ASSIGNMENT 1 – SOLUTION

PART-01

R11.

At time t0 the sending host begins to transmit. At time t1 = L/R1, the sending host completes transmission and the entire packet is received at the router (no propagation delay). Because the router has the entire packet at time t1, it can begin to transmit the packet to the receiving host at time t1. At time t2 = t1 + L/R2, the router completes transmission and the entire packet is received at the receiving host (again, no propagation delay). Thus, the end-to-end delay is L/R1 + L/R2.

R12

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.

R19

a) 500 kbps

b) 64 seconds

c) 100kbps; 320 seconds

R24

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; linklayer frame: encapsulates network-layer datagram with a link-layer header

Problem 6

a) dprop = m/s seconds.
b) dtran = L/R seconds.
c) dend-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) We want $m = L / R\, s = (1500\times8 / 10\times10^6) * (2.5 \times 10^8) = 3 \times 10^5 = 300$ km

Problem 10

The first end system requires L/R_1 to transmit the packet onto the first link; the packet propagates over the first link in d_1/s_1; the packet switch adds a processing delay of d_{proc}; after receiving the entire packet, the packet switch connecting the first and the second link requires L/R_2 to transmit the packet onto the second link; the packet propagates over the second link in d_2/s_2. Similarly, we can find the delay caused by the second switch and the third link: L/R_3, d_{proc}, and d_3/s_3. Adding these five delays gives

$$d_{end-end} = L/R_1 + L/R_2 + L/R_3 + d_1/s_1 + d_2/s_2 + d_3/s_3 + d_{proc} + d_{proc}.$$

To answer the second question, we simply plug the values into the equation to get: $0.0048 + 0.0048 + 0.0048 + 0.02+0.016 + 0.004 + 0.003 + 0.003 = 0.0604$ sec.

Problem 20

Throughput = $\min\{R_s, R_c, R/M\}$

Problem 25

a) Bandwidth-delay Product = R x **D**prop
   $= (5 \times 10^6) \times ((20000\times10^3) / (2.5\times10^8))$
   = 400,000 bits
b) 400,000 bits
c) The bandwidth-delay product of a link is the maximum number of bits that can be in the link.

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): Solution:

message segmented into: 100 packest
each packet length: 10,000 bit

Time to send 1^{st} 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 1^{st} switch = time at which 1st packect is recieved at second switch = 2×2 msec = 4msec

c) Time at which first packet recieved at destination host $= 0.002 \times 3 = 0.006$ sec.
Every 0.002sec 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.

PART-02

a) When circuit switching is used, at most 6 circuit-switched users that can be supported. This is because each circuit-switched user must be allocated 25 Mbps bandwidth, and there is 150 Mbps of link capacity that can be allocated.
b) No. Under circuit switching, the 11 users would each need to be allocated 25 Mbps, for an aggregate of 275 Mbps - more than the 150 Mbps of link capacity available