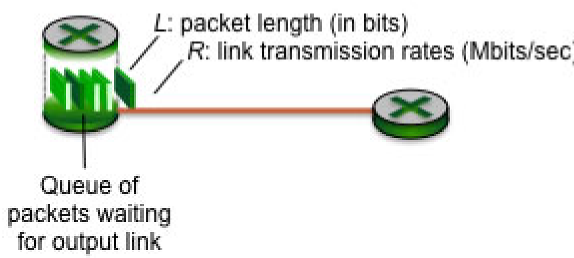
CS5222 Computer Networks and Internets

Tutorial 1

1. Consider the figure below, in which a single router is transmitting packets over a single link with transmission rate *R* Mbps, to another router at the other end of the link. Suppose that the packet length is *L*= 16,000 bits, and that the link transmission rate along the link to the router at the right side is *R* = 1,000 Mbps.
   (a) What is the transmission delay (the duration needed to transmit all bits of a packet to the router at the right side)?
   (b) What is the maximum number of packets per second that can be transmitted by the link?

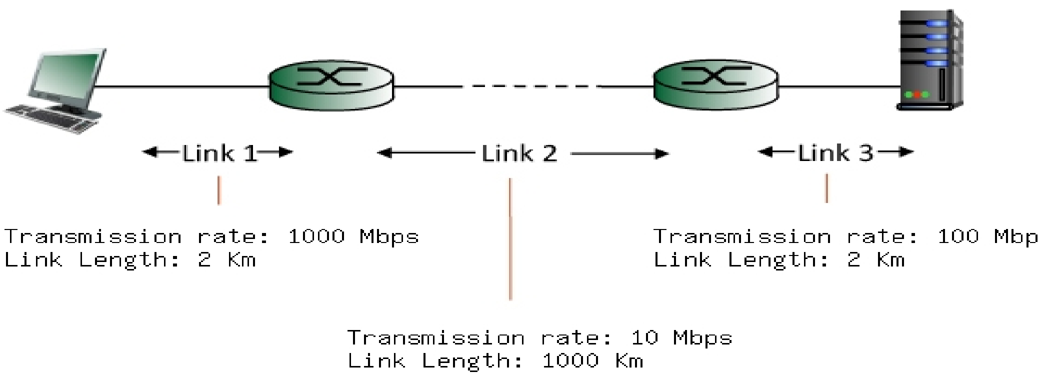


Solution:

(a) The link transmission delay = L/R = 16,000 bits / 1,000 Mbps = $16*10^{-6}$ second.

(b) The link can transmit 1/0.000016=62,500 packets per second.

2. Consider the figure below, with three links, each with the specified transmission rate and link length. Find the end-to-end delay (including the transmission delays and propagation delays on each of the three links, but ignoring queueing delays and processing delays) from when the left host begins transmitting the first bit of a packet to the time when the last bit of that packet is received at the server at the right side. The speed of light propagation delay on each link is $3x10^8$ m/sec. Note that the transmission rates are in Mbps and the link distances are in Km. Assume a packet length of **12,000** bits. Give your answer in milliseconds.



Solution: 1 second=1,000 millisecond

Link 1 transmission delay = L/R = 12,000 bits / 1,000 Mbps = 0.012 msec.
Link 1 propagation delay = d/s = 2 Km / $3*10^8$ m/sec = 0.00667 msec.
Link 2 transmission delay = L/R = 12,000 bits / 10 Mbps = 1.2 msec.
Link 2 propagation delay = d/s = 1,000 Km / $3*10^8$ m/sec = 3.333333 msec.
Link 3 transmission delay = L/R = 12,000 bits / 100 Mbps = 0.12 msec.
Link 3 propagation delay = d/s = 2 Km / $3*10^8$ m/sec = 0.00667 msec.

The total end-to-end delay thus is the sum of these six delays: 4.67867 msec.

3. Suppose that users share a 10 Mbps link, i.e., they all send their traffic to a node which has a 10Mbps link to forward the traffic received from the users. Suppose that each user transmits continuously at 5 Mbps when transmitting, but each user transmits only 20% of the time.
(a) When circuit switching is used, how many users can be supported?

Answer: 10/5=2 users. (the resource is always reserved for each user)

(b) Suppose that there are **4** users and packet switching is used. What is the fraction of time that the queue at the node is not empty?

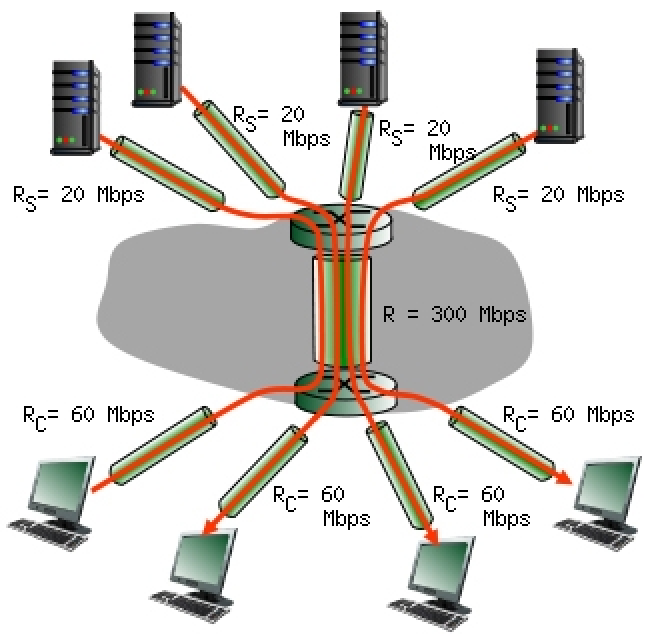
Answer: only when there are exactly 3 users sending at the same time, or there are 4 users sending at the same time, the queue will not be empty.

The probability of 3 users sending their packets at the same time is 4*0.2*0.2*0.2*0.8=0.0256, as each user has the equal opportunity to be the user who does not send a packet.

The probability of 4 users sending their packets at the same time is 0.2*0.2*0.2*0.2=0.0016.

Therefore, the probability that the queue at the node is not empty is: 0.0256+0.0016=0.0272.

4. Consider the scenario shown below, with four different servers connected to four different clients over four three-hop paths. The four pairs share a common middle hop with a transmission capacity of R = 300 Mbps. The four links from the servers to the shared link have a transmission capacity of R_S = 20 Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of R_C = 60 Mbps per second:
   a) What is the maximum achievable end-end throughput (in Mbps) for each of four client-to-server pairs, assuming that the middle link is fair-shared (i.e., divides its transmission rate equally among the four pairs)?
   b) Which link is the bottleneck link for each session?
   c) Assuming that the senders (servers) are sending at their maximum rates, what are the link utilizations of the sender links (R_S), the middle link (R), and the client links (R_C)?



Answer:

a) The maximum achievable end-end-throughput of each pair is 20 Mbps.
b) The first hop (between a server and one-hop router) is the bottleneck link, since the first-hop transmission capacity of 20 Mbps is less than a quarter of the shared-link transmission capacity (300/4 = 75 Mbps) and less than the third-hop transmission capacity of 60 Mbps.
c) The utilization of sender links is 100%. The utilization of the middle link is 80/300=26.67%. The utilization of receiver links is 80/240=33.33%.