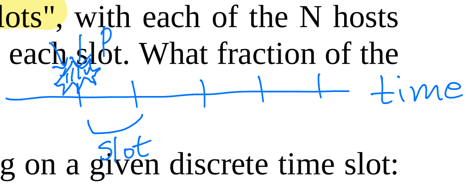
Homework Chapter #1 Solution

1. **(Problem 4)** A factor in the delay of a store-and-forward packet-switching system is how long it takes to store and forward a packet through a switch. If switching time is 10usec, is this likely to be a major factor in the response of a client-server system where the client is in New York and the server is in California? Assume the propagation speed in copper and fiber to be 2/3 the speed of light in vacuum.

   Solution:

   Switching time is not a major factor in the response of a client-server system since the switching time is 1/25000 the total propagation delay between New York and California. Note that the total propagation delay is 5000km / ((2/3) * 3*10^8) m/sec = 25000usec while the switching time is 10usec. Since the switching delay will not exceed a few hundred microseconds even if there are a few switches, it will not be a big deal comparing to the total end-to-end delay.

2. **(Problem 9)** A disadvantage of a broadcast subnet is the capacity wasted when multiple hosts attempt to access the channel at the same time. As a simplistic example, suppose that time is divided into discrete "slots", with each of the N hosts attempting to use the channel with probability p during each slot. What fraction of the slots will be wasted due to collisions?

   Solution:

   There are only three types of events possibly happening on a given discrete time slot: (1) No transmission attempt at all, i.e., the slot is idle with probability P_{idle}, (2) A successful transmission with probability P_{suc}, (3) More than one transmission attempts that results in collision with probability P_{col}. Since they are mutually exclusive and complete, $P_{col} + P_{suc} + P_{idle} = 1$.

   If 'p' is the probability of an attempt of a host in a 'slot', then the probability of 'no attempt' is (1-p). Now according to binomial distribution the probability that r hosts attempt while the rest (N-r) hosts do not send is

   $$P(r\ hosts\ attempt) = \binom{N}{r} p^r (1-p)^{N-r}$$

   $\sum_{r=2}^{N} NCr\, p^r (1-p)^{N-r}$

   In order for the slot to be idle there should be no attempt and therefore $r = 0$. After putting $r = 0$ in above equation, we get

   $$P(0\ hosts\ attempt) = \binom{N}{0} p^0 (1-p)^N = \frac{N!}{0!(N-0)!}(1-p)^N = (1-p)^N$$

   Therefore $P_{idle} = (1-p)^N$.

   Now let us find probability of success. In order for transmission to be successful there should be exactly one host attempting in a given slot with probability p while the remaining hosts will not attempt with probability (1-p).

   $$P(1\ host\ attempts) = \binom{N}{1} p^1 (1-p)^{N-1} = \frac{N!}{1!(N-1)!} p(1-p)^{N-1} = Np(1-p)^{N-1}$$

   $1 = (p + (1-p))^N$

   $= \sum_{r=0}^{N} NCr\, p^r (1-p)^{N-r}$

   Therefore $P_{suc} = Np(1-p)^{N-1}$.

   Since $P_{col} = 1 - P_{suc} - P_{idle}$, we get $P_{col} = 1 - Np(1-p)^{N-1} - (1-p)^N$. Namely the fraction of slots wasted due to collision is P_{col}.

   $= \sum_{r=2}^{N} NCr\, p^r (1-p)^{N-r}$

3. **(Problem 10)** What are two reasons for using layered protocols? What is one possible disadvantage of using layered protocols?

Solution:

Reason 1: Divide-and-Conquer. It is easy to implement complicated functions based on the services provided from the lower layer.

Reason 2: Isolation. It is easy to replace an old protocol with a newly designed protocol with little or no affects to other layers.

One Possible Disadvantage: Header overhead. Each layer to interact with its corresponding layer adds specific type of headers to the traffic that goes from one layer to the other. These headers are regarded as overhead and add to the total transmission and processing delay which will adversely affect the performance.

4. **(Problem 11)** What is the principal difference between connectionless communication and connection-oriented communication? Give one example of a protocol that uses (i) connectionless communication; (ii) connection oriented communication.

Solution:

The principal difference between the two types of communications is in-order delivery not reliability. A ***connection oriented*** communication is one that establishes and releases connection before and after initiating a communication, respectively. TCP (Transmission Control Protocol) is an example of such protocols that allows a byte steam originating at one machine to be delivered in sequence and without error to any other machine in the Internet.

On the other hand, ***connectionless communication*** is initiated without establishing a connection. UDP (User Datagram Protocol) is an example of connectionless communications. It is also widely used for client-server-type request-reply queries and applications in which prompt delivery is more important than reliable and in-order delivery, such as transmitting speech or video.

5. **(Problem 18)** A system has an n-layer protocol hierarchy. Applications generate messages of length M bytes. At each of the layers, an h-byte header is added. What fraction of the network bandwidth is filled with headers?

Solution:

Message	M
Layer 1	M+h
Layer 2	M+h+h
…	
…	
Layer n	M+nh

As shown in the above figure, there are *n* layers and each layer adds *h* bytes as a header to the message M. Therefore the total header size after the last layer would be *hn* bytes and the total size of the packet will become *M+nh* bytes. Hence, the fraction of bandwidth filled with headers is nh/(M+nh)

$50\text{Mbps} \cdot \frac{nh}{M+nh}$

6. **(Problem 22)** When transferring a file between two computers, (at least) two acknowledgement strategies are possible. In the first one, the file is chopped up into packets, which are individually acknowledged by the receiver, but the file transfer as a whole is not acknowledged. In the second one, the packets are not acknowledged

individually, but the entire file is acknowledged when it arrives. Discuss these two approaches.
Solution:

Strategy 1: File is chopped into packets and each one is individually acknowledged.

Strategy 2: Not individual packets but the entire file is acknowledged.

Overhead for Strategy 1: Let the size of acknowledgement for each packet is '*A*' bytes. If the total number of packets transmitted in Strategy 1 is '*N*' then the total number of ACK packets is *N*A* bytes

Overhead for Strategy 2: Let '*A'* bytes be the size of the acknowledgement packet that is sent after the whole file is received successfully.
There may be several aspects to consider but let us consider network status only. If the status of the channel is good or if network is error-free, then strategy 2 is better as overhead is only *A* bytes for transmitting the whole file. In contrast, if the status of the channel is bad, then strategy 1 is better assuming that size of the whole file is 'F bytes' and packet size is 'P bytes' where F>>P. In this case, transmitting the whole file as one data packet is infeasible in case it is corrupted due to the bad channel.

one bit error rate p ⇒ error probability?
N-bit packet $1-(1-p)^N$

7. **(Problem 26)** Ethernet and wireless networks have some similarities and some differences. One property of Ethernet is that only one frame at a time can be transmitted on an Ethernet. Does 802.11 share this property with Ethernet? Discuss your answer.
Solution:
Basically, Ethernet and wireless networks are a broadcasting network where only one sender transmits a frame. Unlike Ethernet, however, in 802.11 it is not possible for the station to listen channel when it is transmitting a frame and therefore it can't stop transmission even though the frames are useless. Also, a node in 802.11 can send data even when another is sending a frame since the node can't listen another's transmission. This happens when a node is placed out of the power range of another node. Finally, more than one transmission at a time can also result in successful delivery if 802.11 is in ad-hoc mode and each pair of transmitter-receiver is not in each other's transmission range. exposed problem

Collision 여부 모름

hidden station problem

8. **(Problem 35)** The ping program allows you to send a test packet to a given location and see how long it takes to get there and back. Try using ping to see how long it takes to get from your location to several known locations. From these data, plot the one-way transit time over the Internet as a function of distance. It is best to use universities since the location of their servers is known very accurately. For example, berkeley.edu is in Berkeley, California, mit.edu is in Cambridge, Massachusetts, vu.nl is in Amsterdam, the Netherlands, www.usyd.edu.au is in Sydney, Australia, and www.uct.ac.za is in Cape Town, South Africa.
Solution:
Ping commands to some of the university websites do not respond. It could be due to the firewall installed on the university network. I, instead, used other universities to experiment the use of 'Ping' command.
Ping Command Results:
For Berkeley.edu
Ping statistics for 169.229.216.200:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milliseconds:

Minimum = 143ms, Maximum = 146ms, Average = 144ms
For mit.edu
Ping statistics for 23.59.9.86:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milliseconds:
Minimum = 89ms, Maximum = 93ms, Average = 90ms

For vu.nl
Ping statistics for 37.60.194.64:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milliseconds:
Minimum = 278ms, Maximum = 289ms, Average = 281ms
For brad.ac.uk
Ping statistics for 143.53.240.215:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milliseconds:
Minimum = 285ms, Maximum = 295ms, Average = 288ms

For ksu.edu.sa
Ping statistics for 212.57.194.232:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milliseconds:
Minimum = 315ms, Maximum = 322ms, Average = 317ms
For snu.edu
Ping statistics for 64.89.44.97:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milliseconds:
Minimum = 209ms, Maximum = 220ms, Average = 215ms