CS 536 (Park) **Midterm** **Oct. 20 (Mon.), 1997**

PROBLEM 1 (25 pts)

(a) What is the main criterion for distinguishing between LAN networking and WAN networking? What is the secondary criterion? Do they always concur? If not, what is such an example?

(b) What is the "bully effect"? Why is it relevant for modern network systems? What is ATM's role in this? Does ATM truly "solve" this problem? If not, why not?

(c) Telephone networks—except for the local loop—are digital employing TDM to arbitrate sharing of bandwidth. Assuming a telephone network is made up of T1 links only, what are the operations needed to set up a valid connection when making a call? Be concrete keeping in mind the TDM context. In what two scenarios can a call set-up fail?

(d) What are the two fundamental methods for achieving reliable communication over an unreliable network? What are their pros/cons? Do both achieve 100 % reliability? If not, how can you fix it?

PROBLEM 2 (25 pts)

(a) Assume an IP packet P has arrived at a router R destined for host A. Assuming A is attached to one of the LANs R is attached to, describe the address translation and forwarding mechanisms involved for P to reach its destination A. Your account must be complete. What sequence of events transpires when A is not on the same LAN as R? Does ARP still come into play?

(b) What are the two ways of implementing circuit switching? What are their pros/cons? Which one would you use for "long-lived" connections and which one would you use for "short-lived" ones?

(c) Direct Sequence Code Division Multiplexing is claimed to have tolerance to noise which is a function of the code rate-to-data rate ratio $r : 1$. That is, for every data bit, r code bits are used in the encoding. What is the worst-case noise condition (expressed as a function of r) under which *error-correction* can be achieved? What is the worst-case noise condition under which *error-detection* can be achieved? Explain your reasoning.

(d) Assume you have been abducted by aliens to "Planet Fiber" to set up their telephony system where every household is wired via optical fiber. You are informed that their hearing range is 100 kHz–600 kHz and that they would like to be able to carry 1000 conversations simultaneously. Having just taken CS 536 the previous semester, you proceed to design a baseband solution using TDM. Show this solution. What is the resultant data rate? What is the minimal bandwidth of the fiber channel that you would need to carry the signals?

PROBLEM 3 (30 pts)

(a) Assume you are the network manager at an organization that has been assigned a type-B IP address (14-bit network/16-bit host). To reflect the structural composition of your organization which is composed of 16 department networks, each containing 64 subnetworks, each subnetwork connecting up to 64 hosts, you are asked to redesign the router software to carry out *subsubnetwork masking*. How would you go about doing that? What would your typical routing table now look like?

(b) Assume you are using the stop-and-wait protocol to reliably transport data across a link of 100 Mbps bandwidth and 10 ms latency, If your frame size is X bits, then ignoring header overhead, what is the file transfer completion time of a file of size S bits assuming a noiseless channel? Assume that S is bounded above by the delay-bandwidth product of the link.

What is the throughput of stop-and-wait under a *noisy* channel where the probability of a frame of size S getting corrupted (i.e., one of its bits flipped) is $p = \varepsilon S$ where $\varepsilon > 0$ and $p \leq 1$ for the S values considered? Here, *throughput* is defined to be the number of noncorrupted frames arriving at the receiver per unit time "in the long run" when the sender is acting as an infinite source. Are there conditions under which the optimal S (w.r.t. throughput) is strictly less than the delay-bandwidth product?

PROBLEM 4 (40 pts)

(a) We discussed ARQ with positive acknowledgement and the role of RTT and timers in the context of triggering retransmissions. What happens if ARQ is used with negative acknowledgement? Describe in detail the protocols executed at the sender and receiver. Has there been a shift in processing complexity between sender and receiver? If so, in what direction? What are the pros/cons of a negative acknowledgement scheme over a positive ACKing scheme?

(b) [Bonus Question] Sketch the approximate analysis of the CSMA/CD protocol carried out in class with k hosts accessing the channel with probability p during time interval 2τ where τ is the link latency. First, compute the probability η that some host successfully acquires the channel. How does this probability vary as p is increased?

Next, compute the contention time T which is the time interval that no station successfully acquires the channel. From this, compute the mean contention time $\mathbf{E}(T)$ noting the summation formula $\sum_{i=1}^{\infty} ia^i = a/(1-a)^2$, $-1 < a < 1$.

Finally, compute the utilization ρ and express it as a function of bandwidth B, frame size F, and bus length L. If CSMA/CD is to be used over high-bandwidth networks, what other quantities must be adjusted for this to be feasible? If backward compatibility with the existing Ethernet frame format is a consideration, what variable needs to be controlled?

In what senses is the above analysis only approximate?