CS 536 (Park) **Midterm** **Oct. 22 (Wed.), 2025**

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 (40 pts)

(a) Suppose a point-to-point link from A to B has latency d msec and bandwidth r bps. Given a file of size s bytes, what is the minimum completion time for transferring the file assuming the link is perfectly reliable? What is the rationale behind the formula? If s is 1 KB, d is 30 msec, and r is 1 Gbps, does it make sense to increase bandwidth to 2 Gbps to improve completion time? Explain your reasoning.

(b) Why did Ethernet's CD necessitate a 46 B minimum payload requirement? Does IEEE 1901 (i.e., Ethernet over powerline) need an analogous minimum payload size? In the context of transmitting 802.11 frames using CSMA/CA, why is DIFS significantly longer than SIFS? Suppose an 802.11 frame is transmitted by a wireless station to the AP of a BSS that is connected to a wired distribution system comprised of Ethernet switches. Assume the frame is destined to a server connected to one of the Ethernet switches. Explain why the 802.11 header must contain three address fields.

PROBLEM 2 (40 pts)

(a) Suppose OFDMA is used to support communication in the frequency range 5 GHz to 6 GHz. The system supports $n = 1000$ users where each user gets a single (sub)carrier frequency to transmit its bit stream. How do we choose the carrier frequencies? What is the symbol period of the system? Assuming AM with 8 levels, what is the resultant bandwidth (bps) delivered to each user? What is the bandwidth (bps) of the system as a whole? Does increasing n to 10000 increase system bandwidth 10-fold? Explain.

(b) In lab2, IPv4 addresses (in dotted decimal format) were used to specify a destination lab machine to whom a packet carried as payload of Ethernet was transmitted. Assuming the source (or client) lab machine does not know the 48-bit MAC address of the destination IPv4 address, how does ARP (Address Resolution Protocol) discover the MAC address of the IPv4 address? Since ARP packets are carried as payload of Ethernet frames, specify what the DIX Ethernet header fields should contain. Suppose an Ethernet switch receives an Ethernet frame sent from the client destined to a 48-bit destination MAC address. Given that the switch has multiple links/ports (e.g., 24) how does it know on which link to forward the frame? What happens if the switch does not know on which link to send out the frame?

PROBLEM 3 (20 pts)

What is the throughput formula of stop-and-wait assuming no packet losses? Explain why a (binary) sequence number is required for correct operation of the protocol using an example scenario. Describe the performance issue of stop-and-wait that sliding window aims to mitigate. Assuming a maximum window (or buffer) size M (in unit of equal size packets)—the same window size at sender and receiver for simplicity—how large must the sequence number space be to achieve correctness? What are the pros/cons of positive vs. negative ACK with respect to the network conditions they are better suited for?

BONUS PROBLEM (10 pts)

The word "bandwidth" is an overloaded term. Describe four distinct usages of bandwidth as discussed in class. For which of the four usages does sending a long sequence of 0's (i.e., data bits $000000 \cdots 000$) vs. a mix of 0's and 1's (e.g., $010110 \cdots 101$) have an effect?