CS 536 (Park) **Midterm** **Oct. 15 (Tue.), 2002**

The exam is closed-book/closed-note. The exam duration is 1 hour and 15 minutes. Please keep your answers focused and to-the-point. If you do not know the answer to a question, return to it after solving the ones that you know.

PROBLEM 1 (40 pts)

(a) From a physical layer perspective (i.e., signals and information transmission), what are the key differences between a communication network and a highway network? There are at least two fundamental differences that should not be missed.

(b) What is the delay-bandwidth product and why is it relevant for traffic management in computer networks? Sketch its impact in Ethernet's CSMA/CD and stop-and-wait.

(c) ARQ and FEC are two basic approaches for achieving reliable communication over an unreliable network such as IP internetworks. What are their relative merits and weaknesses? When CNN carries live interviews from trouble spots thousands of miles away by satellite, which technology is more appropriate?

(d) Why do we care about bandlimited signals? What would happen to networking if we lived in a universe where signals are not bandlimited (even approximately)? What is the most canonical example of a bandlimited signal relevant for networking? Can you think of a second one?

PROBLEM 2 (30 pts)

(a) Assume telephone companies have decided to use IP internetworks to carry all their voice traffic, and would like to use their TDM-based digital backbone (think of T1) to carry high quality audio music (i.e., 20 Hz–20 KHz; approximate bandwidth 20 KHz). Assuming 24 simultaneous channels or audio transmissions are to be supported by the TDM baseband network, each audio signal quantized at 16 bits, design a frame format where each frame has an additional start bit at the front. What is the bit rate (bps) associated with the new standard (call it, AUDIO-1)?

(b) ARQ has a requirement that the sender window size (SWS) be less than half the maximum sequence number allowed when numbering packets:

$$\text{SWS} = (\text{MaxSeqNum} + 1)/2.$$

First, show why this is required in the special case of stop-and-wait. Then, extend the reasoning and explanation to ARQ. If you have 16 bits in the packet header to encode sequence numbers and a packet is of size 1 Kbits, can an ARQ configured with these parameters fill a 100 Mbps FastEthernet? What is the utilization?

(c) Direct sequence CDMA—take the simple case where there is only a single user and multiplexing is not a concern—is considered to be fault-tolerant with respect to noise, i.e., bit errors or flips, in the channel. Sketch a scheme that is tolerant with respect to any 3-bit error pattern. Illustrate the fault-tolerance property by using an example where a single bit (say the value 1) is being transmitted from sender to receiver.

PROBLEM 3 ($30 = 10 + 20$ pts)

(a) From a multiple access point-of-view, what are the key differences between a wired Ethernet LAN and a wireless LAN?

(b) Assuming stations in an Ethernet environment use CSMA/CD to access the shared medium, design a *greedy MAC* protocol that by being selfish "outwits" other stations running CSMA/CD, thereby monopolizing the shared resource. Sketch how your protocol works and explain why it is able to monopolize bandwidth. You can assume all stations always have packets to transmit. What would happen if two stations were to run your protocol? Is there a difference with the case where all stations use your protocol?

BONUS PROBLEM (15 pts)

Given that 48-bit Ethernet addresses are globally unique and internetworking can be achieved, in principle, by protocols at the link layer, is there a case to be made for creating a protocol layer above the MAC layer? Sketch a scheme where an Ethernet switch forwards frames destined to a station connected to another Ethernet switch.