COMPUTER COMMUNICATION NETWORKS (UE22EC351A)

Department of Electronics and Communication Engineering

COMPUTER COMMUNICATION NETWORKS (UE22EC351A)

UNIT 1: INTERNET ARCHITECTURE AND APPLICATIONS – Class 6 – Numerical Problems on Delay, Loss & Throughput in Packet-Switched Networks

Department of Electronics and Communication Engineering

COMPUTER COMMUNICATION NETWORKS

UNIT 1– Class 6 – Numericals on Delay, Loss & Throughput in Packet-Switched Networks

Department of Electronics and Communication Engineering

- Numerical 4: 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 sec

- Numerical 4 (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?
  - Solution:

    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 of transmission will not exceed the link rate so no queuing occurs. Therefore,

$$P(no\ queuing) = P(\leq 3\ users\ are\ active)$$
$$= P(0\ users\ active) + P(1\ user\ active) + P(2\ users\ active) + P(3\ users\ active)$$

- Solution (contd.):

$$P(no\ queuing) = (1-p)^{10} + 10C_1 p(1-p)^9 + 10C_2 p^2(1-p)^8 + 10C_3 p^3(1-p)^7$$
$$= 0.9872$$

- Numerical 5: 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?

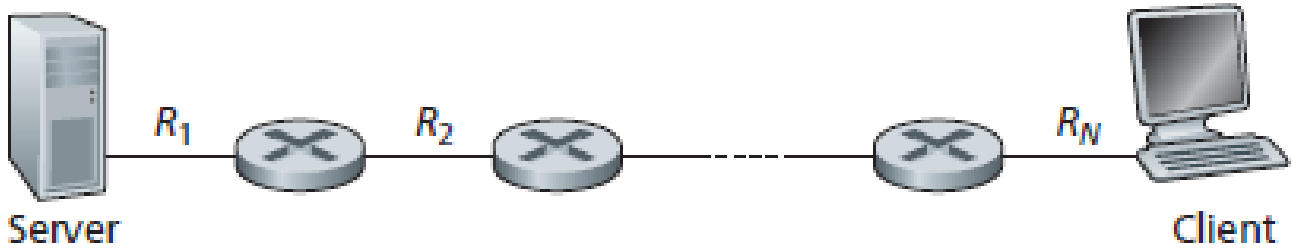
- Solution:

  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

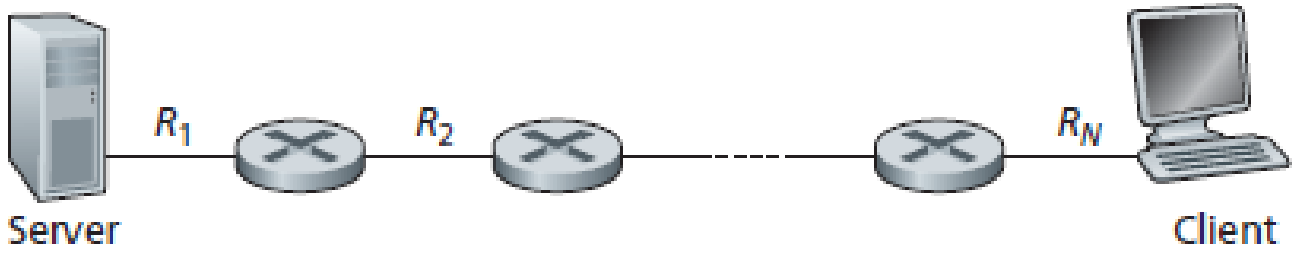
- Numerical 6: Consider the figure below where transmission delay is the only significant delay. Each link is 2Mbps. Suppose the number of links N is 3. Calculate the end to end delay for the two cases given below. Note that each switch is a store and forward switch.
  1. If message of size 8 Mb is transferred 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. L = 10 kb. End to end delay = 800 × 3 × L/R =12 sec



What about throughput of the connection?

What if the links have different rates?

- Numerical 6: Solution (Continued)

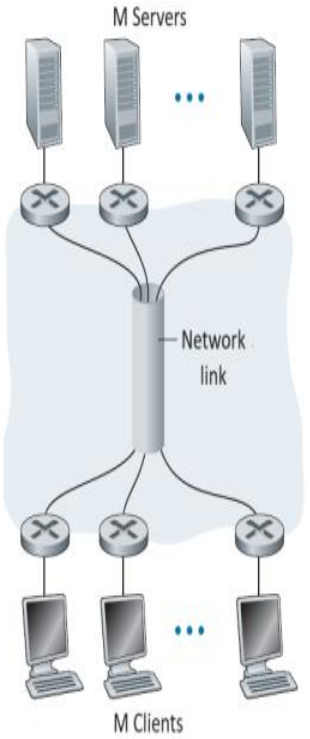


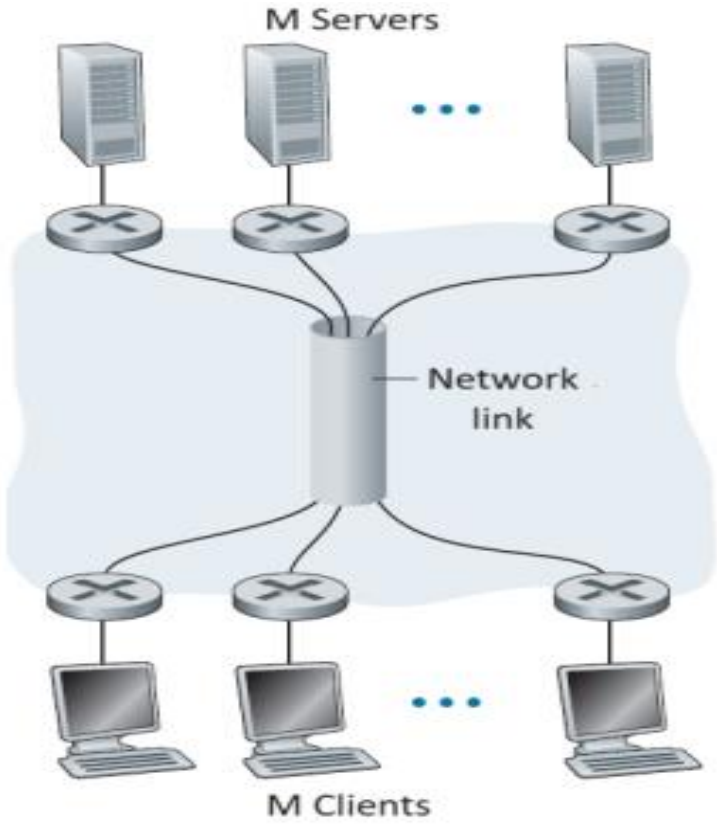
What about throughput of the connection?

What if the links have different rates?

- Ignoring the delays, the throughput is usually constrained by the lowest link rate on the path. In case of multiple flows, the lowest link rate is divided proportionally among the flows. In the above example, where transmission delay is the only significant delay and all links had same link rate, the overall time taken to transfer 800 packets of 10 kb length took 12 seconds. Therefore, the throughput is given by 8 Mb / 12 sec = 0.667 Mbps

- 8) Consider the network given in the next slide where M client-server pairs communicate through the common network link.
- Denote Rs , Rc , and R for the rates of the server links, client links, and network link.
- Assume all other links have abundant capacity and that there is no other traffic in the network besides the traffic generated by the M client-server pairs. Answer the following:
- 1) Derive a general expression for maximum throughput for any user in terms of Rs , Rc , R, and M. ---------- 2 marks
- 2) Suppose one of the clients has to transfer a file of size F = 32 Mb to corresponding server and the values of Rs, Rc, R, and M are 2 Mbps, 1 Mbps, 5 Mbps and 10 respectively. Find the minimum time taken to transfer the file. ---------- 3 marks





- 13) Solution
- 1) The maximum throughput is given by min(Rs,Rc,R/M) because the network link is divided equally among the M Connections.
- 2) Given the values of Rs, Rc, R and M we get the maximum throughput as 500 kbps. Therefore, the minimum file transfer time is given by F/min(Rs,Rc,R/M) = 32*10^6/ 500*10^3 = 64 seconds

THANK YOU

Department of Electronics and communication engineering