Exam 1 (Midterm), Spring 2002
Computer Science 516
Computer Communication Networks
University at Albany

Prof. William A. Maniatty

March 25, 2002

1 Some Hints

Your professor suggests the following preparation strategies:

- This exam is open book and open notes (your own books and notes that is!). Calculators are permitted, networked devices are not.
- Write neat clean answers, since if the grader cannot understand you on the real exam, it will go badly for you.
- Show your work, if you are guessing the grader will not give much credit (even if you get lucky and guess right).
- Define your notation (you can use tables and/or diagrams).
- Set up the solution symbolically and simplify before plugging numbers in, it is easier to follow for the grader (and will get you most of the points).
- You can solve problems out of order, but keep the work for each problem in one place, and mark it clearly.

2 The Problems

1. Protocol Layering and Design (25 %):

    (a) Briefly describe the services that the data link layer provides.

    (b) (5 %) Compare and contrast the goals (*not* the mechanisms) of ARQ and flow control (5 %).

    (c) What services does a *reliable* protocol provide (5 %)?

    (d) For end-to-end connections, if frame sizes exceed the Maximum Transfer Unit (MTU), some node along the way will need to fragment the packet. The TCP protocol suite has an end-to-end protocol, the path MTU discovery (PMTU) protocol for estimating the MTU.

        i. At what layer is the MTU establishment protocol implemented (5 %)?

        ii. Should PMTU be implemented as a data protocol or as a control protocol? Justify your answer (5 %).

2. Network Systems programming (10 %): Assume a BSD style sockets programming environment.

    (a) (10 %) How do datagram and streaming sockets differ?

    (b) (5 %) What functionality does the listen system call provide?

3. The Physical Layer and Information Theory (25 %):

    (a) (10 %) Modern telephone systems use pulse code modulation (PCM). During transmission of a signal, distortion may occur, recall how pulse code modulation can recover from errors. Suppose a device using PCM has voltages over $+0.5$ and -0.5 volts with 128 signal levels. What is the maximum level of signal distortion that can be corrected?

    (b) (10 %) Suppose your grade for this course is being transmitted across noisy channel (the horror!). Suppose the grade, an 'A', is encoded in ASCII as $0x41$ (in decimal that would be 65).

        i. Derive a Hamming code using odd parity (so the parity ensures that an odd number of bits are 1) and that the bits are numbered starting at 1 with check bits are at the power of two positions (as per the lecture).

        ii. Suppose that the noise corrupts the Hamming Code transmission in problem 3(b)i, so that the data bits are corrupted, and the data sent is an ASCII 'E', (hexadecimal $0x45$). The metadata (the parity bits) are not corrupted. Show the Hamming code, can the the error be detected and corrected (5 %)? Why or why not?

iii. Suppose that the noise corrupts the Hamming Code transmission in problem 3(b)i previous step, so that the data bits are corrupted, and the data sent is an ASCII 'B', (hexadecimal $0x42$). The metadata (the parity bits) are not corrupted. Show the Hamming code (5 %), can the the error be detected and corrected (5 %)? Why or why not?

(c) (5 %) Consider the CRC which has the generating polynomial: $G(x) = x^5 + x + 1$.Give the CRC for the message 10101011_2.

4. ARQ and Performance (25 %) Consider a packet switched network with a sender and a receiver. Suppose that the network has a mean propagation delay of 0.01 seconds, and a mean bandwidth of 12 Mbps. Due to heavy congestion, the packet loss rate is 1% on average. Suppose that the mean information frame size is 1500 Bytes, and the packet header and trailer meta data is 80 Bytes (constant). Suppose that ack and nack frames are 80 Bytes (just headers, they contain no data).

   (a) What is the efficiency of a stop-and-wait protocol in the presence of errors for this scenario and how many information frames could have been sent while waiting for the acknowledgment (10 %).

   (b) Suppose go-back-N ARQ is used with a sender window size of 64 and we are considering increasing the window size to 256. What is the efficiency of the protocol in the presence of errors for each window size, which window size should we choose (10 %)?

   (c) Suppose that the window size selected in problem 4b is used, but we are interested in changing the protocol to use selective-repeat ARQ. What would the efficiency of the protocol in the presence of errors be (5 %)?

5. Multiplexing and Telephony (15 %) Consider a concentrator, with an offered load is 50 Erlangs.

   (a) What is the minimum number of output trunks required to handle that load with a blocking probability of 1%? Show your work (5 %).

   (b) Suppose that the concentrator's load is expected to increase to 60 Erlangs over the next 5 years, after which the cabling will be upgraded with an anticipated 10 fold increase in bandwidth. In the short term, assume that the system can handle this year's load, but will be in difficulties starting next year. To handle this load we need to act now, and we have two choices. Satellite bandwidth is available for the projected 4 years at $\$5 \times 10^7$ per year to reroute the projected surplus. Alternatively we can add additional trunks at $\$10^8$ dollars to add cable with an extra $\$5 \times 10^6$ per added trunk (each trunk can handle 1 Erlang of load). Which solution should we choose (10 %)?