R 12. 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. FDM requires sophisticated analog hardware to shift signal into appropriate frequency bands.

R 19. a) 500 kbps

b) 64 seconds

c) 100kbps; 320 seconds

R 22. Five generic tasks are error control, flow control, segmentation and reassembly, multiplexing, and connection setup. Yes, these tasks can be duplicated at different layers. For example, error control is often provided at more than one layer.

R 24. Application-layer message: data which an application wants to send and passed onto the transport layer; transport-layer segment: generated by the transport layer and encapsulates application-layer message with transport layer header; network-layer datagram: encapsulates transport-layer segment with a network-layer header; link-layer frame: encapsulates network-layer datagram with a link-layer header.

R 25. Routers process network, link and physical layers (layers 1 through 3). (This is a little bit of a white lie, as modern routers sometimes act as firewalls or caching components, and process Transport layer as well.) Link layer switches process link and physical layers (layers 1 through2). Hosts process all five layers.

Problem 6

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

b) d_{tran} = L/R seconds.

c) $d_{end\text{-}to\text{-}end}$ = (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) We want m = L / R s = (1500×8 / 10×106) * (2. 5 × 108) = 3 × 105 = 300 km.

Problem 7

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 (56 * 8 / 64*103) sec = 7msec.

The time required to transmit the packet is (56×8) / 10×106 sec = 44. 8μ sec.

Propagation delay = 10 msec.

The delay until decoding is 7m + 44. 8μ + 10m = 17. 0448m sec.

A similar analysis shows that all bits experience a delay of 17.0448 msec.

Problem 20

Throughput = min{Rs, Rc, R/M}

Problem 28

a)

P28: Solution:

from problem P25

distance = m = 20,000 Km

R = 5Mbps

$S = 2.5 \times 10^8$ m/s

L = 800,000 bits.

(a): How long does it take to send file...

$$d_{prop} = \frac{m}{S} = \frac{20{,}000 \times 10^3 \text{ m}}{2.5 \times 10^8 \text{ m/s}} = 0.08 \text{ sec}$$

$$d_{trans} = \frac{L}{R} = \frac{800{,}000 \text{ b}}{5 \times 10^6 \text{ b/s}} = 0.16 \text{ sec}$$

$$T = d_{prop} + d_{trans} = 0.08 + 0.16$$

$$\simeq 0.24 \text{ sec}$$

$$= 240 \text{ msec}$$

b)

b) File divided into 20 packets.

Length of each packet = 40,000bits

$d_{prop} = d/s = \frac{2\times10^7}{2.5\times10^8} = 0.08sec = 80msec$

$d_{trans} = \frac{40000}{5\times10^6} = 0.008 sec = 8msec$

time required to transmit n packets $= n(2d_{prop} + d_{trans})$

" " " " 20 " $= 20(2\times80+8)$

$= 20(160+8) = 20(168)$.

$= 3360msec$

c) Breaking up a file takes longer to transmit because each data packet and its corresponding acknowledgement packet add their own propagation delays.

Problem 31

a) Time to send message from source host to first packet switch = 106 / 5×106 = 0. 2sec with store-and-forward switching, the total time to move message from source host to destination host =0. 2sec × 3hops = 0. 6sec

b)

(b): Solution:

message segmented into = 100 palkest
each packet length = 10,000 bit

Time to send 1st packet from source host to first packet switch = $\frac{\text{Leangth of each packet}}{R} = \frac{10000 \text{ bits}}{5 \times 10^6 \text{ b/s}} = 0.002$ sec $= 2$ msec

time at which 2nd packet is recieved at 1st switch = time at which 1st packet is recieved at second switch = 2×2 msec = 4 msec

c)

c) Time at which first packet recieved at destination host = $0.002 \times 3 = 0.006$ sec.
Every 0.002 sec 1 packet will be recieved.
So time at which last 100th packet is recieved = 0.006 sec $+ (100-1) \times 0.002$ sec
$= 0.204$ sec

d)

i. Without message segmentation, if bit errors are not tolerated, if there is a single bit error, the whole message has to be retransmitted (rather than a single packet).
ii. Without message segmentation, huge packets (containing HD videos, for example) are sent into the network. Routers have to accommodate these huge packets. Smaller packets have to queue behind enormous packets and suffer unfair delays.

e)

i. Packets have to be put in sequence at the destination.

ii. Message segmentation results in many smaller packets. Since header size is usually the same for all packets regardless of their size, with message segmentation the total amount of header bytes is more.