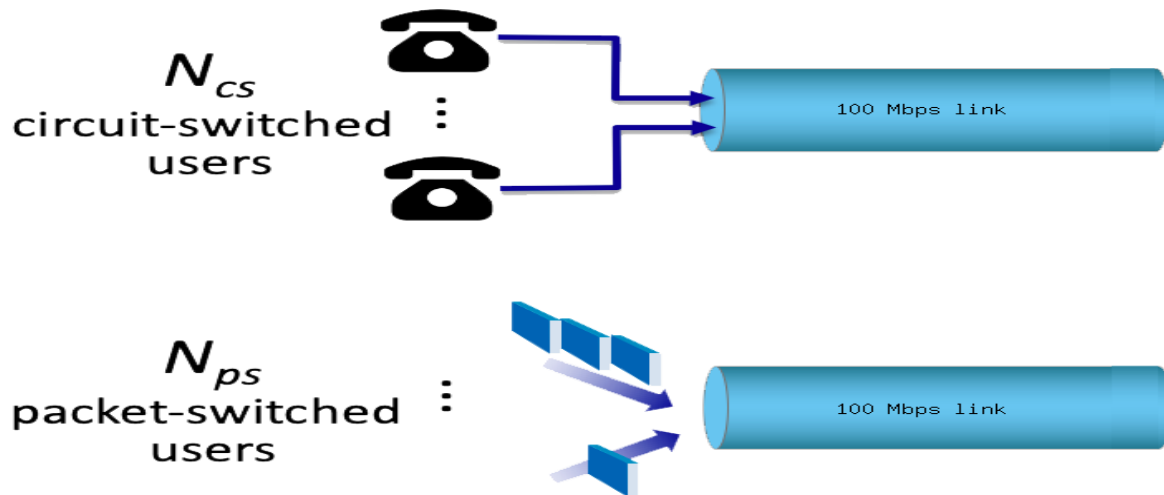


Quantitative Comparison of Packet Switching and Circuit Switching

Consider the two scenarios below:

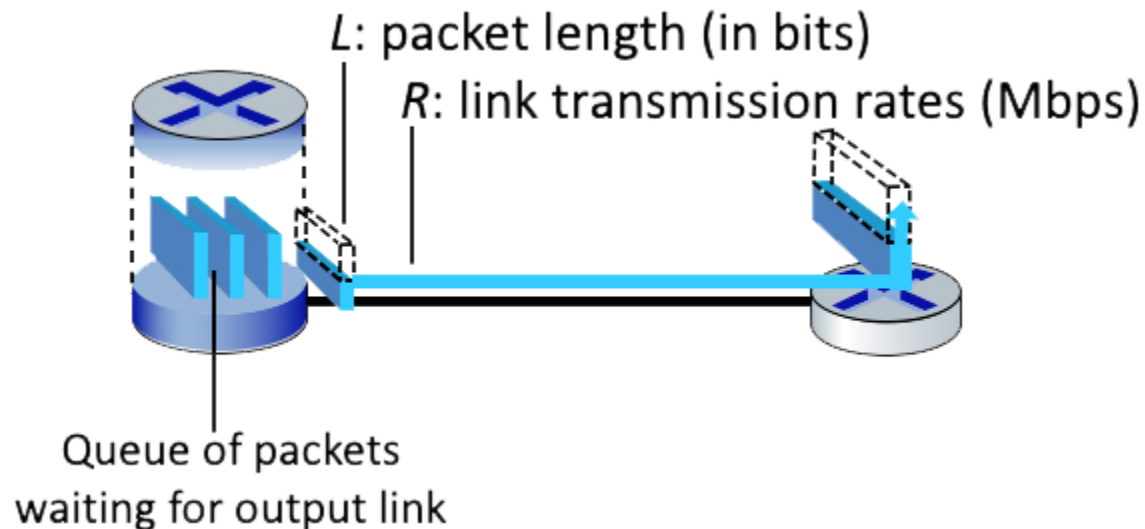
- A circuit-switching scenario in which N_{cs} users, each requiring a bandwidth of 20 Mbps, must share a link of capacity 100 Mbps.
- A packet-switching scenario with N_{ps} users sharing a 100 Mbps link, where each user again requires 20 Mbps when transmitting, but only needs to transmit 30 percent of the time.



1. When circuit switching is used, what is the maximum number of users that can be supported?
2. Suppose packet switching is used. If there are 9 packet-switching users, can this many user be supported under circuit-switching? Yes or No.
3. Suppose packet switching is used. What is the probability that a given (specific) user is transmitting, and the remaining users are not transmitting? (9 packet-switching users)

Computing the one-hop transmission delay

Consider the figure below, in which a single router is transmitting packets, each of length L bits, over a single link with transmission rate R Mbps to another router at the other end of the link.



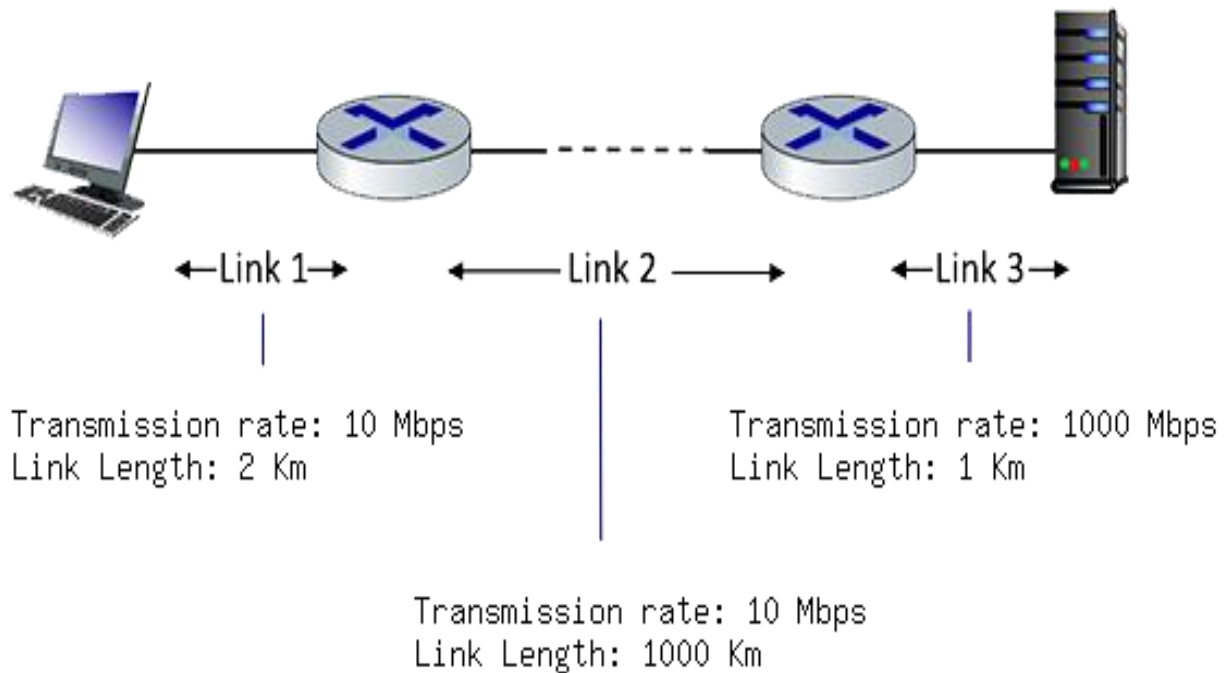
Suppose that the packet length is $L = 8000$ bits, and that the link transmission rate along the link to router on the right is $R = 100$ Mbps.

Question List

1. What is the transmission delay?
2. What is the maximum number of packets per second that can be transmitted by this link?

Computing end-end delay (transmission and propagation delay)

Consider the figure below, with three links, each with the specified transmission rate and link length.



Assume the length of a packet is 16000 bits. The speed of light propagation delay on each link is 3×10^8 m/sec

Round your answer to two decimals after leading zeros

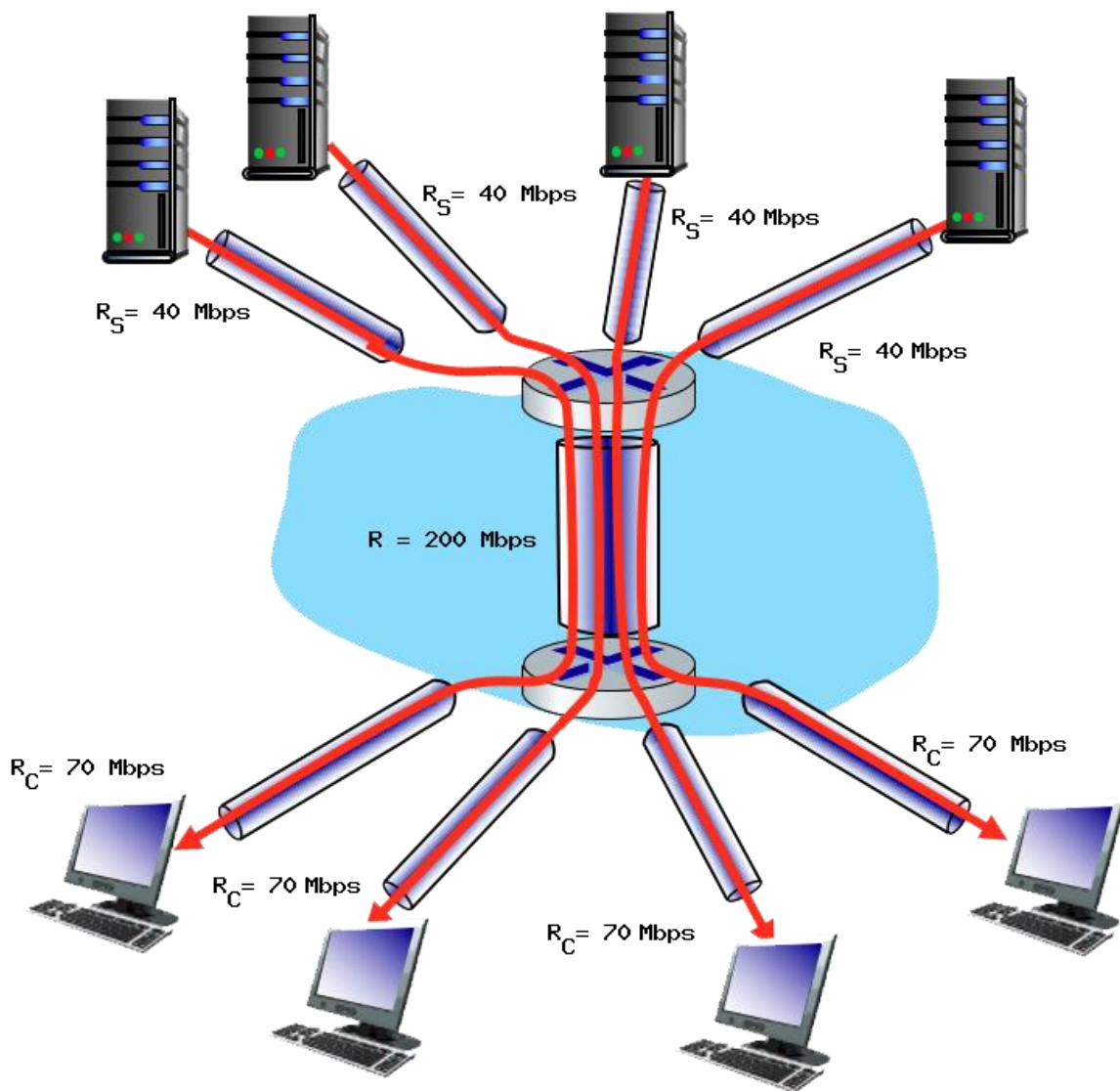
Question List

1. What is the transmission delay of link 1?
2. What is the propagation delay of link 1?
3. What is the total delay of link 1?
4. What is the transmission delay of link 2?

5. What is the propagation delay of link 2?
6. What is the total delay of link 2?
7. What is the transmission delay of link 3?
8. What is the propagation delay of link 3?
9. What is the total delay of link 3?
10. What is the total delay?

End to End Throughput and Bottleneck Links

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 $R = 200$ Mbps. The four links from the servers to the shared link have a transmission capacity of $R_S = 40$ Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of $R_C = 70$ Mbps.

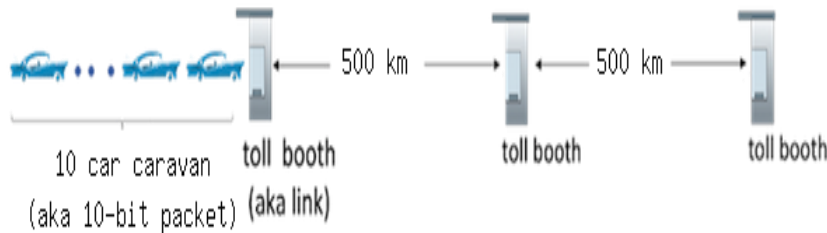


Question List

1. What is the maximum achievable end-end throughput (in Mbps) for each of four client-to-server pairs, assuming that the middle link is fairly shared (divides its transmission rate equally)?
2. Which link is the bottleneck link? Format as R_c , R_s , or R
3. Assuming that the servers are sending at the maximum rate possible, what are the link utilizations for the server links (R_s)? Answer as a decimal
4. Assuming that the servers are sending at the maximum rate possible, what are the link utilizations for the client links (R_c)? Answer as a decimal
5. Assuming that the servers are sending at the maximum rate possible, what is the link utilizations for the shared link (R)? Answer as a decimal

Car - Caravan Analogy

Consider the figure below,



Suppose the caravan has **10 cars**, and that the tollbooth services (that is, transmits) a car at a rate of **one car per 2 seconds**. Once receiving serving a car proceeds to the next toll booth, which is 500 kilometers away at a rate of **20 kilometers per second**. Also assume that whenever the first car of the caravan arrives at a tollbooth, it must wait at the entrance to the tollbooth until all of the other cars in its caravan have arrived, and lined up behind it before being serviced at the toll booth. (That is, the entire caravan must be stored at the tollbooth before the first car in the caravan can pay its toll and begin driving towards the next tollbooth).

Question List

1. Once a car enters service at the tollbooth, how long does it take until it leaves service?
2. How long does it take for the entire caravan to receive service at the tollbooth (that is the time from when the first car enters service until the last car leaves the tollbooth)?
3. Once the first car leaves the tollbooth, how long does it take until it arrives at the next tollbooth?
4. Once the last car leaves the tollbooth, how long does it take until it arrives at the next tollbooth?

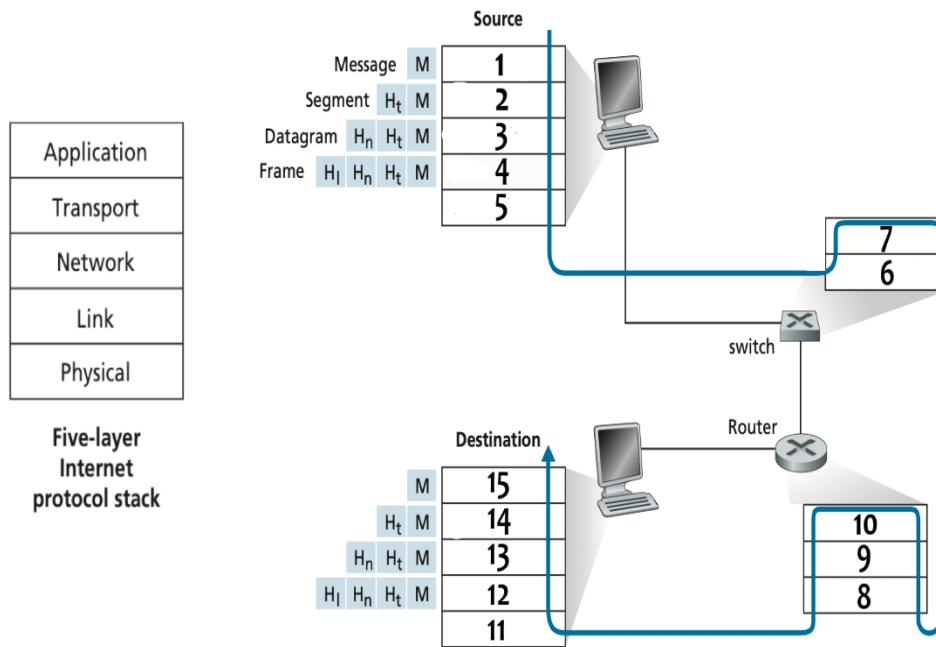
5. Once the first car leaves the tollbooth, how long does it take until it enters service at the next tollbooth?

6. Are there ever two cars in service at the same time, one at the first toll booth and one at the second toll booth? Answer Yes or No

7. Are there ever zero cars in service at the same time, i.e., the caravan of cars has finished at the first toll booth but not yet arrived at the second tollbooth? Answer Yes or No

The IP Stack and Protocol Layering

In the scenario below, imagine that you're sending an http request to another machine somewhere on the network.



Question List

1. What layer in the IP stack best corresponds to the phrase: 'moves datagrams from the source host to the destination host'?
2. What layer in the IP stack best corresponds to the phrase: 'handles messages from a variety of network applications'?
3. What layer in the IP stack best corresponds to the phrase: 'passes frames from one node to another across some medium'?
4. What layer in the IP stack best corresponds to the phrase: 'handles the delivery of segments from the application layer, may be reliable or unreliable'?
5. What layer in the IP stack best corresponds to the phrase: 'bits live on the wire'?
6. What layer corresponds to box 1?

7. What layer corresponds to box 2?
8. What layer corresponds to box 3?
9. What layer corresponds to box 4?
10. What layer corresponds to box 5?
11. What layer corresponds to box 6?
12. What layer corresponds to box 7?
13. What layer corresponds to box 8?
14. What layer corresponds to box 9?
15. What layer corresponds to box 10?
16. What layer corresponds to box 11?
17. What layer corresponds to box 12?
18. What layer corresponds to box 13?
19. What layer corresponds to box 14?
20. What layer corresponds to box 15?