CS 536 (Park) **Midterm** **Mar. 19 (Tue.), 2024**

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 (45 pts)

(a) Given a point-to-point link between sender A and receiver B of bandwidth c (bps) and latency d (msec), the completion time of a file of size S bytes sent from A to B under no losses is given by transmission time S/c plus d. Explain the logic behind the formula. Suppose A and B decide to utilize the stop-and-wait protocol just in case losses occur. Let K (bytes) be the fixed size of a data packet transmitted from A to B. For simplicity we will assume K divides S evenly. Assume bandwidth and latency are symmetric (same in both directions), and ACK packets from B to A are of size T bytes. Derive the formula for completion time under the assumption that no losses and timeouts occur. Ignore a separate bit required as header to encode the sequence number.

(b) Using IPv4 class A address as example, explain why classful addresses are considered inefficient. What are classless (CIDR) addresses, and how have they helped reduce waste? One of the IPv4 address blocks assigned to Purdue is 128.10.0.0/16. Suppose a server on the east coast sends an IPv4 packet with destination address 128.10.112.131 (one of our lab machines). If a router located in Chicago were to forward the packet, what bits would it need to inspect? If an IP router within Purdue's intranet were to forward the packet, what subnet ID and subnet mask need to be specified as an entry in its routing table? What would the third column of the entry contain (two possibilities)?

(c) What is the hidden station problem in IEEE 802.11 wireless LANs? How does RTS/CTS help mitigate the problem? Can RTS frames not collide, thus defeating the benefit of using RTS/CTS? Explain your reasoning. In what way has the role of RTS/CTS been expanded in Wi-Fi 6 and 7?

PROBLEM 2 (36 pts)

(a) Suppose an ISP is allowed to use frequency range 1 GHz–2 GHz to provide wireless network access to its customers. Under what conditions might FDMA be a feasible bandwidth sharing solution? What is the advantage of OFDMA over FDMA? Suppose the number of customers is $n = 1000$. What are OFDMA's carrier frequencies for the n users for the frequency range? What is the value of the symbol period? What is the nominal throughput (bps) provided to each user assuming 8-level amplitude modulation? Why can OFDMA configured with 10000 carrier frequencies to allocate 10 subcarriers per user not increase throughput?

(b) TCP uses 3-way handshake involving FIN packets to terminate a connection. What is the intuitive reason behind the protocol not guaranteeing correct termination? What is the "hack" employed by TCP to deal with the problem in real-world deployments? Describe a scenario where it fails. Why is connection establishment using SYN packets considered a simpler problem than connection termination?

PROBLEM 3 (19 pts)

Suppose 3 Ethernet switches X, Y, Z are connected to each other by direct links, and 30 hosts connect to the 3 switches, 10 hosts per switch. Only one of the 3 switches, Y, connects to an IP router via a point-to-point link. Suppose an IPv4 packet arrives at Y from the IP router. Assume the destination IP address h belongs to a host (i.e., Ethernet interface) that is connected to switch Z. What are the general principles of LAN routing (i.e., IP is not involved) within the 3-switch extended LAN? Given that Y has 13 interfaces—10 Ethernet interfaces to its directly connected hosts, 2 Ethernet interfaces connecting to switches X and Z, an interface connecting to the IP router—what actions would Y take to forward the IP packet in the extended Ethernet LAN? Describe worst-case and best-case scenarios with respect to Ethernet frames generated by Y to achieve delivery.

BONUS PROBLEM (10 pts)

Suppose you are a venture capitalist and a friend pitches the idea of running CSMA/CD Ethernet over electrical wires in residential buildings. Ignoring that broadband over powerline already exists, from a technical perspective why would you reject CSMA/CD as a viable protocol? Suppose the friend of a friend submits a proposal to use CSMA in a balloon equipped with a wireless access point held stationary several miles above a densely populated city to provide Internet access. Why would you recommend against using CSMA? Why would using OFDMA make more sense?