Question 1 (segmentation)

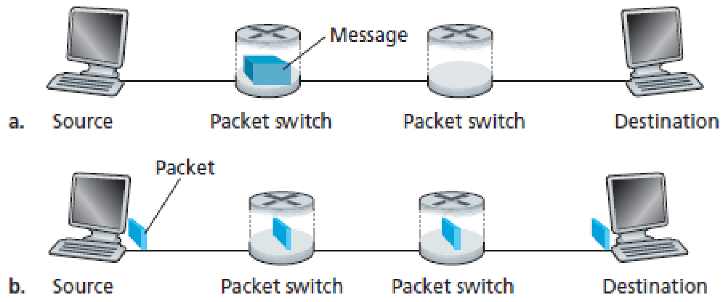

Figure 1

a) L_f= 1 MByte
R= 1 Mbps

Time for the file to move one hop= L_f/R= $1\times8\times10^6/10^6$= 8 sec
Total time= 3×8= 24 seconds

b) Number of packets= 4000
L_p= 2 Kb
R= 1 Mbps

Let T(1) denote the time for 1 packet to arrive at destination, i.e. to move 3 hops.
$T(1)= 3\times(2\times10^3/10^6)=3\times0.002=0.006$ sec

Packet n arrives at destination 0.002 sec after packet n-1:

$$T(n) = T(n-1) + 0.002$$

By recurrence,

$$T(n) = T(1) + (n-1)\times0.002$$
$$T(n) = 0.006+0.002\times n - 0.002$$
$$T(n) = 0.002\times n + 0.004$$

Hence, $T(4000)=0.002\times4000 + 0.004 = 8.004$ sec

Question 2 (non persistent HTTP)

a) $4\times RTT_0 = 4\times1.5 = 6$ sec time for name resolution
$RTT_1+RTT_1 = 2+2 = 4$ sec time for one TCP connection + receiving the HTML file
$7\times(RTT_1+RTT_1)= 7\times4= 28$ sec time for receiving 7 objects, each requires a TCP connection

A total of 38 seconds.

b) $4\times RTT_0 = 4\times1.5 = 6$ sec time for name resolution
$RTT_1+RTT_1 = 2+2 = 4$ sec time for one TCP connection + receiving the HTML file
$RTT_1+RTT_1 = 2+2 = 4$ sec time for one TCP connection + receiving 4 objects in parallel
$RTT_1+RTT_1 = 2+2 = 4$ sec time for one TCP connection + receiving 3 objects in parallel

A total of 18 seconds.

Question 3 (steady state) .

Assumptions: Assume that the system is in state S_0, S_1, S_2 , S_3 with probability P_0, P_1, P_2, P_3 respectively. Also, $\frac{P_a}{P_d} = \frac{1}{3}$.

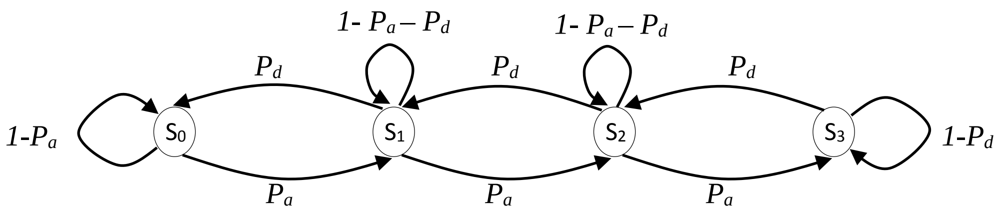

Figure 2

Based on Figure 2 and since $\frac{P_a}{P_d} = \frac{1}{3}$:

$P_0=3P_1$ $\quad$ $P_1=3P_2$ $\quad$ $P_2=3P_3$ $\quad$ (1)

Also, $P_3 + P_2 + P_1 + P_0 = 1$: $\quad$ (2)

(1) and (2) ==> $P_3 + 3P_3 + 9P_3 + 27P_3 = 1$

$40P_3=1$ ==> $P_3 = 1/40$ $\quad$ $P_2 = 3/40$ $\quad$ $P_1 = 9/40$ $\quad$ $P_0 = 27/40$

In other words: $P_3 = 0.025$ $\quad$ $P_2 = 3*0.025=0.075$ $\quad$ $P_1 = 3*0.075=0.225$ $\quad$ $P_0 = 3*0.225=0.675$

Part 1: true

- DNS, the domain name system, is a transport layer protocol.
- A circuit-switched network can guarantee a certain amount of end-to-end bandwidth for the duration of a call.
- HTTP and DNS have in-band control messages.
- Transmission delay is normally shorter than propagation delay for small packets.
- It takes 1 msec for a packet of length 1 Kb to transmit over a link of distance 5 Km, propagation speed of 10^6 mps, and transmission rate of 10^6 bps, neglecting any other delays.
- In BitTorrent, while a peer does not have any chunk it cannot become a top-four uploader for any other peer.
- HTTP response messages can have an empty message body.

Part 1: false

- If there are 50 users in a system each of which is active only 10% of the time, the probability of having at least 11 users active at the same time is significantly (e.g. more than 10 times) higher than the probability of having exactly 11 users active.
- The time between any two packet arrivals is called inter-arrival time.
- TLS, the transport layer security, is a transport layer protocol.