Solutions: Homework week 1

Review questions:

1. There is no difference. Throughout this text, the words “host” and “end system” are used interchangeably. End systems include PCs, workstations, Web servers, mail servers, Internet-connected PDAs, WebTVs, etc.
2. A networking program usually has two programs, each running on a different host, communicating with each other. The program that initiates the communication is the client. Typically, the client program requests and receives services from the server program.
3. A circuit-switched network can guarantee a certain amount of end-to-end bandwidth for the duration of a call. Most packet-switched networks today (including the Internet) cannot make any end-to-end guarantees for bandwidth.
4. 1.Dial-up modem over telephone line: residential; 2. DSL over telephone line: residential or small office; 3. Cable to HFC: residential; 4. 100 Mbps switched Etherent: company; 5. Wireless LAN: mobile; 6. Cellular mobile access (for example, WAP): mobile

5. If we want more bandwidth, we can just buy it; we can put a second fibre next to the first one and thus double our bandwidth. This does not, however, do anything to reduce the delay.
   Reducing delay is a more complex task. To make the delay shorter we need to improve the protocol software, the operating system, or the network software. In other words, the major bottleneck when delay is concerned is the transmission time of the hosts and nodes involved in the communication, including time waiting in the queues of the nodes in the network. If the physical distance between the nodes is large we have a propagation delay (bounded by the speed of light) which also has to be taken into account when calculating the delay. In other words: delay = propagation + transmit + queue+processing

Problems:

Problem 1.

There is no single right answer to this question. Many protocols would do the trick. Here's a simple answer below:

Messages from ATM machine to Server

```
Msg name              purpose
--------              -------
HELO <userid>         Let server know that there is a card in the
                      ATM machine
                      ATM card transmits user ID to Server
PASSWD <passwd>       User enters PIN, which is sent to server
```

```
BALANCE               User requests balance
WITHDRAWL <amount>    User asks to withdraw money
BYE                   user all done
```

Messages from Server to ATM machine (display)

```
Msg name              purpose
--------              -------
PASSWD                Ask user for PIN (password)
OK                    last requested operation (PASSWD, WITHDRAWL)
                      OK
ERR                   last requested operation (PASSWD, WITHDRAWL)
                      in ERROR
AMOUNT <amt>          sent in response to BALANCE request
BYE                   user done, display welcome screen at ATM
```

Correct operation:

```
client                          server

HELO (userid)    --------------> (check if valid userid)
                 <-------------   PASSWD
PASSWD <passwd>  --------------> (check password)
                 <-------------   OK (password is OK)
BALANCE          -------------->
                 <-------------   AMOUNT <amt>
WITHDRAWL <amt>  --------------> check if enough $ to cover
                                  withdrawl
                 <-------------   OK
ATM dispenses $
BYE              -------------->
                 <-------------   BYE
```

In situation when there's not enough money:

```
HELO (userid)    --------------> (check if valid userid)
                 <-------------   PASSWD
PASSWD <passwd>  --------------> (check password)
                 <-------------   OK (password is OK)
BALANCE          -------------->
                 <-------------   AMOUNT <amt>
WITHDRAWL <amt>  --------------> check  if  enough  $  to  cover
withdrawl
                 <-------------   ERR (not enough funds)
error msg displayed
no $ given out
BYE              -------------->
                 <-------------   BYE
```

Problem 2.

a) A circuit-switched network would be well suited to the application described, because the application involves long sessions with predictable smooth bandwidth requirements. Since the transmission rate is known and not bursty, bandwidth can be reserved for each application session circuit with no significant waste. In addition, we need not worry greatly about the overhead costs of setting up and tearing down a circuit connection, which are amortized over the lengthy duration of a typical application session.

b) Given such generous link capacities, the network needs no congestion control mechanism. In the worst (most potentially congested) case, all the applications simultaneously transmit over one or more particular network links. However, since each link offers sufficient bandwidth to handle the sum of all of the applications' data rates, no congestion (very little queueing) will occur.

Problem 3

a) The time to transmit one packet onto a link is $(L+h)/R$. The time to deliver the first of the M packets to the destination is $Q(L+h)/R$. Every $(L+h)/R$ seconds a new packet from the $M-1$ remaining packets arrives at the destination. Thus the total latency is

$$t_s + (Q+M-1)(L+h)/R.$$

b) $(Q+M-1)(L+2h)/R$

c) The time required to transmit the message over one link is $(LM+2h)/R$. The time required to transmit the message over Q links is $Q(LM+2h)/R$.

d) Because there is no store-and-forward delays at the links, the total delay is

$$t_s + (h+ML)/R.$$

Problem 4

a) $d_{prop} = m/s$ seconds.

b) $d_{trans} = L/R$ seconds.

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

d) The bit is just leaving Host A.

e) The first bit is in the link and has not reached Host B.

f) The first bit has reached Host B.

g) Want

$$m = \frac{L}{R}S = \frac{100}{28\times 10^3}\left(2.5\times 10^8\right) = 893\,\text{km}.$$

Problem 5

Consider the first bit in a packet. Before this bit can be transmitted, all of the bits in the packet must be generated. This requires

$$\frac{48\cdot 8}{64\times 10^3}\text{ sec=6msec.}$$

The time required to transmit the packet is

$$\frac{48 \cdot 8}{1 \times 10^6} \text{ sec} = 384 \mu \text{ sec.}$$

Propagation delay = 2 msec.
The delay until decoding is

$$6\text{msec} + 384\mu\text{ sec} + 2\text{msec} = 8.384\text{msec}$$

A similar analysis shows that all bits experience a delay of 8.384 msec.

Problem 6

It takes LN/R seconds to transmit the N packets. Thus, the buffer is empty when a batch of N packets arrive.

The first of the N packets has no queueing delay. The 2nd packet has a queueing delay of L/R seconds. The nth packet has a delay of $(n-1)L/R$ seconds.

The average delay is

$$\frac{1}{N}\sum_{n=1}^{N}(n-1)L/R = \frac{L}{R}\frac{1}{N}\sum_{n=0}^{N-1}n = \frac{L}{R}\frac{1}{N}\frac{(N-1)N}{2} = \frac{L}{R}\frac{(N-1)}{2}.$$