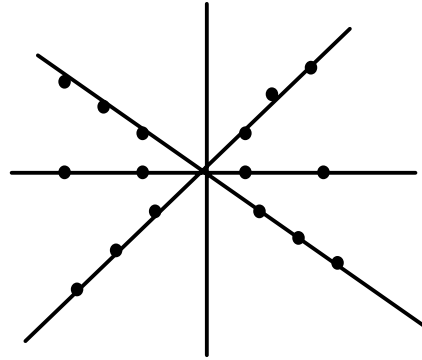


Figure 1. Modem constellation Diagram

(1b) An analog signal with the highest harmonic of 20 kHz is being transmitted via a digital channel using delta modulation. What is the maximum resulting data rate (in kbps)? **Sampling rate = 2\*20 kHz=40Ksamples/sec; With Delta modulation, there is 1 bit/sample. So data rate = 40 kbps.**

(1c) A message of 3000 bytes is being sent using packet switching from node A to node C via node B (see Figure 2). Determine the time between the first bit leaving node A and the last bit reaching node C. Ignore processing delay at each node. (Propagation speed = 250 km/millisecond)

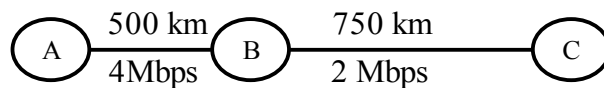
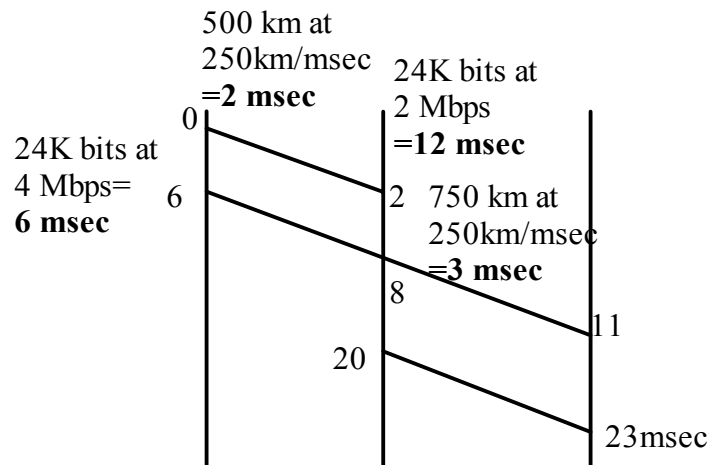


Figure 2.



Question	Points	Answer
1a	8	# Of amplitude levels = 3 # Of phase levels = 6 Data rate (kbps) = 38.4 kbps
1b	8	Maximum data rate (kbps) = 40 kbps
1c	14	Time (milliseconds) = 23

**WORK AREA:**

**Question 2:**

(2a) Determine the checksum generated for a 5-bit frame of 10101 using the generating polynomial  $G(x) = x^2 + 1$ ?

(2b) If stations A and B use a 30-kbps satellite channel (round-trip delay = 270 milliseconds) to communicate using 1000-byte frames with stop-and-wait protocol, what is the maximum data rate that may be obtained if 1 in 5 frames are in error?

**$P = 0.2$ ; trans. time =  $8000/30 = 800/3$  msec;  $a = 270/800/3 = 81/80$ ;**

**$U = 0.8/(1 + 162/80) = 0.2644$ ; Data rate =  $30 * 0.2644 = 7.932$  kbps**

(2c) What bit stream is sent out by a data link layer that uses bit stuffing to send the following string of data: **11111011101111100**?

Question	Points	Answer
2a	10	Checksum: 01
2b	10	Maximum data rate (kbps): 7.932 kbps
2c	10	Bits sent out: 1111100111011111000

**WORK AREA:**

**Question 3:**

(3a) If stations A and B use a 50-kbps satellite channel (round-trip delay = 270 milliseconds) to communicate using 1000-byte frames using Go-back-n protocol with 4-bit sequence numbers, what is the maximum data rate that may be obtained if 1 in 4 frames are in error?  **$P=0.25$ ;  $\text{Trans. Time}=8000/50 = 160 \text{ msec}$ ;  $a=270/160=1.6875$ ;  $2a+1=4.375$ ;  $N = 15$ ;  $U = 0.75/(1+2*1.6875*0.25)=0.4068$ ;  $\text{Data rate} = 0.4068*50 = 20.34 \text{ kbps}$**

(3b) Node A, of question (3a), just began transmitting and transmitted all frames in its window. What actions (if any) are taken by A's data link layer when it receives an **ACK 3** from B?

(3c) What is the obtained maximum data rate if stations A and B in question **3a** employ a selective-repeat protocol?

**$N=8$ ;  $2a+1=4.375$ ;  $U = 1-P=0.75$ ;  $\text{Data rate} = 0.75*50 = 37.5 \text{ kbps}$**

Question	Points	Answer
3a	10	Maximum data rate (kbps)= 20.34 kbps
3b	10	Actions: Adjust sender window to Send 4-15-2; Send frames 15,0,1,2; Note that frames 4-14 have already been sent and 4's timer did not timeout yet.
3c	10	Maximum data rate (kbps)=37.5 kbps

**WORK AREA:**

**Question 4:**

(4a) Provide an intuitive explanation for higher performance of 0.1-persistence CSMA when compared to 0.5 persistent CSMA at high loads.

(4b) In an eight-station (stations A-H) LAN using adaptive tree walk protocol, if stations B, E, and F contend for a slot starting at **slot 0**, determine the slot numbers in which each of the three stations will be successful. (A-H are connected in that order from left to right in the tree)

Slot 0: B, E, F compete

Slot 1: B

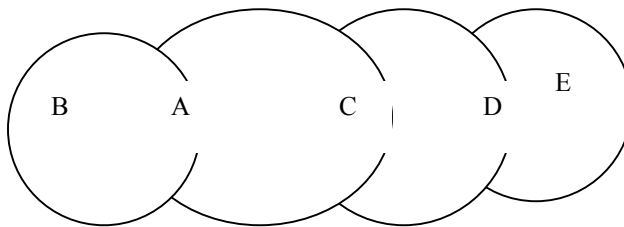
Slot 2: E, F

Slot 3: E, F

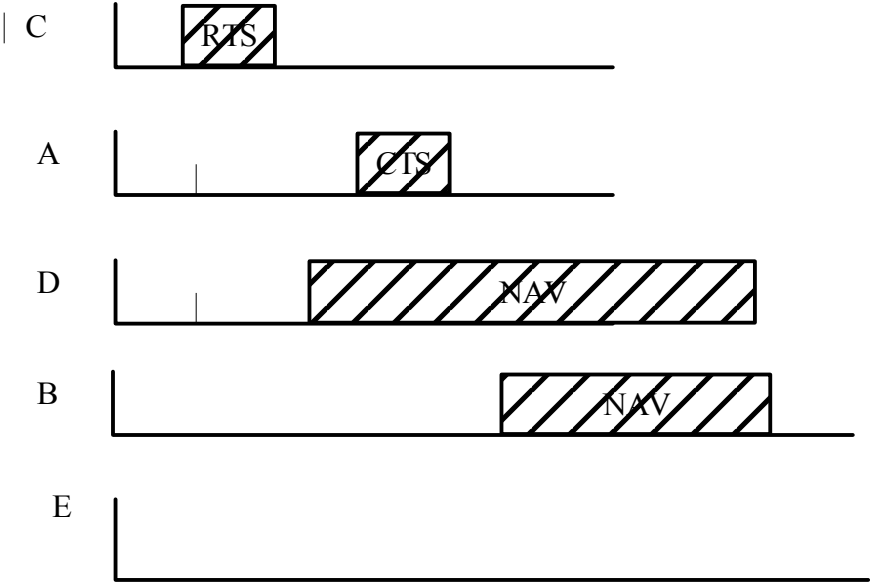
Slot 4: E

Slot 5: F

(4c) Wireless stations A-E in Figure 3 employ MACAW algorithm for multiple access. First C transmits RTS to A to which A responds back with CTS. When and what information (if any) is learnt about the medium by the other four stations? (Hint: Illustrate through a diagram with time as the X-axis)



**Figure 3. Wireless stations**

Question	Points	Answer
4a	10	0.1 persistent vs. 0.5-persistent: The chance of collision is less in 0.1 persistent since only once in 10 times a slot is free, frame is transmitted. So 0.1-persistent is less greedy. So overall system throughput is high.
4b	10	<b>Slot for B: 1</b> <b>Slot for E: 4</b> <b>Slot for F: 5</b>
4c	10	<b>When and what information (for B, D, E)</b>   <p>The diagram shows five horizontal timelines for stations C, A, D, B, and E. Station C sends an RTS frame. Station A sends a CTS frame. Station D sends a NAV frame. Station B sends a NAV frame. Station E has no activity shown.</p>

**Question 5:**

(5a) Ten stations are connected using a 1-Gbps 2-km 802.3 LAN (propagation speed of 200 km/millisecond). What is the minimum frame length (bytes) needed?

**End-to-end delay = 10 microsec; 2\*end-to-end delay = 20 microsec;**

**Minimum frame length = 10\*1K = 10 K bits = 2500 bytes**

(5b) Represent the data string **110011** using Manchester encoding and differential Manchester encoding.

(5c) Referring to the Bluetooth data frame (Figure 4), answer the following:

- (i) Why is the header repeated three times?
- (ii) Why is the address field only 3 bits in length?
- (iii) What do the bits F and A represent?

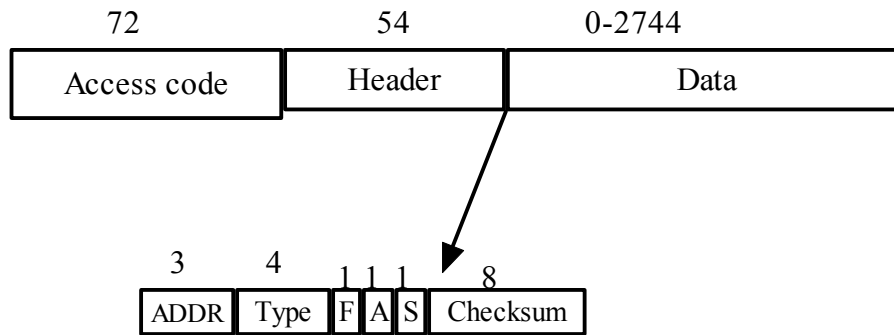
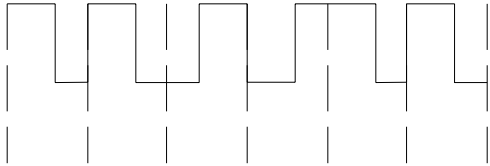
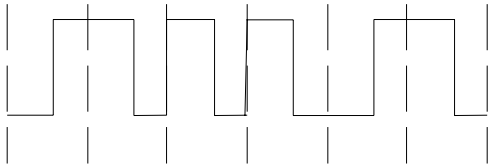


Figure 4. Typical Bluetooth Dataframe

Question	Points	Answer
5a	10	<b>Minimum frame length (in bytes) = 2500</b>
5b	10	<p><b>Manchester encoding:</b></p> <p>1 1 0 0 1 1</p>  <p><b>Differential Manchester:</b></p> 
5c	10	<p><b>(i) For reliability, since wireless medium is prone to errors.</b></p> <p><b>(ii) To support 1 master and 7 active slaves.</b></p> <p><b>(iii) A – Acknowledgement bit; F – Flow bit.</b></p>

**WORK AREA:**

## Appendix for Midterm Examination

- Signal-to-noise ratio (dB) =  $10 \log_{10} (S/N)$
- Attenuation in decibels =  $10 \log_{10} (\text{Transmitted power/received power})$
- Maximum data rate =  $2 H \log_2 V$  bits/sec
- Maximum number of bits/sec =  $H \log_2 (1+S/N)$
- $\text{Pr}[k] = G^k e^{-G}/k!$
- $S=Ge^{-2G}$
- $S=Ge^{-G}$
- $E = e^G$
- $P_k = e^{-G}(1-e^{-G})^{k-1}$
- Channel efficiency =  $P/(P+2\Gamma/A)$
- Channel efficiency= $1/(1+2BLe/cF)$

$$\text{Stop-and-wait: } U = \frac{(1-P)}{(1+2a)}$$

$$\text{Selective reject: } U = \begin{cases} 1-P & N > 2a+1 \\ \frac{N(1-P)}{(1+2a)} & N < 2a+1 \end{cases}$$

$$\text{Go-back-N: } U = \begin{cases} \frac{1-P}{1+2aP} & N > 2a+1 \\ \frac{N(1-P)}{(1+2a)(1-P+NP)} & N < 2a+1 \end{cases}$$