COMPUTER COMMUNICATION NETWORKS

Prajeesha

Department of Electronics and Communication Engineering

COMPUTER COMMUNICATION NETWORKS

Delay Analysis - Numerical

Prajeesha

Department of Electronics and Communication Engineering

Delay Analysis - Numerical

Numerical 1: Consider a 3 Mbps link being shared by 10 users.

- Suppose we want to achieve maximum throughput using circuit switching. What should be the maximum data packet size for a user assuming 10% guard interval? Assuming a user wants to transmit 64000 bits of data how much time will he take to complete full data transmission?
- <u>Solution:</u>

Throughput is maximized so link rate is divided equally among the users. So per user gets (R) 0.3Mbps.

Slot time = 1/10 = 0.1s

Transmission delay (d_t) = 0.09 sec (i.e., excluding the 10% of the slot time).

So the maximum packet size L = dt * R =0.3M * 0.09 = 27 kb

To transfer 64000 bits of data, the user spends

64kb / 27kb = 2.37

Numerical 1 (contd.): Consider a 3 Mbps link being shared by 10 users.

- Suppose packet switching is used. What is the maximum achievable throughput? Assuming every user is active only 10% of the time and transmits at a rate of 1Mbps. What is the probability of no queuing?
- <u>Solution:</u>

Maximum achievable throughput is 3Mbps. However, user only transmits at the rate of 1Mbps.

Probability of one user being active (p) is 0.1.

As long as there are less than or equal to 3 active users, the rate

ccurs.

$$P(no\ queuing) = P(\leq 3\ users\ are\ active)$$

$$= P(0\ users\ active) + P(1\ user\ active) + P(2\ users\ active) + P(3\ users\ active)$$

$$P(no\ queuing) = (1-p)^{10} + 10C_1 p(1-p)^9 + 10C_2 p^2(1-p)^8 + 10C_3 p^3(1-p)^7$$

$$= 0.9872$$

- Numerical 2: Suppose there is a 10 Mbps microwave link between a geostationary satellite and its base station on Earth. Every minute the satellite takes a digital photo and sends it to the base station. Assume a propagation speed of 2.4×10^8 m/s.

  What is the propagation delay of the link?

  What is the bandwidth-delay product, $R \cdot d_{prop}$?

  Let x denote the size of the photo. What is the minimum value of x for the microwave link to be continuously transmitting?

  - Solution:

  Propagation delay is (36000 km)/(2.4×10^8 m/s) = 150 ms

  Bandwidth-delay product 1500 kb

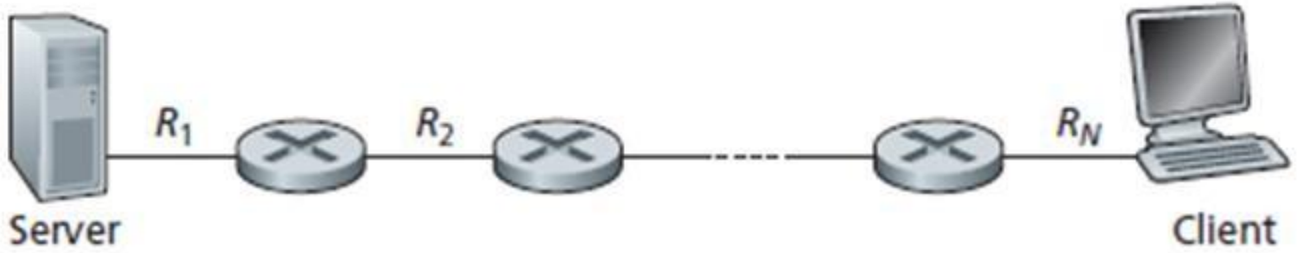
  Time between photo transmission is 60s therefore, transmit 600 Mb

- Numerical 3: Consider the figure below where transmission delay is the only significant delay. Each link is 2Mbps. Suppose the number of links N is 3. Calculate the end to end delay for the two cases given below. Note that each switch is a store and forward switch.

1. If message of size8 Mb is transferred without segmentation.
2. If the message is segmented into 800 packets of 10 kb length.

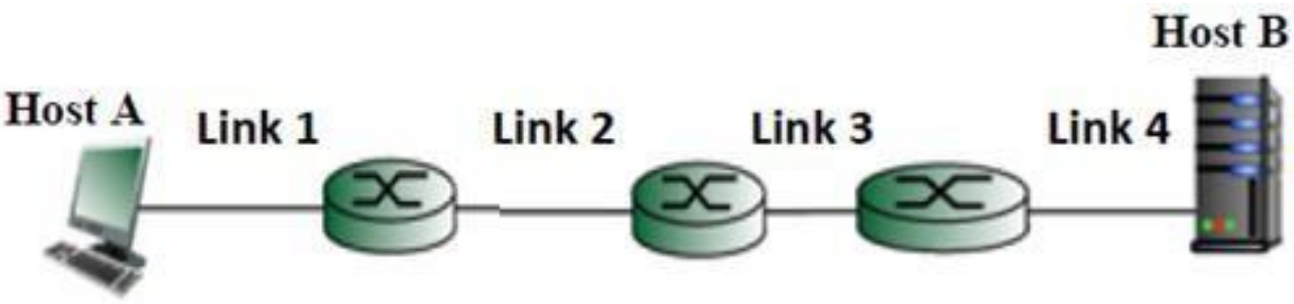
- Solution:

1. L = 8 Mb, End to end delay = 3 × L/R = 12 sec
2.



- <u>Numerical 4:</u>

Calculate the time taken in transmission of 20,000 bits from host A to B. The data is divided into 5 packets of 4000 bits each. All four links have an identical rate of 2 Mbps and 10 Km long. Assume optical link & no processing or queuing delays. (Note-Speed of light in optical fiber is approximately 70% the speed of light).



- Numerical 4 (Cont.):

Solution:

- Speed of light in optical fiber is approximately 70% the speed of light $c_o = 2\times 10^8 m/s$
- Propagation delay per link is given by $d_p = \frac{d}{c_o} = 10\times 10^3 /2\times 10^8$ = 50μs
- Transmission time for all the bits at host A is $d_t = \frac{L}{R} = 4000 /2\times 10^6$ = 2ms
- At $4\times\frac{L}{R}$ the 5th packet starts transmission at Host A, at $5\times\frac{L}{R}+ d_p$ the 5th packet is at R1, at $6\times\frac{L}{R}+2d_p$ the 5th packet is at R2, at $7\times\frac{L}{R}+ 3d_p$, the 5th packet is at R3 and at $8\times\frac{L}{R}+ 4d_p$, the 5th packet is at Host B.
- Therefore, the total time taken is $8\times\frac{L}{R}+ 4d_p$ = $8\times 4000 /2\times 10^6$ + (4×50μs) = 16.2ms

Numerical 1

- Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that n DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT of $RTT_1, \ldots, RTT_n$. Further suppose that the Web page associated with the link contains exactly one object, consisting of a small amount of HTML text. Let RTT_0 denote the RTT between the local host and the server containing the object. Assuming zero transmission time of the object, how much time elapses from when the client clicks on the link until the client receives the object?

Numerical1 (Cont)

Solution:

Total elapsed time = Delay accessing n DNS servers recursively + RTT due to TCP connection establishment + RTT due to HTTP request-response

$$= \sum_{i=1}^{n} RTT_i + 2\, RTT_0$$

Numerical 1 (Cont): Suppose the HTML file references eight very small objects on the same server. Neglecting transmission times, how much time elapses with

1. Non-persistent HTTP with no parallel TCP connections?
2. Non-persistent HTTP with the browser configured for 5 parallel connections?
3. Persistent HTTP (no parallel connections)?

Numerical 1 (Cont.):

Solution:

1. Non-persistent with no parallel connections : $\Sigma_{i=1}^{n} RTT_i + 2\ RTT_0 + 16\ RTT_0$

The first two terms as before. The 3rd term is equal to No. of objects * (RTT due to TCP handshake + RTT due to HTTP request-response)

2. Non-persistent with 5 parallel connections : $\Sigma_{i=1}^{n} RTT_i + 2\ RTT_0 + 4\ RTT_0$

The first two terms as before. First 5 out of the 8 objects can be downloaded in parallel and then the remaining 3 objects can be downloaded in parallel. Each object is downloaded after establishing a separate TCP connection. Hence, we get the 3rd term 4 RTT_0

3. Persistent with no parallel connections : $\Sigma_{i=1}^{n} RTT_i + 2\ RTT_0 + 8\ RTT_0$

The first two terms as before. The TCP connection has been established for the HTML file already. As we are dealing with persistent connection, we request each object on the existing TCP connection. Hence the 3rd term is simply No. of objects multiplied with the RTT due to HTTP request-response.

Numerical 2 :

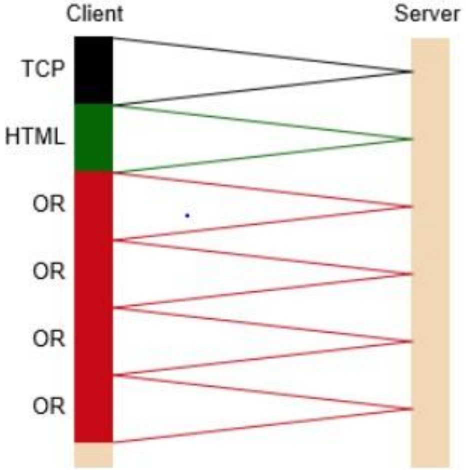
Draw a simple timing diagram indicating the delays involved in retrieving a web page containing the base HTML object and 4 additional images using

(i) Persistent HTTP
(ii) Non-persistent HTTP and
(iii) Persistent HTTP with three parallel connections. Assume size of all objects to be negligible. Express total delay in terms of RTT.

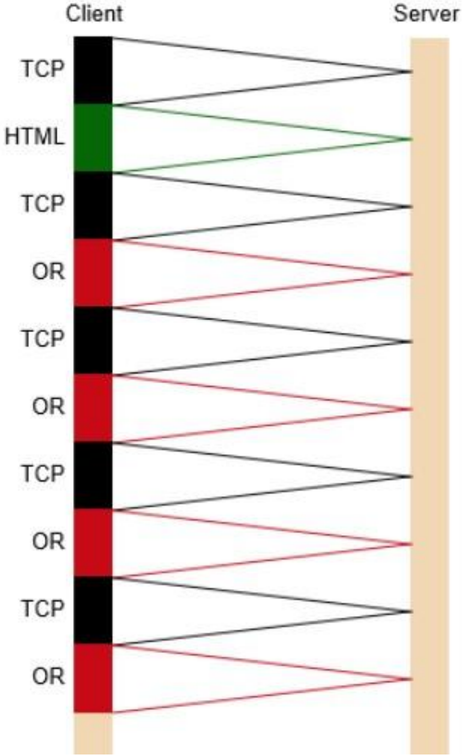
Numerical 2 :

Solution:

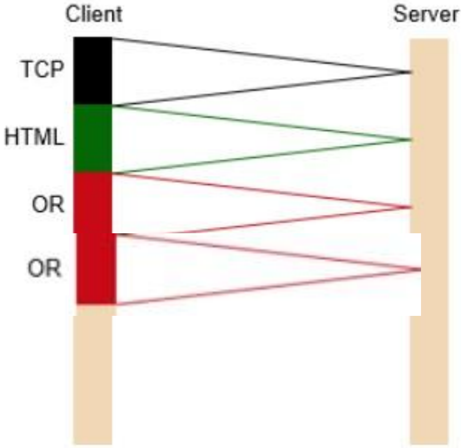
(i)
Persistent HTTP
6 RTT



(ii)
Non-Persistent
10 RTT



(iii)
Persistent with parallel
4 RTT



THANK YOU

Prajeesha
Department of Electronics and Communication Engineering