CS 536 (Park) **Midterm** **Oct. 18 (Mon.), 2004**

Remarks: Please keep the answers compact, yet precise and to-the-point. Long-winded answers that do not address the key points are of limited utility. Binary answers that give little indication of understanding are not good either. Time is not meant to be plentiful. Make sure not to get bogged down on a single problem.

PROBLEM 1 (40 pts)

(a) What is the distinction between broadband and baseband networks? Why is "high speed" networks a misnomer? Given the apparent superiority of broadband over baseband, why would classical CSMA/CD Ethernet follow a baseband technology?

(b) Suppose FDM is used in the 100–110 GHz band to support 10 users where carrier frequencies, starting at 100 GHz, are separated by 1 GHz. Assume AM with 8 levels is used to encode data bits. What is the total data rate (bps) of the 10-user FDM system? What is the baud rate of the system? Are the individual user data rates equal?

(c) Internet traffic measurement during the past ten years has shown that the overwhelming majority of Internet traffic is file transfer traffic, where most files are small (a few kilobytes) but a few are very large (tens of megabytes and larger), also referred to as "mice and elephants." Is TDM, as used in telephony, a suitable MAC for supporting file transfers? Explain your reasoning. Why was TDM appropriate for voice traffic? From a bandwidth utilization point-of-view, why would packetization of voice that abandons circuit-switched TDM in favor of packet-switching (i.e., Voice-over-IP) be meaningful?

(d) How is a switched CSMA/CD Ethernet different from a classical bus CSMA/CD Ethernet? What role does CSMA/CD play in switched Ethernet? When two switched Ethernet switches are connected to each other by a point-to-point link, do they need to converse using CSMA/CD? Explain.

PROBLEM 2 (30 pts)

(a) Suppose you are starting a new digital satellite radio service for the discerning audio listener who is prepared to pay extra for 0–20 KHz frequency range super-quality audio. Assuming 10 bits are used to quantize an audio sample, what is the traffic requirement of this digital radio broadcast application? Supposing not all 10-bit sample patterns occur equally likely in a typical digital audio broadcast, what can you do to further reduce the application's bandwidth requirement? Describe the technical steps you would need to take to estimate the best possible case, i.e., least possible bandwidth usage so that you can architect an economically viable networking system.

(b) What are the advantages of using DSSS CDMA over TDMA for supporting N voice or data users? Which of the advantages can be addressed in TDMA through coding tricks? Which one cannot?

(c) Suppose Stop-and-Wait is used on a point-to-point link from host A to host B to transmit a very large file. Assume the data frame size is F bits, the ACK frame size F' bits, bandwidth is B bps, and one-way propagation latency is L msec (same in both directions). What is the throughput (bps) of the Stop-and-Wait protocol? Now, suppose the link from A to B is noisy so that a data frame gets corrupted with independent probability p (corrupted frames are discarded at B's NIC). For simplicity, assume ACK frames in the opposite direction do not get corrupted. Supposing the retransmission timer at A is perfectly set, what is the average reliable throughput of Stop-and-Wait in the long run? What is the utilization?

PROBLEM 3 (30 pts)

(a) Imagine environmental activism has outlawed cellular towers and, in place, satellite digital phones/PDAs are used to provide Internet VoIP/data service to the general public. Instead of TDMA or CDMA, suppose contention-based CSMA with explicit ACK frames and exponential backoff is proposed as the MAC to share the uplink bandwidth among multiple users. What technical reasons make this a bad idea? Architecturally, is providing general purpose Internet access via satellites a viable approach? What are the key architectural features that make such a design intrinsically challenging for non-broadcast networking?

(b) What are the general principles underlying frame forwarding/routing in a network of Ethernet switches? Is the routing mechanism employed scalable (i.e., does it work well as the number of nodes and switches increases)? Explain why or why not. At the cost of complicating the switch design, what additional mechanisms might be introduced to improve routing performance? What additional issues are introduced in ESS WLANs, and how can they be handled? Describe how your version of re-association would work.

BONUS PROBLEM 4 (10 pts)

Suppose in the digital satellite radio example of Problem 2(a), you decide to transmit 10-bit quantized audio samples as is (say the cost of reducing the bandwidth requirement was on par with that of procuring extra frequency from the FCC). Suppose that due to atmospheric noise during transmission, up to 3 bits in a 10-bit frame may get corrupted, i.e., flip. Since the super-audio service contract with your customers precludes payment by the customer if the 0–20 KHz audio quality is violated, you decide to employ error correction by creating a frame of size $10+k$ bits. Noting that for k "not-too-large" (say 6 or 7) 2^{10+k}—more importantly, its square 2^{20+2k}—is not an astronomical number that may be tackled brute-force, how would you go about determining the best k to use to achieve error-correction? Sketch the procedure. If you did not need to minimize k, what would be a simple solution to correct for 3 bit flips in transmitted frames?