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Problems 1
CS372

Review Questions:

1. What is the difference between a host and an end system? List several different types of end systems. Is a Web server an end system?

End systems are also referred to as hosts because they host application programs. There is no difference between a host and an end system and they can be used interchangeably. Some types of end systems would include clients and servers and some examples of those would be smartphones, desktops and laptops. Yes a web server is an end system.

23. What are the five layers in the Internet protocol stack? What are the principal responsibilities of each of these layers?

Five Layers:

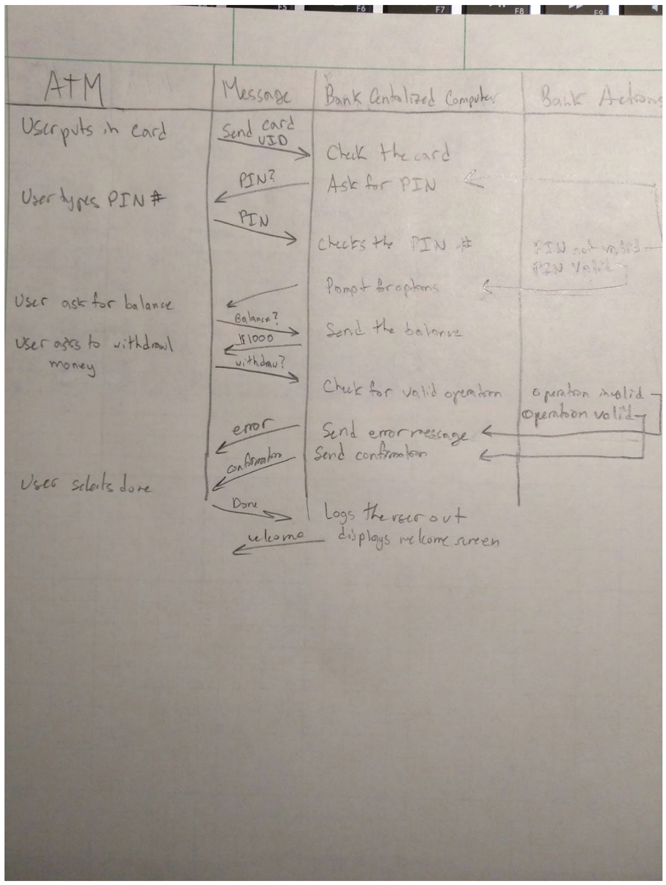
1. Application - where network applications and their application-layer protocols reside
    a. Protocols include: HTTP, SMTP, FTP
2. Transport - transports application-layer messages between application endpoints
    a. Protocols include: TCP and UDP
3. Network - responsible for moving network-layer packets called datagrams from one host to another
    a. Delivers the segment to the transport layer in the destination host
4. Link - routes a datagram through a series of routers between the source and destination
    a. Protocols include: Ethernet and WiFi
5. Physical - Moves the individual bits within the frame from one node to the next
    a. Protocols include: twisted-pair copper wire, single-mode fiber optics

28. Suppose Alice and Bob are sending packets to each other over a computer network. Suppose Trudy positions herself in the network so that she can capture all the packets sent by Alice and send whatever she wants to Bob; she can also capture all the packets sent by Bob and send whatever she wants to Alice. List some of the malicious things Trudy can do from this position.

Trudy is in the position where she can pass along malware and viruses to either Alice or Bob. She can also use IP Spoofing to impersonate either Alice or Bob and pass along fake or bad information to either one.

Problems:

1. Design and describe an application-level protocol to be used between an automatic teller machine and a bank's centralized computer (BCC). Your protocol should allow a user's card and password to be verified, the account balance to be queried, and an account withdrawal to be made. Specify your protocol by listing the messages exchanged and the action taken by the automatic teller machine or the bank's centralized computer on transmission and receipt of messages. Sketch the operation of your protocol for the case of a simple withdrawal with no errors, using a diagram similar to that of Figure 1.2. Explicitly state the assumptions made by your protocol about the underlying end-to-end transport service



Message from ATM	Action
HELLO <UID>	Informs BCC there is a user, and has it check the UID
PASSWD <PIN>	User enters in the PIN which is sent to the BCC
BAL	Informs the BCC the user wants to view their balance
WTHDRW <AMT>	Informs the BCC the user wants to withdraw the AMT specified
EXIT	User is done and the BCC can log them out

Message from Bank	Action
PASSWD	Prompts the user for their password
VALID	The latest request was valid
ERR	The latest request was invalid
BAL <AMT>	Sends the user their requested balance amount
EXIT	User has exited the machine, can now display welcome screen

Protocol Assumptions:

- Connection Oriented - there must be a secure connection between the ATM and the Bank
- Reliable Transport - there can be no loss of data or data out of order
- Flow Control - small amount of data is being transferred
- Congestion Control - cannot congest the network
- Timing - not too time sensitive
- Minimum Bandwidth Guarantees - the messages are few and small in size

4. Consider the circuit-switched network in Figure 1.13. Recall there are 4 circuits on each link. Label the four switches A, B, C, and D going in the clockwise direction

a. What is the maximum number of simultaneous connections that can be in progress at any one time in this network?
    - 16 simultaneous connections

b. Suppose that all connections are between switches A and C. What is the maximum number of simultaneous connections that can be in progress?
    - 8 Simultaneous connections

c. Suppose we want to make four connections between switches A and C, and another four connections between switches B and D. Can we route these calls through the four links to accomodate all eight connections?
    - Yes we can

6. Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is s meters/sec. Host A is to send a packet of size L bits to Host.

a. Express the propagation delay, dprop, in terms of m and s
    - $d_{prop} = m/s_{seconds}$

b. Determine the transmission time of the packet, dtrans, in terms of L and R
    - $d_{trans} = L/R_{seconds}$

c. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay

- $d_{end-to-end} = (m/s\ +\ L/R)_{seconds}$

d. Suppose Host A begins to transmit the packet at time t=0. At time t=dtrans, where is the last bit of the packet?
   - The bit is just leaving Host A

e. Suppose dprop is greater than dtrans. At time t=dtrans, where is the first bit of the packet?
   - The first bit is in the link and has not reached Host B

f. Suppose dprop is less than dtrans. At time t=dtrans, where is the first bit of the packet?
   - The first bit has reached Host B

g. Suppose s = 2.5*10^8, L=120 bits, and R = 56 kbps. Find the distance m so that dprop = dtrans
   - $m = \frac{L}{R}s = \frac{500}{56*10^3}(2.5 * 10^8) = 2232\ km$

7. We consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A converts analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 56-byte packets. There is only one link between Hosts A and B; its transmission rate is 2Mbps and its propagation delay is 10 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created until the bit is decoded?

- We must wait for the entire packet to be generated, for the packet to be transmitted over the 2 Mbps link and for one propagation delay
- $\frac{(56*8)}{64{,}000} + \frac{(56*8)}{2*10^6} + 0.01 = 17.223\ ms$

10. Consider a packet of length L which begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let di, si, and ri denote the length, propagation speed, and the transmission rate of link i for i = 1,2,3. The packet switch delays each packet by dproc. Assuming no queuing delays in terms of di, si, ri, and L, what is the total end to end delay for the packet? Suppose the packet is 1500 bytes, the propagation speed on all three links is 2.5 * 10^8 m/s, the transmission rates are 2 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5000 km, the length of the second link is 4000 km and the length of the last link is 1000 km.

- The first end system requires L/R_1 to transmit the packet onto the first link and propagates over the first link in d_1/s_1 and the packet switch adds d_{proc}
- $d_{end-to-end} = \frac{L}{R_1} + \frac{L}{R_2} + \frac{L}{R_3} + \frac{d_1}{s_1} + \frac{d_2}{s_2} + \frac{d_3}{s_3} + d_{proc} + d_{proc}$
- $d_{end-to-end} = 3(\frac{L}{R}) + 2(d_{proc}) + \frac{d_1}{s_1} + \frac{d_2}{s_2} + \frac{d_3}{s_3}$
- $d_{end-to-end} = 3(0.0057) + 0.003 + 0.003 + 0.02 + 0.016 + 0.004 = .064s = 64ms$

11. In the above problem, suppose R1=R2=R3=R and dproc = 0. Further suppose the packet switch does not store-and-forward packets but instead immediately transmits each bit it receives before waiting for the entire packet to arrive. What is the end-to-end delay?

- $d_{end-to-end} = (\frac{L}{R} + \frac{d_1}{s_1} + \frac{d_2}{s_2} + \frac{d_3}{s_3})$

- $d_{end-to-end} = (0.0057 + 0.02 + 0.016 + 0.004) = 0.457s = 46ms$

18. Perform a Traceroute between source and destination on the same continent at three different hours of the day.

a. Find the average and standard deviation of the round-trip delays at each of the three hours

Time:	**Average:**	**Standard Deviation:**
11 PM	0.74ms	0.181
12 AM	0.534	0.42

b. Find the number of routers in the path at each of the three hours. Did the paths change during any of the hours?
   - Yes the number of routers changed from 10 to 14

c. Try to identify the number of ISP networks that the Traceroute packets pass through from source to destination. Routers with similar names and/or similar IP addresses should be considered as part of the same ISP. In your experiments, do the largest delays occur at the peering interfaces between adjacent ISPs?
   - It looked like there was 5 and 3 ISPs and the largest delay was at the peering interfaces

d. Repeat the above for a source and destination on different continents. Compare the intra-continent and inter-continent results

29. Suppose there is a 10 Mbps microwave link between a geostationary satellite and its base station on Earth. Every minute the satellite takes a digital photo and sends it to the base station. Assume a propagation speed of 2.4*10^8m/s.

a. What is the propagation delay of the link?
   - The distance between earth and a geostationary satellite is $3.6 * 10^7 m$
   - $d_{prop} = \frac{3.6*10^7}{2.4*10^8} = 0.15s = 150ms$

b. What is the bandwidth-delay product, R*dprop?
   - $R * d_{prop} = 1,500,000\ bits$

c. Let x denote the size of the photo. What is the minimum value of x for the microwave link to be continuously transmitting?
   - 600,000,000 bits

30. Consider the airline travel analogy in our discussion of layering and the addition of headers to protocol data units as they flow down the protocol stack. Is there an equivalent notion of header information that is added to passengers and baggage as they move down the airline protocol stack?

- Yes there is