CS 536 (Park) **Midterm** **Oct. 10 (Thu.), 2019**

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 value. 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 (42 pts)

(a) The T1 TDMA link is designed to support 24 users (i.e., channels) where each user gets 8 bits per time slot. Ignoring the 1-bit control overhead and assuming 100 users instead of 24, derive the bps bandwidth of the modified T1 TDMA system. Explain the rationale behind the steps in the derivation. Assuming 2-level pulse amplitude modulation, what is the pulse width (in unit of second) of a single bit? (Specify what calculation needs to be performed without carrying out the calculation.) Suppose the modified T1 TDMA system is to be operated over copper wire of bandwidth 3 MHz. Is this a viable idea? Explain your reasoning.

(b) Suppose we are using sliding window to implement reliable communication and our packet header has 3 bits for representing sequence numbers. What is the maximum sender window size (SWS) allowed? Using an example scenario, explain why SWS bigger than this maximum can cause confusion and faulty operation at the receiver.

(c) CSMA/CD Ethernet's frame has a minimum payload (i.e., body) size constraint of 46 bytes. Explain how this came about from consideration of the maximum diameter of an allowed network (2500 m), its round-trip latency (51.2 μs), link bandwidth (10 Mbps), and collision detection (CD) protocol. Assuming frame format cannot be changed due to backward compatibility, what has to happen to enable 100 Mbps link speed over CSMA/CD? Powerline Ethernet may use CSMA for data transmission over electrical power lines in buildings. Why is CD not well-suited in this setting? To run CSMA without CD, what protocol component must be added? Suppose the building in question houses thousands of office workers each contending for bandwidth using CSMA. Why is this not an effective way of using CSMA over electrical power lines?

PROBLEM 2 (38 pts)

(a) Suppose the 5–6 GHz frequency range is to be used to support wireless communication for 1000 users using OFDMA. Describe the steps involved in how carrier frequencies are allocated where one user is assigned one carrier frequency. Assuming 8-level AM, show how the bps bandwidth of each user and the bps of the system as a whole is derived. What happens to the bps of each user and the bps of the system if the number of supported users is reduced from 1000 to 100? Suppose regulations at a future time dictate that the OFDMA system must operate in the 3–4 GHz frequency range. What change is required at the sender? How does this impact bps bandwidth?

(b) Suppose stop-and-wait is used to reliably transport files over a full-duplex point-to-point link of latency d msec (one-way) and bandwidth B bps (in each direction). Data packet size is F (bits) of which $P < F$ (bits) is payload size. ACK packet size is A (bits). We will ignore operating system and other extraneous overhead. Assuming a lossless system—no data or ACK packets go missing—and latency d is deterministic (i.e., constant), derive the completion time for sending a file of size S (bits) where S is a multiple of P. What is the throughput (bps) of the protocol? Assuming a timeout of $2d$, what is completion time if every other data packet is dropped (i.e., 50% loss rate)? Sliding window aims to improve performance of stop-and-wait in high delay-bandwidth product networks. Under what condition of F, d, and B is sliding window likely to yield significant throughput gain? Explain.

PROBLEM 3 (20 pts)

Ethernet's CSMA/CD, upon detection of first-time collision, waits for some time before re-attempting transmission. How is this wait time chosen by every host/NIC? (Use the constant 51.2 μs in your explanation.) Among all the possible ways of choosing wait time, why is this method used? What happens when retransmission results in yet another collision? What about k consecutive collisions? What is Ethernet's "backoff" method, viewed as a function of k, focused on achieving? What is another method for choosing wait time as a function of k that may be reasonable? Since Ethernet's MAC uses retransmission, is Ethernet a reliable link technology? Given the nondeterministic nature of CSMA/CD, why does it make sense to choose CSMA/CD as the MAC protocol of wired LANs and CSMA for wireless LANs? Under what conditions might OFDMA, TDMA, or CDMA be preferable?

BONUS PROBLEM (10 pts)

In Problem 3 of lab2, the file server marks the last data packet with sequence number 2. The client, upon receiving the last data packet, returns an ACK with sequence number 2 and terminates. What issue does this raise, and how is it addressed in our file transfer protocol? Is it a correct solution? Explain your reasoning.