Review Questions

- Suppose the network layer provides the following service. The network layer in the source host accepts a segment of maximum size 1,200 bytes and a destination host address from the transport layer. The network layer then guarantees to deliver the segment to the transport layer at the destination host. Suppose many network application processes can be running at the destination host.
  a. Design the simplest possible transport-layer protocol that will get application data to the desired process at the destination host. Assume the operating system in the destination host has assigned a 4-byte port number to each running application process.
  b. What is the difference between routing and forwarding?
  c. What is the concept of Software-Defined Networks?

- Describe how packet loss can occur at output ports. Can this loss be prevented by increasing the switch fabric speed?

- Compare and contrast the IPv4 and the IPv6 header fields. Do they have any fields in common?

Problems

1.

This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. 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 B.

a. Express the propagation delay, d_{prop}, in terms of m and s.
b. Determine the transmission time of the packet, d_{trans}, in terms of L and R.
c. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.
d. Suppose Host A begins to transmit the packet at time $t = 0$. At time $t = d_{trans}$, where is the last bit of the packet?
e. Suppose d_{prop} is greater than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?
f. Suppose d_{prop} is less than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet?
g. Suppose $s = 2.5 \cdot 10^8$, $L = 120$ bits, and $R = 56$ kbps. Find the distance m so that d_{prop} equals d_{trans}.

2.

In this problem, 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 one link between Hosts A and B; its transmission rate is 2 Mbps 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 (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

3.

Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that n DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT of $RTT_1, . . ., RTT_n$. Further suppose that the Web page associated with the link contains exactly one object, consisting of a small amount of HTML text. Let RTT_0 denote the RTT between the local host and the server containing the object. Assuming zero transmission time of the object, how much time elapses from when the client clicks on the link until the client receives the object?

4.

Consider the rdt 3.0 protocol. Draw a diagram showing that if the network connection between the sender and receiver can reorder messages (that is, that two messages propagating in the medium between the sender and receiver can be reordered), then the alternating-bit protocol will not work correctly (make sure you clearly identify the sense in which it will not work correctly). Your diagram should have the sender on the left and the receiver on the right, with the time axis running down the page, showing data (D) and acknowledgment (A) message exchange. Make sure you indicate the sequence number associated with any data or acknowledgment segment.

5.

Consider the TCP procedure for estimating RTT. Suppose that $\alpha = 0.1$. Let
$\texttt{SampleRTT}_1$ be the most recent sample RTT, let $\texttt{SampleRTT}_2$ be the next
most recent sample RTT, and so on.

a. For a given TCP connection, suppose four acknowledgments have been
   returned with corresponding sample RTTs: $\texttt{SampleRTT}_4$, $\texttt{SampleRTT}_3$,
   $\texttt{SampleRTT}_2$, and $\texttt{SampleRTT}_1$. Express $\texttt{EstimatedRTT}$ in terms of
   the four sample RTTs.

b. Generalize your formula for n sample RTTs.

c. For the formula in part (b) let n approach infinity. Comment on why this
   averaging procedure is called an exponential moving average.

6.

Recall the macroscopic description of TCP throughput. In the period of time
from when the connection's rate varies from $W/(2 \cdot RTT)$ to W/RTT, only one
packet is lost (at the very end of the period).

a. Show that the loss rate (fraction of packets lost) is equal to

$$L = \text{loss rate} = \frac{1}{\dfrac{3}{8}W^2 + \dfrac{3}{4}W}$$

b. Use the result above to show that if a connection has loss rate L, then its
   average rate is approximately given by

$$\approx \frac{1.22 \cdot MSS}{RTT \sqrt{L}}$$

7.

Consider a datagram network using 8-bit host addresses. Suppose a
router uses longest prefix matching and has the following forwarding
table:

Prefix Match	Interface
1	0
10	1
111	2
otherwise	3

For each of the four interfaces, give the associated range of destination host
addresses and the number of addresses in the range.