1. Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R1 = 500 kbps, R2= 2 Mbps, and R3 = 1 Mbps.
   a. Assuming no other traffic in the network, what is the throughput for the file transfer?
   b. Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B
   c. Repeat (a) and (b), but now with R2 reduced to 100 kbps.

2. Consider the circuit-switched network in Figure 1. Recall that there are 4 circuits on each link. Label the four switches A, B, C and D, going in the clockwise direction.
   a. What is the maximum number of simultaneous connections that can be in progress at any one time in this network?
   b. Suppose that all connections are between switches A and C. What is the maximum number of simultaneous connections that can be in progress?
   c. Suppose we want to make four connections between switches A and C, and another four connections between switches B and D. Can we route these calls through the four links to accommodate all eight connections?

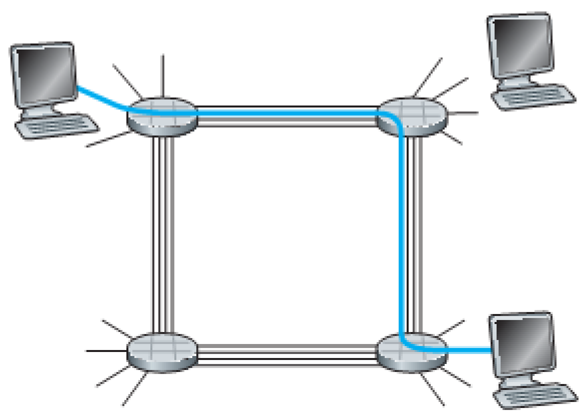

Figure 1

3. Consider a packet of length L which begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let d_i, s_i, and R_i denote the length, propagation speed, and the transmission rate of link i, for i= 1, 2, 3. The packet switch delays each packet by d_proc. Assuming no queuing delays, in terms of d_i, s_i, R_i, (i= 1,2,3), and L, what is the total end-to-end delay for the packet? Suppose now the packet is 1,500 bytes, the propagation speed on all three links

is 2.5 * 10^8 m/s, the transmission rates of all three links are 2 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second link is 4,000 km, and the length of the last link is 1,000 km. For these values, what is the end-to-end delay?

4. Consider Figure 2. Now suppose that there are M paths between the server and the client. No two paths share any link. Path k(k= 1, . . ., M) consists of N links with transmission rates $R_{k1}$, $R_{k2}$,……….,$R_{kN}$ (where, k is path number and 1,2,…N are the links number between server and client). If the server can only use one path to send data to the client, what is the maximum throughput that the server can achieve? If the server can use all M paths to send data, what is the maximum throughput that the server can achieve?

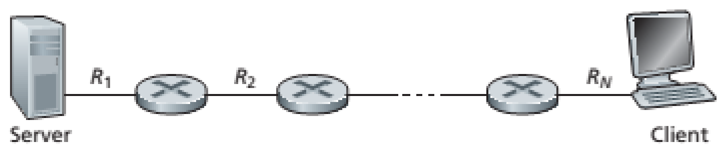


Figure 2

5. Consider Figure 2. Suppose that each link between the server and the client has a packet loss probability p,and the packet loss probabilities for these links are independent. What is the probability that a packet (sent by the server) is successfully received by the receiver? If a packet is lost in the path from the server to the client, then the server will re-transmit the packet. On average, how many times will the server re-transmit the packet in order for the client to successfully receive the packet?

6. You are designing a data transfer system for a large video streaming platform. The platform has multiple data centers connected through a path with 3-4 switches. To ensure smooth video playback, the video files are split into multiple packets, and pipelining is used to enhance transmission efficiency. Each switch introduces a propagation delay of 2.5 milliseconds, and the transmission time for each packet is 1.5 milliseconds. The pipeline can accommodate up to 3 packets simultaneously. Assuming a video file size of 600 MB, calculate the total time taken to complete the transmission of the video from the source data center to the destination data center.