Name: _____ Grade: _____

Due Date: Thursday, March 9rd at class time
You may not speak to others about the midterm. If you have any questions, only ask me. Thank you.

1. (20 pts) **IP fragmentation and reassembly**

   A message is sent from host A to host B. The message size is 2300 bytes and A's protocol breaks the message into three datagrams. The first two are 800 bytes of data and the third is 700 bytes of data. The header size is not specified but the size is in addition the data byte allotment. There exist several routes from A to B.

   - Datagram 1 goes through routers C then D. C's MTU is 400 and D's MTU is 300.
   - Datagram 2 goes through routers C then E. C's MTU is 400 and E's MTU is 500.
   - Datagram 3 goes through router F. F's MTU is 300.

   Assume the following fields are available for fragmentation and reassembly in the header of each datagram.

   - *ID*
   - *Data length in bytes*
   - *Fragment Offset in bytes*
   - *More Flag*

   Notice that these fields are taken from IP with modifications made for simplification. The major simplification is all fields are in byte units. You may assume no errors or congestion occur during transmission and propagation.

   (a) (2 pts) Draw a possible internetwork of hosts and routers from the description given.
   (b) (3 pts) Show the header (only four fields) for each of the three datagram leaving A.
   (c) (6 pts) Show the header for each entering and exiting datagram at each router.
   (d) (9 pts) Show, using a diagram of data structures and header information, how B reassembles the incoming datagrams to the original three datagrams. Demonstrate how your data structure and header are used together. No code is necessary. You may not assume any particular order of datagram delivery.

2. (10 pts) **UDP and TCP**

   (a) (5 pts) Why is UDP needed? Why can't a user program directly access IP?
   (b) (5 pts) Compare and contrast UDP sockets and TCP sockets. Answer this question from both the transport and application level (programmer) perspective.

3. (10 pts) **IPv4 and IPv6**

   List two new or changed features in IPv6. Discuss how each one affects the Internet Protocol including the affects to inter-networking issues. Be thorough in your discussion.

4. (10 pts) **ATM**

   (a) (2 pts) What features of ATM provide for a high-speed network? Provide a brief description of how each feature affects the speed of the network.

   (b) (2 pts) What does ATM guarantee about the delivery of cells and what does it not guarantee (regardless of quality of service)?

   (c) (6 pts) Outline a reassembly algorithm for ATM. We did not cover this in lecture. Use your knowledge of ATM to derive a valid reassembly algorithm.

5. (10 pts) **High-speed LANs**

   (a) (4 pts) What hardware and software changes/additions have been made to traditional Ethernet to achieve 100 Mbps, 1000 Mbps and 10000 Mbps(10 Gbps)?

   (b) (6 pts) Compare and contrast *hubs*, *layer 2 switches*, and *layer 3 switches* relative to achieving high data rates.

6. (10 pts) **High-speed LANs II** Consider a bus LAN with a number of equally spaced stations with a data rate of 1000 Mbps and a bus length of 1.8 km.

   (a) (5 pts) What is the mean time to send a frame of 4000 bits to another station, measured from the beginning of transmission to the end of reception? Assume a propagation speed of 300m/μs.

   (b) (5 pts) If two stations begin to transmit at exactly the same time, their packets will interfere with each other. If each transmitting station monitors the bus during transmission, how long before it notices an interference, in seconds? In bit times?

7. (10 pts)**Probability**

   (a) (5 pts) A taxicab was involved in a fatal hit-and-run accident at night. Two cab companies, The Green and The Blue, operate in the city. You are told that:

   - 85% of the cabs in the city are Green and 15% are Blue
   - A witness identified the cab as Blue

   The court tested the reliability of the witness under the same circumstances that existed on the night of the accident and concluded that the witness was correct in identifying the color of the cab 80% of the time. What is the probability that the cab involved in the incident was Blue rather than Green?

   (b) (5 pts) In the carnival game known as *chuck-a-luck*, a player plays an amount E as an entrance fee, selects a number between one and six, and then rolls three dice. If all three dice show the number selected, the player is paid four times the entrance fee; if two dice shows the number, the player is paid three times the entrance fee, and if only one die shows the number, the player is paid twice the entrance fee. If the selected number does not show up, the player is paid nothing. Let X denote the player's gain in a single play of this game, and assume the dice are fair. Determine the probability function of X.

8. (10 pts)**Queuing Analysis**

   (a) (5 pts) Consider a coffee counter with a single server at which tired students arrive according to a Poisson process. Let the mean arrival rate be two students per ten minutes and assume the serving time is exponentially distributed with an average of 180 seconds per student.

      i. What is the average queue length?

      ii. How long does a student have to wait in the queue?

      iii. Find the average queue length and waiting time in the queue if the service time decreases to 120 seconds per student.

   (b) (5pts) The owner of a shop observes that on average 18 customers per hour arrive and there are typically 8 customers in the shop. What is the average length of time each customer spends in the shop?

9. (20 pts) **Stop-and-Wait Protocol**

   (a) Assume host X and host Y are executing a Stop-and-Wait protocol. Host X is the sender and host Y is the receiver.

      i. (4 pts) Draw the time-space diagram for X successfully sending 3 frames to Y. Include all necessary frames and include sequence numbers. Assume X's sequence number is initialize to `0`.

      ii. (4 pts) X's timer is set to `low`. What happens? Clearly demonstrate with a time-space diagram.

   (b) (6 pts) A channel has a date rate of 4 Kbps and a propagation delay of 20 ms. For what range of frame sizes does Stop-and-Wait give an efficiency (utilization) of at least 50%?

   (c) (6 pts) No mention has been made of reject (`REJ`) frames in the Stop-and-Wait `ARQ` discussion. Why is it not necessary to have `REJ0` and `REJ1` for the Stop-and-Wait `ARQ`?

10. (10 pts) **Sliding Window Protocol**

    Two neighboring nodes (A and B) use a sliding-window protocol with a 3-bit sequence number. As the `ARQ` mechanism, *Go-Back-N* is used with a window size of 4. Assuming that A is transmitting and B is receiving, show the window positions for the following succession of events:

   (a) Before A sends any frames

   (b) After A sends frames `0`, `1`, `2` and receives acknowledgment from B for `0` and `1`.

   (c) After A sends frames `3`, `4`, and `5` and B acknowledges `4` and the `ACK` is received by A.

11. (10 pts) **Utilization**

    (11.3 from text) Consider the use of 1000-bit frames on a 1-Mbps satellite channel with a 270-ms delay. What is the maximum link utilization for

    (a) Stop-and-wait flow control?

    (b) Continuous flow control with a window size of 7?

    (c) Continuous flow control with a window size of 127?

    (d) Continuous flow control with a window size of 255?

12. (20 pts) **Frame Relay Traffic Management**

    (a) Describe traffic management in Frame Relay. You must include B_c, B_e, CIR, T and the corresponding use of specific header fields.

    (b) A user is connected to a Frame Relay network through a T-1 line (1.55Mbps). The granted `CIR` is 1 Mbps with a B_c of 5 millions bits per 5 seconds and B_e of 1 millions bits per 5 seconds. Answer the following questions:

        i. What is the access rate?

        ii. Can the user send data at 1.6Mbps?

        iii. Can the user send data at 1 Mbps all the time? Is it guaranteed that frames are never discarded in this case? If the answer is no, is it guaranteed that frames are discarded only if there is congestion?

        iv. Can the user send data at 1.2 Mbps all the time? Is it guaranteed that frames are never discarded in this case? If the answer is no, is it guaranteed that frames are discarded only if there is congestion?

        v. What is the maximum data rate the user can use all the time without worrying about the frame being discarded?

        vi. If the user wants to take a risk, what is the maximum data rate the can used with no chance of discarding if there is no congestion?