Computer Networking: CS6843
Midterm Examination

Fall 2013

21 Oct, 2013

Instructions

- Put your name and student number on every exam book that you use!

- The exam is closed book.

- You have 90 minutes to complete the exam.

- For questions that ask for an explanation or reason, give very short and to-the-point answers.

- If you get stuck on one problem go on to another problem.

1. (10 points) There are 2^N hosts in an organization. You have been given the task of designing a protocol to transfer a large file from host 1 to the other $2^N - 1$ hosts. Sending the file from host i to host j takes T seconds, for any pair i and j, irrespective of whether other hosts are communicating at the same time. Therefore sending the file from Host 1 to all the other $2^N - 1$ hosts, one by one, would take $T * (2^N - 1)$ seconds. This is too long.

   (a) (5 Points) What is the smallest possible amount of time needed to make sure that each host has the file?
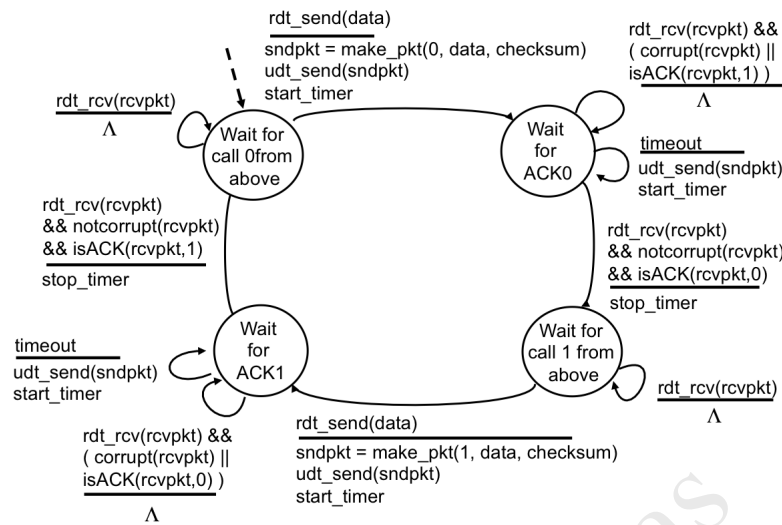   *Answer: T*N*

   (b) (5 Points) What is the corresponding protocol?
   Answer: In each time slot of T seconds, the number of hosts that have the file can double because each host that has the file can give it to hosts that don't have it. In the beginning only host 1 has it. In the first time slot of T seconds, host 1 gives it to host 2, so after one time slot host 1 and 2 have it. In the 2nd time slot host 1 gives it to host 3 and host 2 gives it to host 4, so at the end of the 2nd time slot, the first 4 hosts have it. Doubling in this manner in each time slot of T seconds, the total time needed is $T * \log_2$ of the number of hosts, which is T*N.

2. (20 points) The Internet suffers from several imperfections, including bit errors and packet loss. Consider the following protocol for end-to-end reliable data transfer between two hosts on the Internet. The operation of the Sender is encoded in the form of a finite state machine shown below. There are 4 states as shown below. In each case, the trigger for a state transition is specified above a horizontal line, and the action to be taken is written beneath the line. The symbol Λ denotes 'do nothing'.

   (a) (4 Points) Why are sequence numbers necessary in data packets sent from Sender to Receiver?
   Answer: To distinguish between a new packet and a retransmitted packet.

(b) (3 Points) Why are just two sequence numbers sufficient?
Answer: Because this is a stop and wait protocol, that is, only one packet is sent at a time, as opposed to a sliding window protocol. Therefore the sender only needs to distinguish between two states – whether the packet was correctly received, or there was a dropped packet. Therefore 1 bit is sufficient.

(c) (3 Points) Why must ACKs from the receiver to the Sender contain sequence numbers?
Answer: The receiver needs to indicate 1 bit of information to inform the sender whether the packet was correctly received or not. This can either be an ACK/NACK, or ACK with 1 bit sequence number.

(d) (3 Points) How are bit errors detected at the receiver?
Answer: Using a checksum.

(e) (3 Points) How is a packet dropped by the Internet detected at the sender?
Answer: Using a timeout.

(f) (4 Points) Explain why in the state "Wait for call 1 from above", the Sender might receive a packet from the Receiver (rdt_rvc(rcvpkt) event) and why the finite state machine says that the Sender must do nothing about it.
Answer: The receiver must also use a timer because the imperfect network can cause packet loss in the receiver to sender direction too. Therefore, it is possible for the receiver to send a duplicate ACK if its timer expires and it has not obtained the next packet from the Sender, since it does not know if its ACK was received by the Sender. The sender need not do anything in this state because it has already received the ACK.

3. (10 Points) A process in Host C has a UDP socket with port number 200. Suppose host A and host B each send a UDP segment to host C with destination port number 200.
Answer:

(a) (2 Points) Will both of these segments be directed to the same socket at host C?
Answer: Yes.

(b) (4 Points) How does the process at host C figure out that these segments originated from two different hosts?
Answer: Using the source IP address in the IP header in the packets.

(c) (4 Points) What identifiers does the operating system on C use to define a unique socket in this scenario?
Answer: Source port and destination port

4. (20 Points) Alice visits the webserver that hosts nytimes.com on port 80 to browse today's news.

   (a) (2 Points) What application layer protocol, and transport layer protocol are used by users who visit the website to read news in a web browser?
   Answer: HTTP, TCP

   (b) (2 Points) How can Alice find out the IP address of the web server hosting nytimes.com?
   Answer: Using a DNS lookup on nytimes.com OR using 'dig nytimes.com'

   (c) (2 Points) How can Alice find out the identities of the intermediate routers between her computer and the webserver of nytimes.com?
   Answer: Using traceroute on the IP address in part (b) above.

   (d) (2 Points) Are these intermediate routers aware of the application layer protocol identified in part (a)?
   Answer: No

   (e) (2 Points) Are the intermediate routers aware of the transport layer protocol identified in part (a)?
   Answer: No

   (f) (2 Points) One day while reading the news at nytimes.com, Alice is greeted with a message saying "You have read your maximum of 10 free articles this month. Please buy a subscription for $19.99 to continue". How does nytimes.com know that Alice has read 10 articles this month?
   Answer: Using a cookie, that is, a file that are stored locally by the browser on Alice's machine that contains this information.

   (g) (2 Points) While Alice is visiting nytimes.com, Bob also decides to visit nytimes.com from his own computer. We also know that the web server at nytimes.com uses persistent connections. Are Alice's and Bob's requests sent through the same socket at the web server hosting nytimes.com?
   Answer: No.
   Do both of the sockets have port 80?
   Answer: Yes

   (h) (2 Points) What identifiers does the operating system on the webserver use to define a unique socket in this scenario?
   Answer: Source port, source IP, destination port, destination IP.

   (i) (2 Points) Alice find a news item that is showing live video of a sports event. She clicks on it to view the video. What transport layer protocol do the video packets travel over, and why?
   Answer: UDP, because live video is a loss tolerant application (old dropped packets are not important any more).

   (j) (2 Points) After a while Alice visits nytimes.com again, and she finds when she types 'nytimes.com' in her browser and hits enter, she realizes (say, using Wireshark) that her computer visits a different IP address than the one she visited earlier. Explain in 1-2 sentences how this is possible?
   *Answer: The DNS server responding to the DNS query from Alice replies with multiple IP addresses instead of one, typically rotating the order in which they appear in the DNS response. This is done for load balancing, so that each server hosting nytimes.com has roughly the same amount of traffic. The browser typically picks the first IP address in the DNS response.*

5. (20 Points) Consider the following pipelined reliable data transfer protocol. The sender at all times maintains a window of a maximum of N packets that have not been acknowledged by the Receiver. An ACK sent from the Receiver to the Sender indicates that a specific packet has been received, but does not indicate anything about packets with smaller sequence numbers. When the Sender realizes that a packet has been lost, it resends that packet alone. When the receiver receives a packet out of order (i.e. before it has received all packets with smaller sequence numbers), it buffers it.

   (a) (5 Points) What is the advantage of the protocol above, compared to the protocol in Question (2)?
   Answer: The utilization of the network between the sender and the receiver is much higher. In the protocol in Question 2, the network is idle for most of the time. Sending a window of packets instead of just one at a time allows more efficient utilization of the network, or in other words it will take less time to send a large file from sender to receiver using the pipelines protocol.

   (b) The figure below shows the state of the Sender at a given time. Each box represents a sequence number. The shaded boxes 1 to 4 are sequence numbers for which the Sender has sent packets and received ACKs. Sequence #15 onwards is not currently useable by the Sender. The Sender has received ACKs for sequence numbers 7 and 11 from the Receiver.

   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | |
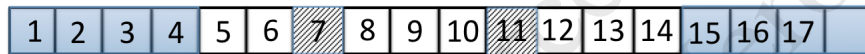
   (b.1) (5 Points) What is the value of N?
   Answer: 10. Will also accept 8 as an answer, because the diagram shows 8 un-ACKed packets (packets 7 and 11 have been ACKed).

   (b.2) (5 Points) If the Sender times out at this stage, what will it do next?
   Answer: Resend packet 5.

   (b.3) (5 Points) If the Sender receives an ACK for sequence #6, what will it do to its window?
   Answer: Nothing. Will also accept the following as as answer: the sender will include packet 15 in its window and transmit packet 15. However, in order to accept this second possible answer, the answer to part (b.1) above should be 8.

6. (10 Points) Suppose there are 5 users whose traffic is being multiplexed over a single link with a capacity of 1 Mbps.

   (a) (5 Points) Suppose each user generates 100 kbps when busy, but is only busy (i.e., has data to send) 10% of the time. Would circuit-switching or packet-switching be preferable in this scenario? Why?
   Answer: Here, circuit switching is preferable since each of the users will each get a dedicated allocation of 100 kbps.

   (b) (5 Points) Now suppose that the link capacity is still 1 Mbps, but the amount of traffic each user has to send when busy is increased to 1 Mbps, and that each of the 5 users still only has data to send 10% of the time. Would circuit-switching or packet-switching be preferable in this scenario? Why?
   Answer: Here, packet switching is preferable. We can not allocate 1Mbps per user in circuit- switching mode. Packet switching will work well since the aggregate average traffic rate is 0.5 Mbps and the link is a 1 Mbps link.

7. (10 Points) You have decided to build a new Internet application for your new startup.

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(a) (5 Points) The application requires reliable data delivery between sending and receiving hosts (provided by TCP but not by UDP), but it does not require congestion control (TCP provides congestion control, UDP does not). How do you accomplish this?

Answer: Use UDP and program the reliable data delivery logic into the application.

(c) (5 Points) One day you change the DNS entry for your webapp's domain name www.NewWebapp.com from 12.34.56.78 to 87.65.43.21 because you move to a different hosting service. Just after you make the change, a user types in www.newwebapp.com into his browser. Will he be directed to the new IP address? Explain.

Answer: Not necessarily. DNS results are often cached and remain active till the TTL (time to live) value. So a change in the IP address requires some time to propane to all places in the Internet.