Note: In all written assignments, please show as much of your work as you can. Even if you get a wrong answer, you can get partial credit if you show your work. If you make a mistake, it will also help the grader show you where you made a mistake. Your submitted homework should be printed out (i.e., please don’t hand in hand-written answers, unless you need to hand-annotate the printed text, or draw a figure). See the class web-page for more information about handing in homework assignments.

Problem 1. Give an example of a human protocol that takes place between you and your parents/guardians or you and your siblings (other than any protocol discussed in the text in Chapter 1). What messages are exchanged? What are the message formats, and what is the order of message exchange? What actions are taken by each protocol entity on the transmission and/or receipt of a message?

Problem 2. 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 $R = 1$ Mbps. (a) What is the transmission delay (the time needed to transmit all of a packet's bits into the link)? (b) what is the maximum number of packets per second that can be transmitted by the link?[Note: you can generate, solve and get answers for many problems similar to this at http://gaia.cs.umass.edu/kurose_ross/interactive/ (computing the one-hop transmission delay)]

Problem 3. Perform a traceroute from a machine you have access to a seas.ucla.edu. Recall that to do a traceroute, you use the traceroute from a Mac’s terminal program, or the tracert command from the MS-DOS command window on a Windows machine.
For example, on a Mac, you’d enter:

```bash
trace
eroute seas.ucla.edu
```

and then press return

1. What is the average of the round trip delay reported by traceroute from your machine to the first router you see that contains “seas.ucla.edu”? Give your answer in milliseconds.
2. How many routers are in the path?
3. Try the traceroute again some hours or days later, using a different access network is you can. Did the set of routers or the number of routers ever change?
4. Find out the identify an ISP in the path from source to destination. For example, in class we saw a router name that ends in nox.org. Google’ing nox.org shows that nox.org is "Northern Crossroads," a collaborative (that runs a network) of research institutions in New England. There's no right or wrong answer here - just see what you can find about one or more of the ISPs that you find in one of your traceroutes. You will also find the whois command useful. Whois runs natively on Macs and Unix machines. It’s not natively available on a Windows machine, but you can use the site [http://www.whois.net/](http://www.whois.net/) on a windows or a Mac.
5. Repeat steps 1 and 2 [www.iitb.ac.in](http://www.iitb.ac.in), the web page for the Indian Institute of Technology in Bombay (You might want to just visit that page on the web to read about this fine school). But we are interested here in the network path from Umass to IITB. To look at the first 18 routers on the path from your computer to the IITB web server, enter:

```
traceroute -m 16 www.iitb.ac.in
```

and type return (or use the tracert command if you have a PC). What is the round trip delay from your computer to the 18th router?

**Problem 4.** Consider a sensing application, where each sensor generates 1000 bits of information one per minute, and then sends that data to a server. Thus, most of the time, the sensor has nothing to send (having only to send 1 update per minute on average).

1. Would a circuit-switching or packet-switching network work well for this application? Why?
2. Now suppose that the application changes from sensing to remote neurosurgery, where remote surgeons are collaborating on an operation in which each is operating a different medical device at the central server, and seeing a video of the operation. Again, we focus on the only network from remote surgeons to the central server and similarly again assume that each surgeon may generate an action (resulting in a fixed-length 1000-bit update message being sent to a central server) once every minute on average. Most of the time, however, a surgeon does not send an update since s/he is
taking some local action (e.g., inspecting the return video which is rendered locally). Does your answer to 1 above change? Why?


1. Why would someone in China maybe want to access content via a proxy server? To answer this question you will need to read Fallows’ explanation of how a proxy server works (bottom of page 5; you might also want to search around on the web a bit to learn how proxy servers work, although the first few paragraphs of the Wikipedia page on “proxy server” is helpful and gives a good enough overview). [Hint: think about a censor that blocks access to content based on the Internet address of the origin server that is sending the content. For example, if nytimes.com has the original content and send to the client via proxies, nytimes.com is the origin server; in the figure on the Wikipedia page, Bob is the origin server.]