

# Computer Communication Networks: Homework #1

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February 2, 2026

**Q1**

Suppose users share a 6 Mbps link, and the total number of users is 4. Also suppose each user transmits continuously at 2 Mbps when transmitting, but each user transmits only 40 percent of the time. (See the discussion of statistical multiplexing in Section 1.3.)

**A) When circuit switching is used, how many users can be supported?**

$$n_{max} = \frac{B_{out}}{B_{in}} = \frac{6Mbps}{2Mbps} = 3 \text{ Users}$$

**B) Find the probability that a given user is transmitting.**

$$p_{not\ 0} = \binom{4}{0} (0.4)^0 (1 - 0.4)^{4-0} = 0.216 \rightarrow p_{not\ 0} = 1 - 0.1296 = 0.8704$$

**C) Find the probability that only one of the four users is transmitting.**

$$p_1 = \binom{4}{1} * (0.4)^1 (1 - 0.4)^{4-1} = 0.3456$$

**D) Find the probability that at any given time, all four users are transmitting simultaneously. Find the fraction of time during which the queue grows.**

$$p_{all} = \binom{4}{4} * (0.4)^4 (1 - 0.4)^{4-4} = 0.0256$$

Now, the queue grows when there are more active users than there is possible active links, therefore, the fraction of time probability is the same as  $P(4)$  which is 2.56%.

**Q2**

**A) How long does it take a packet of length 3,000 bytes to propagate over a link of distance 3,5000 km, propagation speed  $2.4 \times 10^8$  m/s, and transmission rate 16 Mbps?**

$$d_{prop} = \frac{distance}{speed} = \frac{35,000}{2.4 * 10^8 m/s} \approx 0.1458s \approx 145.8ms$$

**B) More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate Rbps?**

The general form of the propagation delay is:

$$d_{prop} = \frac{distance}{speed}$$

**C) Does this delay depend on packet length?**

The delay does not depend on the packet length. Delay is a function of only distance and speed and not the length.

**D) Does this delay depend on transmission rate?**

No. The transmission rate does not effect the delay whatsoever since it is, again, only based on the speed of the physical medium and the length between the 2 devices.

**Q3**

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=800 kbps, R2=4 Mbps, and R3=1 Mbps.

**A) Assuming no other traffic in the network, what is the throughput for the file transfer?**

Throughput is always limited by the slowest link therefore the throughput 800kbps.

**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?**

If a file is 4 million bytes, then it is 32 million bits. The time it takes is then the following algebra:

$$Time = \frac{Size}{Throughput} = \frac{32 * 10^6}{800 * 10^3} = 40 \text{ seconds}$$

**C) Repeat (A) and (B), but now with R2 reduced to 600 kbps.**

When reduced to 600 kbps, the time taken is now...

$$Time = \frac{Size}{Throughput} = \frac{32 * 10^6}{600 * 10^3} \approx 53.33 \text{ seconds}$$

**Q4****A) Which layers in the Internet protocol stack does a router process?**

The protocol layers used in a router is the Physical, Link, and Network layer.

**B) Which layers does a link-layer switch process?**

The layers that the switch uses are the Link and Physical layer.

**C) Which layers does a host process?**

The host covers all 5 layers, that being the Application, Transport, Network, Link, and Physical layers.

**Q5**

Equation  $d_{end-to-end} = \frac{N*L}{R}$  (Equation 1.1 in textbook) gives a formula for the end-to-end delay of sending one packet of length L over N links of transmission rate R. Generalize this formula for sending P such packets back-to-back over the N links.

$$d_{end-to-end} = (N + P - 1) * \frac{L}{R}$$

## Q6

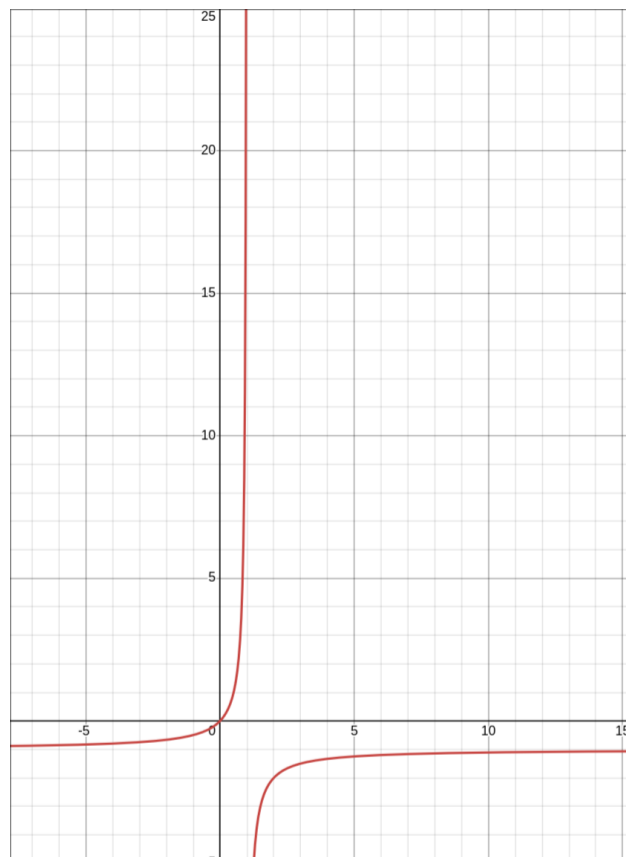
Consider the queuing delay in a router buffer. Let  $I$  denote traffic intensity, that is,  $I = \frac{L \cdot a}{R}$ . Suppose that the queuing delay takes the form  $\frac{I \cdot L}{R \cdot (1 - I)}$  for  $I < 1$ .

A) Provide a formula for the total delay, that is, the queuing delay plus the transmission delay.

$$d_{total} = d_{queueing} + q_{trans} = \frac{I \cdot L}{R \cdot (1 - I)} + \frac{L}{R} = \frac{L}{R} \cdot \left( \frac{I}{1 - I} + 1 \right) = \frac{L}{R} \cdot \left( \frac{I}{1 - I} + \frac{1 - I}{1 - I} \right) = \frac{L}{R} \cdot \left( \frac{1}{1 - I} \right) \rightarrow$$

$$\frac{L}{R} \cdot \left( \frac{1}{1 - \frac{L \cdot a}{R}} \right)$$

B) Plot the total delay as a function of  $\frac{L}{R}$ .



**Q7**

Consider the Figure below. 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.

**A) What is the probability that a packet (sent by the server) is successfully received by the receiver?**

The probability that a packet is successfully received by the receiver is just the probability that all  $N$  links successfully received it. Therefore, it is simply the following:

$$P_{success} = (1 - p)^N$$

**B) 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?**

If a packet is lost in the path, the amount of retries that a packet has to be sent before it succeeds is the following:

$$average\ retries = \frac{1}{(1 - p)^N} - 1$$