SOLUTIONS TO CS 536 MIDTERM, SPRING 2024 (PARK)

P1(a) 15 pts

It takes S/c seconds to for the last bit to be put on the link. Then it takes d msec for the last bit to reach the destination.
8 pts

// Other correct explanations include:
// First bit arrives at destination after d msec plus 1/c to put the bit
// on the link. The last bit is behind the first bit by (S-1)/c seconds.
// Accounting can be done in multiple ways but they need to be logically
// correct.

Let N = S/K be the number of data packets to be transmitted. For each data packet, A -> B transport requires q = K/c (sec) + d (msec) time. Transporting the ack requires r = T/c + d time. Since there are N total packets, completion time is N(q+r).
7 pts

P1(b) 15 pts

Only 2^7 organizations are possible with each organization being allowed 2^{24} IP devices. This is suitable for only very large organizations which have around 16 million IP devices. Otherwise address bits go to waste.
2 pts

CIDR notation a.b.c.d/x allows a variable prefix length x to be specified so that IPv4 address space allocation to an organization can be better customized.
3 pts

128.10.0.0/16 indicates that the last (i.e., most significant) 16 bits of an IPv4 address are inspected to determine path selection.
2 pts

Subnet ID 128.10.112.0
Subnet mask 255.255.255.0
4 pts

Interface number of destination device is connected to a LAN of the router. IP address of next hop router if destination device is not connected to a common (extended) LAN.
4 pts

P1(c) 15 pts

A and B wish to send to C. They are within reach of C but not each other (e.g., C is in-between A and B). Since A and B cannot sense each other, CS does not help prevent simultaneous packet transmission which leads to collision at C.
4 pts

RTS is a much smaller packet that is sent from the senders in an attempt to reserve the shared link (i.e., wireless channel). When an RTS reaches C, say from A, C broadcasts CTS which ACKs the RTS and reserves the link for packet transmission by A. B abstains from transmitting until A has completed transmitting its data packet.
4 pts

Yes, simultaneous transmission of RTS packets by A and B can still collide at C. However, if transmissions by A and B occur with a slight lag, small size of an RTS packet allows the RTS packet that arrives earlier at C, say from A, to be decoded before the RTS packet from B arrives. Hence collision is avoided even though A and B are not able to send each other's transmission. This allows C to broadcast CTS that clears the link for A.
4 pts

In Wi-Fi 6 and 7 the role of RTS/CTS has been expanded to accommodate allocation of carrier frequencies under OFDMA.
3 pts

P2(a) 18 pts

If the number of users is not large then their spectra need not overlap avoiding (inter-channel) interference.
3 pts

In OFDMA carrier frequencies may overlap w.r.t. to the spectra of signals that they carry without causing interference.
3 pts

Bandwidth W = 1 GHz (= 2 GHz - 1 GHz). n = 1000 carrier frequencies are the harmonics of 1 GHz / 1000 = 1 MHz: 1 GHz + 1 MHz, 1 GHz + 2 MHz, ..., 1 GHz + 1000 MHz. That is, 1.1 GHz, 1.2 GHz, ..., 2 GHz.
// It's also fine to use 1 GHz, 1.1 GHz, ..., 1.9 GHz.
// May also use n in place of 1000.
4 pts

Symbol period n / W = 1000 / 1 GHz = 1 microsecond.
3 pts

Since 8 levels means 3 bits per symbol period, 3 Mbps (= 3 bits per microsec).
2 pts

Increasing the number of carrier frequencies n 10-fold increases symbol period n / W 10-fold which decreases throughput (bps) per carrier frequency 10-fold. Thus a conservation holds where assigning 10 carrier frequencies per user leaves throughput unchanged.
3 pts

P2(b) 18 pts

The third packet acknowledges the second packet of the FIN handshake. The sender B of the third packet does not know if its packet has been received by A. If the third packet is lost A will eventually timeout and retransmit the second packet since it may have been lost. If B's third packet is received, A will terminate per 3-way handshake but B cannot since A may not have the third packet. If so, B will have to maintain the connection since a retransmission (second packet) from A may arrive which B must then acknowledge (third packet). This leads to a situation of having to ACK an ACK which goes on ad infinitum.
6 pts

The hack uses a timeout by B so that if a retransmission request is not received by a certain time period then B assumes that A has received the third packet and terminates the connection.
6 pts

A does not receive B's third packet. It keeps retransmitting the second packet which B receives but its retransmitted third packet is not received by A. B will eventually timeout and terminate the connection. A will not.
// Other scenarios similar to the above are equally valid.
4 pts

Connection setup involving SYN packets is made to transmit data (which involves ACK packets in the reverse direction). Hence even if the third packet of the 3-way handshake is lost, subsequent data/ACK packets will perform the role of the lost third packet.
2 pts

P3 19 pts
First principle: build spanning tree (so that packets are not broadcast unnecessarily).
6 pts

Second principle: from source MAC address of an Ethernet frame arriving on an interface, remember the owner of the MAC address as being reachable over said interface. (Learning bridge.)
6 pts

Worst-case: Y does not know how to reach destination MAC hence broadcasts (i.e., forwards packet on multiple interfaces) over outgoing links of the

spanning tree.
4 pts

Best-case: Y has learned that the destination MAC is reachable through a specific interface. It transmits Ethernet frame through that interface.
3 pts

Bonus 10 pts

The CD component of CSMA/CD is ill-advised since guaranteed collision detection requires knowing the maximum diameter and its propagation delay (which determines minimum frame size).
5 pts

CSMA is not recommended since CS over long distances to avoid collision is not effective due to long propagation delays. In dense areas with many users, likelihood of collision is especially pronounced.
3 pts

OFDMA allocates per-user carrier frequencies, hence avoids collision.
// Since users have to go through access control which incurs overhead, adding
// allocation of specific carrier frequencies consumes incremental overhead.
2 pts