Computer Networks
Problem Set 1

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Chapter 1. Introduction

1.1 Imagine that you have trained your St. Bernard, Bernie, to carry a box of three 8-mm tapes instead of a flask of brandy. (When your disk fills up, you consider that an emergency.) These tapes each contain 10 gigabytes. The dog can travel to your side, wher ever you may be, at 18 km/hour. For what range of distances does Bernie have a higher data rate than a transmission line whose data rate (excluding overhead) is 150 Mbps? How does your answer change if (i) Bernie's speed is doubled; (ii) each tape capacity is doubled; (iii) the data rate of the transmission line is doubled.

1.2 Besides bandwidth and latency, what other parameter is needed to give a good characterization of the quality of service offered by a network used for (i) digitized voice traffic? (ii) video traffic? (iii) financial transaction traffic?

1.3 A factor in the delay of a store-and-forward packet-switching system is how long it takes to store and forward a packet through a switch. If switching time is 20 µsec, is this likely to be a major factor in the response of a client-server system where the client is in New York and the server is in California? Assume the propagation speed in copper and fiber to be 2/3 the speed of light in vacuum.

1.4 A client-server system uses a satellite network, with the satellite at a height of 40,000 km. What is the best-case delay in response to a request?

1.5 Five routers are to be connected in a point-to-point subnet. Between each pair of routers, the designers may put a high-speed line, a medium-speed line, a low-speed line, or no line. If it takes 50 ms of computer time to generate and inspect each topology, how long will it take to inspect all of them?

1.6 A group of $2^n - 1$ routers are interconnected in a centralized binary tree, with a router at each tree node. Router i communicates with router j by sending a message to the root of the tree. The root then sends the message back down to j. Derive an approximate expression for the mean number of hops per message for large n, assuming that all router pairs are equally likely.

1.7 A disadvantage of a broadcast subnet is the capacity wasted when multiple hosts attempt to access the channel at the same time. As a simplistic example, suppose that time is divided into discrete slots, with each of the n hosts attempting to use the channel with probability p during each slot. What fraction of the slots will be wasted due to collisions?

1.8 What are two reasons for using layered protocols? What is one possible disadvantage of using layered protocols?

1.9 Suppose that two network endpoints have a round-trip time of 100 milliseconds, and that the sender transmits five packets every round trip. What will be the sender's transmission rate for this round-trip time, assuming 1500-byte packets? Give your answer in bytes per second

1.10 What is the principal difference between connectionless communication and connection-oriented communication? Give one example of a protocol that uses (i) connectionless communication; (ii) connection-oriented communication.

1.11 What does "negotiation" mean when discussing network protocols? Give an example.

1.12 A system has an n-layer protocol hierarchy. Applications generate messages of length M bytes. At each of the layers, an h-byte header is added. What fraction of the network bandwidth is filled with headers?

1.13 The subnet of Fig. 1-12(b) was designed to withstand a nuclear war. How many bombs would it take to partition the nodes into two disconnected sets? Assume that any bomb wipes out a node and all of the links connected to it.

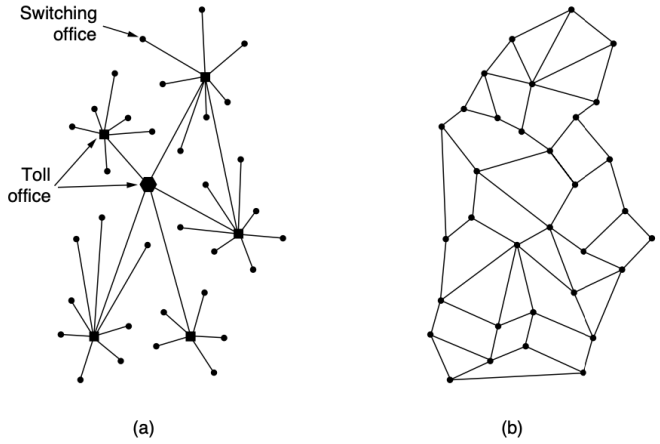

Figure 1-12. (a) Structure of the telephone system. (b) Baran's proposal.

Figure 1: Figure for Exercise 1.13

1.14 The Internet is roughly doubling in size every 18 months. Although no one really knows for sure, one estimate put the number of hosts on it a 1 billion in 2018. Use these data to compute the expected number of Internet hosts in the year 2027. Do you believe this? Explain why or why not.

1.15 When a file is transferred between two computers, two acknowledgement strategies are possible. In the first one, the file is chopped up into packets, which are individually acknowledged by the receiver, but the file transfer as a whole is not acknowledged. In the second one, the packets are not acknowledged individually, but the entire file is acknowledged when it arrives. Discuss these two approaches.

1.16 How long was a bit in the original 802.3 standard in meters? Use a transmission speed of 10 Mbps and assume the propagation speed of the signal in coax is 2/3 the speed of light in vacuum.

1.17 An image is 1600 × 1200 pixels with 3 bytes/pixel. Assume the image is uncompressed. How long does it take to transmit it over a 56-kbps modem channel? Over a 1-Mbps cable modem? Over a 10-Mbps Ethernet? Over 100-Mbps Ethernet? Over gigabit Ethernet?

1.18 Wireless networks are easy to install, which makes them inexpensive since installation costs usually far overshadow equipment costs. Nevertheless, they also have some disadvantages. Name two of them.

1.19 Suppose the algorithms used to implement the operations at layer k is changed. How does this impact operations at layers $k-1$ and $k+1$?

1.20 Suppose there is a change in the service (set of operations) provided by layer k. How does this impact services at layers $k-1$ and $k+1$?

1.21 Provide a list of reasons for why the response time of a client may be larger than the best-case delay.

1.22 The `ping` program allows you to send a test packet to a given location and see how long it takes to get there and back. Try using `ping` to see how long it takes to get from your location to several known locations. From these data, plot the one-way transit time over the Internet as a function of distance. It is best to use universities since the location of their servers is known very accurately. For example, *berkeley.edu* is in Berkeley, California; *mit.edu* is in Cambridge, Massachusetts; *vu.nl* is in Amsterdam; The Netherlands; *www.usyd.edu.au* is in Sydney, Australia; and *www.uct.ac.za* is in Cape Town, South Africa.

1.23 Go to IETF's Web site, *www.ietf.org*, to see what they are doing. Pick a project you like and write a half-page report on the problem and the proposed solution.

1.24 Standardization is very important in the network world. ITU and ISO are the main official standardization organizations. Go to their respective Web sites, *www.itu.org* and *www.iso.org*, and learn about their standardization work. Write a short report about the kinds of things they have standardized.

1.25 The Internet has a large number of networks. Their arrangement determines the topology of the Internet. A considerable amount of information about the Internet topology is available on line. Use a search engine to find out more about the Internet topology and write a short report summarizing your findings.

1.26 Search the Internet to find out some of the important peering points used for routing packets in the Internet at present.

1.27 Write a program that implements message flow from the top layer to the bottom layer of the 7-layer protocol model. Your program should include a separate protocol function for each layer. Protocol headers are sequence up to 64 characters. Each protocol function has two parameters: a message passed from the higher layer protocol (a char buffer) and the size of the message. This function attaches its header in front of the message, prints the new message on the standard output, and then invokes the protocol function of the lower-layer protocol. Program input is an application message.