You have 70 minutes to complete this exam. Time begins after we have all read through the exam questions together and time ends promptly 70 minutes later. You may not read the exam questions before we read them together, and you may not write anything while we are reading those questions together.

Please record your answers in a Word file, in a text file, or on a piece of paper (which could be the last page of this exam or any other paper). You can answer some questions one way (e.g., as Word) and others the other way (e.g., by writing on paper). At the top of every piece of paper or every file in which you write an answer, write your name and the date. If you answer any questions using Word or a text file, submit that file on ELMS and also email it to both oard@umd.edu and rashmi@umd.edu. If you answer any questions on paper, turn in that paper. Make sure your name is on everything that you turn in! And if you use both paper and a file, make a note on each about what can be found in the other so that we don't miss any of your answers.

You may use any information and software that existed before the start of this exam. This means (among other things) that you may search the Web. You may NOT communicate with any other person other than the instructor for any purpose during the exam period, either in person or in any other way, and you may not post anything to any location for any purpose during the exam period. Note that this means you may not have skype, email or any instant messaging application active on any device that you use during the exam, and that that even if you leave the exam room early you may not talk with anyone about anything, you may not send or receive any email, etc. until the exam period ends at 6:15 PM.

Hand write and sign (or, if you type your answers, hand type – no cut and paste – followed by your name) the honor pledge on this exam. (For reference, the honor pledge as stated at http://osc.umd.edu/Uploads/OSC/Honor%20Pledge.pdf, is: "I pledge on my honor that I have not given or received any unauthorized assistance on this exam.")

As strategies for completing the exam, keep the following in mind:
- If you find a question to be ambiguous, you may come to the front of the room to ask about it, but please do so in a way that other students can't hear. If you don't get an answer that resolves your question, then please explain your confusion and any reasonable assumptions that you have made in order to answer the question and include those with your answer so that they can be considered during grading.
- You are more likely to get partial credit for an incorrect answer if you show your work.
- **Be careful not to spend too much time on any one question.** The total available credit on this exam is 25 points. Plan ahead, and don't devote more time to a question than it is worth.

Answer **either** question 1 or question 2 (if you answer both, we will grade only question 1):

1. [10 points] Design an application layer protocol that can be used to control the volume (i.e, the loudness) and the channel number of a television set (one that has an Internet connection!). A complete answer to this question will include a clear and complete definition of the messages that can be sent in each direction and a description of the order in which those messages would be used to accomplish the specified tasks. The description can either be presented using words (e.g., as a narrative) or by using one or more sequence diagrams.

2. [10 points] Imagine you want to send a single 1 kilobyte UDP packet from Maryland to California, and that to get there the packet will need to travel through three links (from the sending host to the first router, then between the first and second router, then between the second router and the destination host). Assume that the routers use the store-and-forward method that we discussed in class and that is described in the book, that the processing delay in each router is 20 microseconds, that the speed of the link between each pair of routers is 20 megabits per second (Mb/s), that the links and routers are arranged in a straight line (so that the total propagation delay is not increased by an indirect routing), that the signal moves at the speed of light (which you can assume is 300,000,000 meters per second), and that the total distance that the signal must travel is 3,000 kilometers. Be careful about the difference between bytes and bits (a byte is 8 bits). Answer both of the following parts of this question:

    a. Assuming that there are no queueing delays, what is the total one-way delay between the time your computer starts to send the message and the time that the host in California finishes receiving it? For full credit, your answer must be exactly correct. For partial credit, show your work.

    b. In reality, queueing delays do sometimes occur. Could these queueing delays be longer that the total delays caused by everything other than queueing (i.e., could the queueing delay more than double the total time for the packet to get there)? If so, how much longer could the queueing delays be? If not, how much shorter would the longest possible queueing delay be?

The exam continues on the next page (there are three more questions!)

Answer **all** of the following questions:

3. [5 points] The Domain Name Service (DNS) is used to look up the IP address for a domain name. When WikiLeaks published content that violated US law, the US government compelled the top-level domain server for the .org domain to remove the resource record for wikileaks.org. Answer both of the following questions:

    a. Explain why this would have made it harder for people to reach the Wikileaks Web site.

    b. Explain why this would not not make it impossible for people to reach the WikiLeaks Web site. To answer this question, simply explain one way that the WikiLeaks Web site could be reached even after the DNS resource record had been removed from top-level domain server for the .org domain.

4. [5 points] Explain why HTTP uses TCP, but Skype prefers instead to use UDP (Skype will choose to use TCP only if UDP is blocked). A good answer will explain why each makes the choice it does (i.e., why HTTP uses TCP and why Skype prefers UDP), and what would not work as well if it made the other choice (i.e., what would not be as good if HTTP chose UDP and what would not be as good if Skype always chose TCP).

5. [5 points total] Consider the following traceroute result from a host in Singapore to a Web server at the National University Singapore:

traceroute to www.nus.sg (137.132.21.27), 30 hops max, 60 byte packets
 1 ge2-8.r01.sin01.ne.com.sg (202.150.221.169) 0.225 ms 0.239 ms 0.280 ms
 2 10.11.34.14 (10.11.34.14) 3.392 ms 3.437 ms 3.458 ms
 3 nus.sgix.sg (103.16.102.57) 29.410 ms 29.423 ms 29.431 ms
 4 202.51.240.81 (202.51.240.81) 3.966 ms 3.991 ms 3.997 ms
 5 nus-gw1.gigapop.nus.edu.sg (202.51.241.14) 4.083 ms 4.151 ms 4.214 ms
 6 nusnet-3-194.dynip.nus.edu.sg (137.132.3.194) 5.093 ms 4.969 ms 4.757 ms
 7 yih0169.pc.nus.edu.sg (137.132.17.169) 4.896 ms 4.900 ms 5.082 ms
 8 yih0134.pc.nus.edu.sg (137.132.17.134) 5.104 ms 5.075 ms 5.089 ms
 9 nusnet-17-39.dynip.nus.edu.sg (137.132.17.39) 5.902 ms 5.841 ms 5.777 ms
10 nusnet-17-30.dynip.nus.edu.sg (137.132.17.30) 5.519 ms 4.877 ms 4.959 ms
11 yih0199.pc.nus.edu.sg (137.132.17.199) 5.353 ms 5.324 ms 5.082 ms
12 nusnet-17-66.dynip.nus.edu.sg (137.132.17.66) 38.182 ms 38.192 ms 38.089 ms

    Line 4 shows three different values for the round trip time between the sending host and the router whose IP address is 202.51.240.81 (which is the fourth different router that packets go through). Why are all three values different?

*** WRITE AND SIGN THE HONOR PLEDGE ***