COMPUTER NETWORKS

Computer Networks and the Internet

Team Networks
Department of Computer Science and Engineering

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Interactive Exercises

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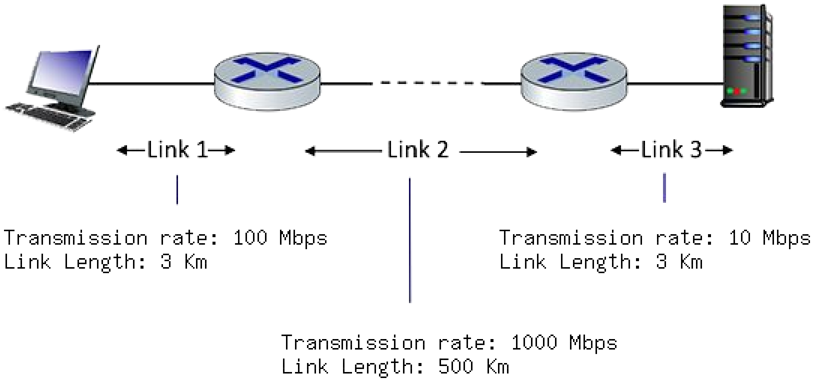
Computing end-end delay (transmission and propagation delay)

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.

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 8000 bits. Give your answer in milliseconds.

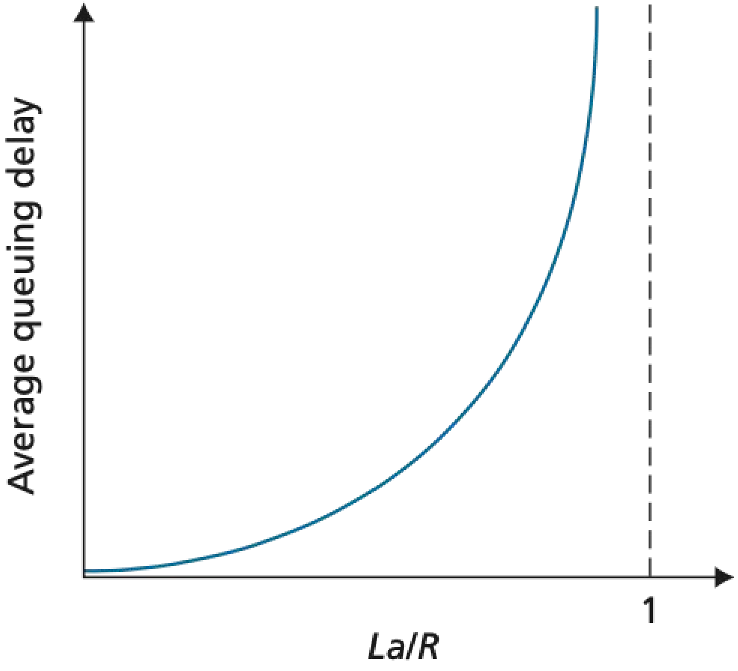
Interactive Exercise – 2 (Solution)

Link 1 transmission delay = L/R = 8000 bits / 100 Mbps =
Link 1 propagation delay = d/s = 3 Km / 3*10**8 m/sec =
Link 1 total delay =
Link 2 transmission delay = L/R = 8000 bits / 1000 Mbps =
Link 2 propagation delay = d/s = 500 Km / 3*10**8 m/sec =
Link 2 total delay =
Link 3 transmission delay = L/R = 8000 bits / 10 Mbps =
Link 3 propagation delay = d/s = 3 Km / 3*10**8 m/sec =
Link 3 total delay =

Total end-to-end delay is the sum of these six delays: 0.0026 **msecs**.

Computing Queuing Delay

Consider the queuing delay in a router buffer.



Assume:

a constant transmission rate of

R = 1800000 bps,

a constant packet-length L = 6700 bits, and

a is the average rate of packets/second.

Traffic intensity I = La/R, and

Queuing delay is calculated as:

I(L/R)(1 - I) for I < 1.

Interactive Exercise – 2 (Questions)

1. In practice, does the queuing delay tend to vary a lot? Answer with Yes or No

2. Assuming that a = 30, what is the queuing delay?

3. Assuming that a = 76, what is the queuing delay?

4. Assuming the router's buffer is infinite, the queuing delay is 0.8647 ms, and 1762 packets arrive. How many packets will be in the buffer 1 second later?

5. If the buffer has a maximum size of 956 packets, how many of the packets would be dropped upon arrival from the previous question?

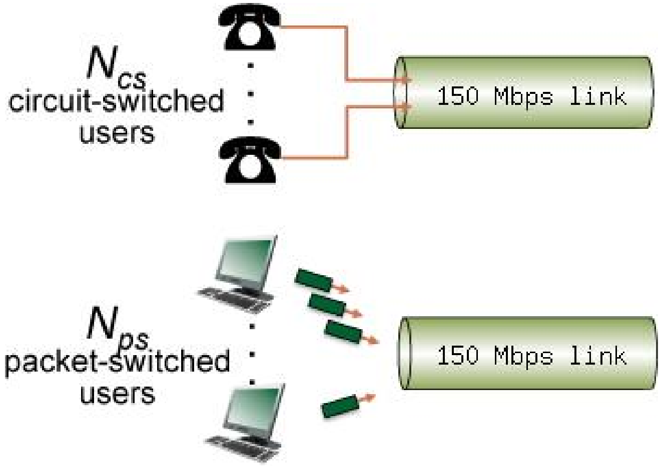
Interactive Exercise – 2 (Solutions)

1. Yes, in practice, queuing delay can vary significantly. We use the above formulas as a way to give a rough estimate, but in a real-life scenario it is much more complicated.
2. Queuing Delay = I(L/R)(1 - I) * 1000 = 0.1217*(7300/1800000)*(1-0.1217) * 1000 = 0.4335 ms.
3. Queuing Delay = I(L/R)(1 - I) * 1000 = 0.3082*(7300/1800000)*(1-0.3082) * 1000 = 0.8647 ms.
4. Packets left in buffer = a - floor(1000/delay) = 1762 - floor(1000/0.8647) = 606 packets.
5. Packets dropped = packets - buffer size = 1762 - 956 = 806 dropped packets.

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 10 Mbps, must share a link of capacity 150 Mbps.
- A packet-switching scenario with N_{ps} users sharing a 150 Mbps link, where each user again requires 10 Mbps when transmitting, but only needs to transmit 30 percent of the time.



Round your answer to two decimals after leading zeros

Interactive Exercise – 3 (Questions)

Answer the following questions:

1. When circuit switching is used, what is the maximum number of circuit-switched users that can be supported? Explain your answer.
2. For rest of the questions, suppose packet switching is used. Suppose there are 29 packet-switching users (i.e., N_{ps} = 29). Can this many users be supported under circuit-switching? Explain.
3. What is the probability that a given (*specific*) user is transmitting, and the remaining users are not transmitting?
4. What is the probability that one user (*any* one among the 29 users) is transmitting, and the remaining users are not transmitting? When one user is transmitting, what fraction of the link capacity will be used by this user?
5. What is the probability that any 15 users (of the total 29 users) are transmitting and the remaining users are not transmitting? (Hint: you will need to use the binomial distribution [1, 2]).
6. What is the probability that *more* than 15 users are transmitting? Comment on what this implies about the number of users supportable under circuit switching and packet switching.

Interactive Exercise – 3 (more)

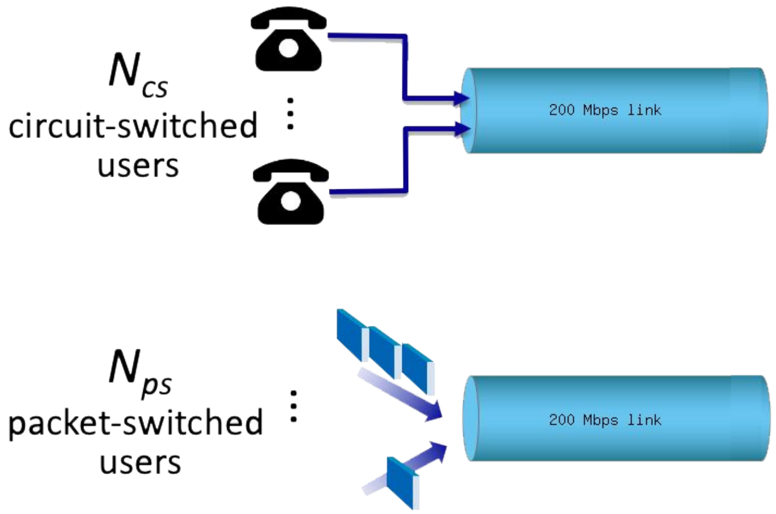
Answers:

1. 15
2. No.
3. 1.37
4. 0.0004
5. 0.00754
6. 0.011653

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 25 Mbps, must share a link of capacity 200 Mbps.
- A packet-switching scenario with N_{ps} users sharing a 150 Mbps link, where each user again requires 25 Mbps when transmitting, but only needs to transmit 20 percent of the time.



Interactive Exercise – 4 (Questions)

Answer the following questions:

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 15 packet-switching users, can this many users 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?
4. Suppose packet switching is used. What is the probability that one user (*any* one among the 15 users) is transmitting, and the remaining users are not transmitting?
5. When one user is transmitting, what fraction of the link capacity will be used by this user? Write your answer as a decimal.
6. What is the probability that any 10 users (of the total 15 users) are transmitting and the remaining users are not transmitting?
7. What is the probability that *more* than 8 users are transmitting?

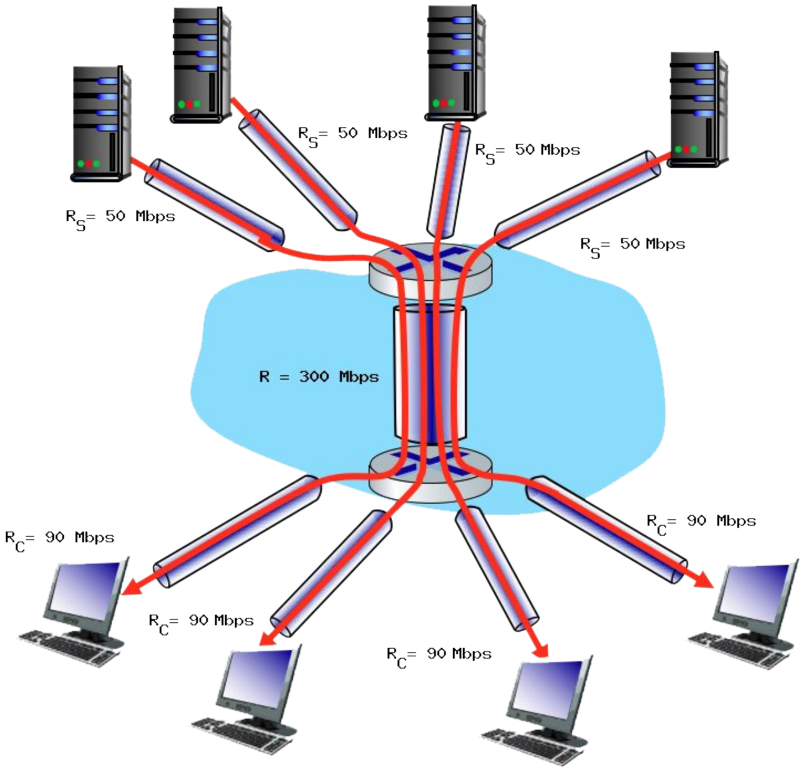
END TO END THROUGHPUT AND BOTTLENECK LINKS

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 = 300 Mbps.

The four links from the servers to the shared link have a transmission capacity of R_S = 50 Mbps.

Each of the four links from the shared middle link to a client has a transmission capacity of R_C = 90 Mbps.



Interactive Exercise – 5 (Questions)

Answer the following questions:

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 Rc, Rs, 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

Interactive Exercise – 5 (Answers)

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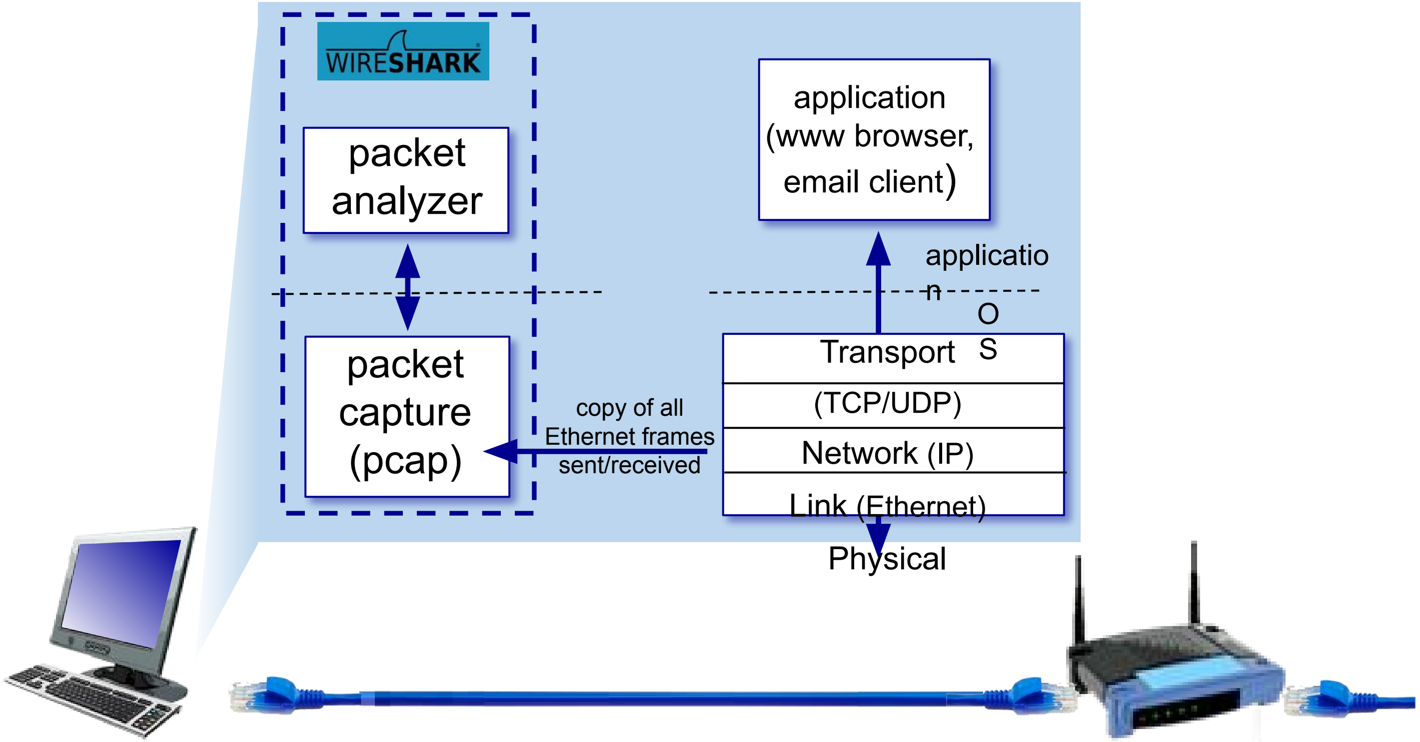
Solutions:

1. The maximum achievable end-end throughput is the capacity of the link with the minimum capacity, which is 50 Mbps
2. The bottleneck link is the link with the smallest capacity between R_S, R_C, and R/4. The bottleneck link is Rs.
3. The server's utilization = $R_{bottleneck} / R_S = 50 / 50 = 1$
4. The client's utilization = $R_{bottleneck} / R_C = 50 / 90 = 0.56$
5. The shared link's utilization = $R_{bottleneck} / (R / 4) = 50 / (300 / 4) = 0.67$

COMPUTER NETWORKS

Wireshark



THANK YOU

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