

SOLUTIONS TO CS 536 MIDTERM, FALL 2021 (PARK)

P1(a) 20 pts

A satellite covering a metropolitan area will have many users competing for shared wireless bandwidth. CS becomes ineffective since chances are that multiple users will attempt to transmit frames at a given time. CD becomes ineffective since long distances in a metropolitan area will require large frames to assure that collision is detected before frame transmission completes. CSMA/CD is not suited for a high load environment which a metropolitan area represents when serviced by geostationary satellites.

8 pts

In high load environments, content-free methods such as TDMA and OFDMA are better suited.

4 pts

Throughput of stop-and-wait and its extension sliding window are inversely related to RTT. That is, higher RTT leads to lower throughput. Hence low orbit satellites have an advantage over geostationary satellites even for file download speed.

8 pts

P1(b) 20 pts

Using Shannon's formula: multiply 1 GHz by $\log(1 + P_s/P_n)$ to get an upper bound on bps achievable by the OFDMA system.

10 pts

When we squeeze in more carrier frequencies n for the given bandwidth $W = 1$ GHz, symbol period n/W increases to assure orthogonality. Although there are more carrier frequencies transmitting bits in parallel, each carrier frequency transmits at a slower rate due to increase of symbol period. Hence system throughput stays invariant.

10 pts

P2(a) 20 pts

A class A address assigns 7 bits for network ID and 24 bits for host ID. A class C address assigns 21 bits for networks ID and 8 bits for host ID. Allocating a class A address to an organization may lead to significant waste of 2^{24} host addresses. Conversely, 2^8 may be too few in the case of a class C address. CIDR specifies the number of bits in the prefix of an IPv4 to be used as organization ID. This allows for a targeted allocation of IP addresses to an organization that better matches its needs.

10 pts

Suppose the two devices use private IP addresses 192.168.10.10 and 192.168.10.11 inside the customer's network. Assume the shared routable IP address assigned by the ISP is 128.10.27.50. When a process at device with 192.168.10.10 bound to port number 60000 sends a packet to the global IP Internet, NAT translates 192.168.10.10:60000 to 128.10.27.50:55000 where 55000 is a port number not yet used by NAT. Similarly, NAT translates 192.168.10.11:60100 to 128.10.27.50:55001. When IP packets arrive from the global Internet destined to 128.10.26.50:55000, NAT replaces the destination IP and port number with 192.168.10.10:60000. Similarly for 192.168.10.11:60100. Hence port number bits are used to augment IPv4 address bits which increases the effective address space of IPv4 significantly.

10 pts

P2(b) 20 pts

On the surface this seems illogical since OFDM may be used to provide contention-free sharing of wireless bandwidth (i.e., OFDMA) while CSMA provides contention-based sharing of the same physical bandwidth.

6 pts

OFDM uses multiple orthogonal carrier frequencies to transmit the bits of a single user. Due to spatial diversity that affects received signal strength of some carrier frequencies, distributing frame bits across multiple carrier frequencies limits decoding errors to bits sent on carrier frequencies with weak signal strength. Using error correction, corrupted bits may be recovered at the receiver from the bits

sent on carrier frequencies whose received signal strength is strong.
8 pts

Main pro of OFDMA:

When load (i.e., number of stations competing for wireless bandwidth) is heavy, the contention-free nature of OFDMA assures high system throughput.
3 pts

Main con of OFDMA:

Before a wireless station can transmit data, it needs to go through an admission control procedure to be allocated a carrier frequency. This coordination overhead is incurred even when load is light and likelihood of collision low.
3 pts

P3 20 pts

Scenario 1: (a) If the switch does not know how to reach the destination MAC address, it broadcasts the frame. (b) If the switch knows that the destination MAC is directly reachable on a specific Ethernet interface, it transmits the frame on that specific interface only. (c) If the switch is part of a spanning tree, it transmits the frame to a neighboring switch in the spanning tree that can reach the destination MAC address.
10 pts

Scenario 2: (a) Looks for a match in the routing table which may involve AND'ing with a subnet mask. (b) If a routing table entry specifies that the destination IP address is directly reachable through a LAN interface, ARP is used to translate IP address into MAC address and LAN frame containing IP packet is sent out through the interface. (c) If a routing table entry specifies that an intermediate IP router is needed to reach the destination IP address, the intermediate IP router's MAC address is found through ARP and a LAN frame is transmitted on the interface where the intermediate IP router is connected.
10 pts

Bonus 10 pts

The third device 10001111110 wins the competition. At bit 1, all three tie and succeed sending 1. At bit 2, the first device loses and drops out since it sends a 1 whereas the others send 0. At bit 3 there is a tie between the second and third device since both send 0. At bit 4 device three wins since it sends 0 whereas device two sends 1.
3 pts

From a scheduling perspective, CAN implements priority scheduling. A potential weakness is starvation of lower priority devices but higher priority devices.
4 pts

CAN uses wired-AND which determines winner/loser upon collision without the winner's bit value being corrupted, called non-destructive arbitration (NDA). Losers recognize that they have lost. Hence no backoff and retransmission is needed.
3 pts