CH 1

Problem 5

Tollbooths are 75 km apart, and the cars propagate at 100km/hr. A tollbooth services a car at a rate of one car every 12 seconds.

a) There are ten cars. It takes 120 seconds, or 2 minutes, for the first tollbooth to service the 10 cars. Each of these cars has a propagation delay of 45 minutes (travel 75 km) before arriving at the second tollbooth. Thus, all the cars are lined up before the second tollbooth after 47 minutes. The whole process repeats itself for traveling between the second and third tollbooths. It also takes 2 minutes for the third tollbooth to service the 10 cars. Thus the total delay is 96 minutes.

b) Delay between tollbooths is 8*12 seconds plus 45 minutes, i.e., 46 minutes and 36 seconds. The total delay is twice this amount plus 8*12 seconds, i.e., 94 minutes and 48 seconds.

Problem 6

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

$$m = \frac{L}{R} s = \frac{120}{56 \times 10^3}\left(2.5 \times 10^8\right) = 536\,\text{km}.$$

Problem 8

a) 20 users can be supported.
b) $p = 0.1$.
c) $\binom{120}{n} p^n (1-p)^{120-n}$.
d) $1 - \sum_{n=0}^{20} \binom{120}{n} p^n (1-p)^{120-n}$.

We use the central limit theorem to approximate this probability. Let X_j be independent random variables such that $P(X_j = 1) = p$.

$$P(\text{ "21 or more users" }) = 1 - P\left(\sum_{j=1}^{120} X_j \le 21\right)$$

$$P\left(\sum_{j=1}^{120} X_j \le 21\right) = P\left(\frac{\sum_{j=1}^{120} X_j - 12}{\sqrt{120 \cdot 0.1 \cdot 0.9}} \le \frac{9}{\sqrt{120 \cdot 0.1 \cdot 0.9}}\right)$$

$$\approx P\left(Z \le \frac{9}{3.286}\right) = P(Z \le 2.74)$$

$$= 0.997$$

when Z is a standard normal r.v. Thus $P(\text{ "21 or more users" }) \approx 0.003$.

Problem 13

a) The queuing delay is 0 for the first transmitted packet, *L/R* for the second transmitted packet, and generally, *(n-1)L/R* for the n^{th} transmitted packet. Thus, the average delay for the *N* packets is:

(L/R + 2L/R + ... + (N-1)L/R)/N
*= L/(RN) * (1 + 2 + ... + (N-1))*
*= L/(RN) * N(N-1)/2*
= LN(N-1)/(2RN)
= (N-1)L/(2R)

Note that here we used the well-known fact:

1 + 2 + ... + N = N(N+1)/2

b) It takes LN/R seconds to transmit the N packets. Thus, the buffer is empty when a each batch of N packets arrive. Thus, the average delay of a packet across all batches is the average delay within one batch, i.e., $(N\text{-}1)L/2R$.

Problem 31

a) Time to send message from source host to first packet switch = $\frac{8 \times 10^6}{2 \times 10^6} \sec = 4 \sec$

With store-and-forward switching, the total time to move message from source host to destination host = $4 \sec \times 3\ hops = 12 \sec$

b) Time to send 1st packet from source host to first packet switch = . $\frac{1 \times 10^4}{2 \times 10^6} \sec = 5\ m\sec$. Time at which 2nd packet is received at the first switch = time at which 1st packet is received at the second switch = $2 \times 5m\sec = 10\ m\sec$

c) Time at which 1st packet is received at the destination host = $5\ m\sec \times 3\ hops = 15\ m\sec$. After this, every 5msec one packet will be received; thus time at which last (800th) packet is received = $15\ m\sec + 799 * 5m\sec = 4.01\sec$. It can be seen that delay in using message segmentation is significantly less (almost 1/3rd).

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.

Problem 33

There are *F/S* packets. Each packet is S=80 bits. Time at which the last packet is received at the first router is $\frac{S+80}{R} \times \frac{F}{S}$ sec. At this time, the first F/S-2 packets are at the destination, and the F/S-1 packet is at the second router. The last packet must then be transmitted by the first router and the second router, with each transmission taking $\frac{S+80}{R}$ sec. Thus delay in sending the whole file is $delay = \frac{S+80}{R} \times (\frac{F}{S} + 2)$

To calculate the value of S which leads to the minimum delay,

$$\frac{d}{dS} delay = 0 \Rightarrow S = \sqrt{40F}$$

CH2

Problem 1

a) F
b) T
c) F
d) F
e) F

Problem 3

The browser first needs to retrieve the IP address corresponding to the server name in the URL. To do so, it contacts the local DNS server (with UDP on port 53) and issues a Type A query. Once it has obtained the IP address, the browser opens a connection (with TCP on port 80) with the web browser and sends an HTTP request in the form GET /about HTTP/1.1 followed by some headers (e.g., the User-agent header). The server replies with an HTTP response containing the HTML document in its body. If the webpage includes other resources, such as images, the browser requests each of them through the same connection or with multiple connections, depending on its settings

Problem 9

a) The time to transmit an object of size L over a link or rate R is L/R. The average time is the average size of the object divided by R:

   Δ = (850,000 bits)/(15,000,000 bits/sec) = .0567 sec

   The traffic intensity on the link is given by $\beta\Delta$=(16 requests/sec)(.0567 sec/request) = 0.907. Thus, the average access delay is (.0567 sec)/(1 - .907) $\approx$ .6 seconds. The total average response time is therefore .6 sec + 3 sec = 3.6 sec.

b) The traffic intensity on the access link is reduced by 60% since the 60% of the requests are satisfied within the institutional network. Thus the average access delay is (.0567 sec)/[1 – (.4)(.907)] = .089 seconds. The response time is approximately zero if the request is satisfied by the cache (which happens with probability .6); the average response time is .089 sec + 3 sec = 3.089 sec for cache misses (which happens 40% of the time). So the average response time is (.6)(0 sec) + (.4)(3.089 sec) = 1.24 seconds. Thus the average response time is reduced from 3.6 sec to 1.24 sec.

Problem 10

The total download time is:

a. $2 \cdot 100$ ms $+ 8 \cdot 10^3$ bits / 10^6 bits/s $+ 5 \cdot (2 \cdot 100$ ms $+ 4 \cdot 10^5$ bits / 10^6 bits/s$) = 3.208$ s

b. $3 \cdot (2 \cdot 100$ ms $+ 4 \cdot 10^5$ bits / 10^6 bits/s$) = 1.8$ s

c. $2 \cdot 100$ ms $+ 4 \cdot 10^5$ bits / 10^6 bits/s $= 0.6$ s

d. $2 \cdot 100$ ms $+ 8 \cdot 10^3$ bits / 10^6 bits/s $+ 5 \cdot (4 \cdot 10^5$ bits / 10^6 bits/s$) = 2.208$ s

Problem 22

For calculating the minimum distribution time for client-server distribution, we use the following formula:

$$D_{cs} = max\ \{NF/u_s,\ F/d_{min}\}$$

Similarly, for calculating the minimum distribution time for P2P distribution, we use the following formula:

$$D_{P2P} = max\{F/u_s,\ F/d_{min},\ NF/(u_s + \sum_{i=1}^{N} u_i)\}$$

Where, F = 15 Gbits = 15 * 1024 Mbits

u_s = 30 Mbps

$d_{min} = d_i$ = 2 Mbps

Note, 300Kbps = 300/1024 Mbps.

Client Server

		N		
		10	**100**	**1000**
	300 Kbps	7680	51200	512000
u	**700 Kbps**	7680	51200	512000
	2 Mbps	7680	51200	512000

Peer to Peer

		N		
		10	**100**	**1000**
	300 Kbps	7680	25904	47559
u	**700 Kbps**	7680	15616	21525
	2 Mbps	7680	7680	7680

Problem 25

Yes. His first claim is possible, as long as there are enough peers staying in the swarm for a long enough time. Bob can always receive data through optimistic unchoking by other peers.

His second claim is also true. He can run a client on each host, let each client "free-ride," and combine the collected chunks from the different hosts into a single file. He can even write a small scheduling program to make the different hosts ask for different chunks of the file. This is actually a kind of Sybil attack in P2P networks.