ICSI516 Homework 4 – Network Layer 20 points

Due date: Monday 11/27 at 11:59PM as a single PDF file via Blackboard

All parts of the assignment are to be completed independently. Submission of the same text by multiple students will be considered cheating. Students caught cheating will receive 0 points for the assignment and will be reported.

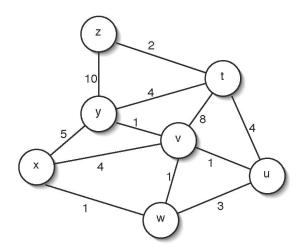
Part 1 [15 points]: Answer the theoretical questions on the following two pages.
Part 2 [5 points]: Complete the Wireshark Lab and answer the questions in the lab. You can download the Wireshark trace for this assignment from http://www.cs.albany.edu/~mariya/courses/csi516F17/hw/ip-wireshark-trace-1

[Theoretical questions]

1. [2 points] Consider a datagram network using 32-bit host addresses. Suppose a router has four links, numbered 0 through 3, and packets are to be forwarded to the link interfaces as follows:

Destination Address Range	Link Interface			
11010000 00000000 00000000 00000000	0			
through				
11010000 1111111 11111111 11111111				
11010001 00000000 00000000 00000000	1			
through				
11010001 00000000 11111111 1111111				
11010001 0000000 0000000 00000000	2			
through				
11010001 1111111 11111111 11111111				
Otherwise	3			

- a. Provide the corresponding forwarding table that has four entries, uses longest-prefix matching, and forwards packets to the correct link interfaces. In other words, what is the prefix that would correspond to each of the address ranges?
- b. What is the correct interface to use for each of the following addresses:
 - 10011000 10010001 01010001 01010101
 - 11010001 0000000 11000011 00111100
 - 11010001 10000000 00010001 01110111
- c. Rewrite the forwarding table you created for part (a) using the a.b.c.d/x notation instead of the binary string notation.
- 2. [2 points] Consider the network in Figure 4.22 of your textbook. Suppose that the ISP instead assigns the router the address 128.111.90.32 and that the network address of the home network is 192.168/16.
 - a. Assign addresses to all interfaces in the home network.
 - Suppose each host has two ongoing TCP connections, all to port 80 at host 112.72.30.127. Provide the six corresponding entries in the NAT translation table in the router.
- 3. [1 points] Calculate the byte overhead (in terms of number of Bytes) introduced by IP fragmentation when a packet of size 5000 Bytes traverses a network with MTU 1200 Bytes. What can the source network do to avoid fragmentation?
- 4. [2 points] Consider the following prefix 169.226.2.0/24.
 - a. Write down the network mask in dotted-decimal notation.
 - b. Calculate the corresponding network address.
 - c. Calculate the corresponding broadcast address.
 - d. How many host addresses are there in this prefix?
 - e. How many IP addresses in total are there in this prefix?
- 5. [2 points] Consider the following network. With the indicated link costs, use Dijkstra's shortestpath algorithm to compute the shortest path from x to all network nodes. Show how the algorithm works by computing a table similar to Table 4.3 in your book.



- 6. [1 point] Consider the three node topology shown in Figure 4.30 in your book. Rather than having the link costs as shown in the figure, use the link costs of c(x,y)=5, c(y,z)=9, and c(x,z)=3. Compute the distance tables after the initialization step and after each iteration of a synchronous version of the distance-vector algorithm (as shown in the book for Figure 4.30).
- 7. [1 point] Compare and contrast the advertisements used by RIP and OSPF.
- 8. [1 point] Why does the Internet need to use different intra-AS and inter-AS protocols?
- 9. [3 points] *Scheduling* and *buffer management* are two key functions that a router performs on its queues.
 - a. What is each of these techniques concerned with?
 - b. Describe how First-In-First-Out (FIFO) scheduling can be detrimental to application performance and discuss advanced techniques to solve this problem following our discussion of [Demers+98, Fair Queueing].
 - c. Describe how Tail Drop buffer management can be detrimental to application performance and discuss advanced techniques to solve this problem following our discussion of [Floyd+93, Random Early Detection].

Wireshark Lab: IP

In this lab, we'll investigate the IP protocol, focusing on the IP datagram. We'll do so by analyzing a trace of IP datagrams sent and received by an execution of the traceroute program. We'll investigate the various fields in the IP datagram, and study IP fragmentation in detail.

To best understand and work through this lab, there are a few resources you can take advantage of. Section 1.4.3 in the text and section 3.4 of RFC 2151 [ftp://ftp.rfc-editor.org/in-notes/rfc2151.txt] review the operation of the traceroute program. You should also read Section 4.4 in the text to be sure you understand IP. If you feel that more detail on IP could help, then you should use RFC 791 [ftp://ftp.rfc-editor.org/in-notes/rfc791.txt].

1. Capturing packets from an execution of traceroute

In order to generate the trace of IP datagrams for this lab, the traceroute program was used to send datagrams of different sizes towards some destination, X. Recall that traceroute operates by first sending one or more datagrams with the time-to-live (TTL) field in the IP header set to 1; it then sends a series of one or more datagrams towards the same destination with a TTL value of 2; it then sends a series of datagrams towards the same destination with a TTL value of 3; and so on. A router must decrement the TTL in each received datagram by 1. If the TTL reaches 0, the router returns an ICMP message (type 11 – TTL-exceeded) to the sending host. As a result of this behavior, a datagram with a TTL of 1 (sent by the host executing traceroute) will cause the router one hop away from the sender to send an ICMP TTL-exceeded message back to the sender; the datagram sent with a TTL of 2 will cause the router two hops away to send an ICMP message back to the sender; the datagram sent with a TTL of 3 will cause the router three hops away to send an ICMP message back to the sender; and so on. In this manner, the host executing traceroute can learn the identities of the routers between itself and destination X by looking at the source IP addresses in the datagrams containing the ICMP TTL-exceeded messages.

For this lab we'll investigate the traceroute program by having it send datagrams of various lengths. As with the previous assignments, the trace you will use in Wireshark has been generated for you. However, if you would like to run the traceroute program yourself to experiment with the different options, follow the following instructions.

Note: experimenting with traceroute is OPTIONAL, yet encouraged:

- Windows. The tracert program provided with Windows does not allow one to change the size of the ICMP echo request (ping) message sent by the tracert program. A nicer Windows traceroute program is *pingplotter*, available both in free version and shareware versions at http://www.pingplotter.com. Download and install *pingplotter*, and test it out by performing a few traceroutes to your favorite sites. The size of the ICMP echo request message can be explicitly set in *pingplotter* by selecting the menu item *Edit->Advanced Options->Packet Options* and then filling in the *Packet Size* field. The default packet size is 56 bytes. Once *pingplotter* has sent a series of packets with the increasing TTL values, it restarts the sending process again with a TTL of 1, after waiting *Trace Interval* amount of time. The value of *Trace Interval* and the number of intervals can be explicitly set in *pingplotter*.
- Linux/Unix. With the Unix traceroute command, the size of the UDP datagram sent towards the destination can be explicitly set by indicating the number of bytes in the datagram; this value is entered in the traceroute command line immediately after the name or address of the destination. For example, to send traceroute datagrams of 100 bytes towards gaia.cs.umass.edu, the command would be:

%traceroute gaia.cs.umass.edu 100

The Wireshark trace was captured through the following steps:

- Packet capture with Wireshark was started on a Windows machine.
- Three sets of traceroutes were executed. In the first set, three pings with a packet size of 56 bytes were sent to a destination. In the second set, three pings with a packet size of 2000 bytes were sent to a destination. In the final set, three pings with a packet size of 3500 bytes were sent to a destination.
- If you try this out with the pingplotter on Windows, you will get a screenshot that looks something like this:

		🏂 gaia.cs.umass.edu - Ping Plo	tter									_ 🗆 ×
		File Edit View Help						_				
		Address to Trace:	Target Name: gaia.cs.umass.edu									0-200
		gaia.cs.umass.edu	P: 128.119.245.12									201-500
		gaia.cs.umass.edu			/2004 9:57:07 PM -	8/22/2004 9:57:09 P						01 and up
		www.smith.edu	Hop PL			DNSName		Avg C		Gra	iph	33
		newworld.cs.umass.edu	1	10.216.228.1					13 0	<u> </u>		55
		www.cs.umass.edu www.aol.com	2	24.218.0.153 24.128.190.197	bar01-p4-0.wsfdh	o1 mo ottbb not			11 14	<u> </u>		
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		www.pingpiotter.com	6	192.5.89.137					17	-	×	
			7	192.5.89.102	ABILENE-GIGAP	-			20		*	
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			<u>9</u> 10	128.119.3.153					23			
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			128.119.	3.153							Graph ti	me = 5 minutes
		Trace Interval: 1 second	2.3									- 30 -
		- Statistics										
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	2 4.866867	192.168.1.100 1	92.168.1		UDP	174 Source port:	: 30955 De	stinat	ion port: ssdp			
	3 4.868147 4 5.363536		92.168.1 92.168.1		UDP UDP	175 Source port: 174 Source port:	: 30955 De	stinat	ion port: ssdp			
	5 5.364799		92.168.1		UDP	175 Source port:						
	6 5.864428	192.168.1.100 1	92.168.1	. 1	UDP	174 Source port:	: 30955 De	stinat	ion port: ssdp			
	7 5.865461 8 6.163045		92.168.1 28.59.23		UDP I CMP	175 Source port: 98 Echo (ping)	request i	d=0x03	ion port: ssdp 00. seg=20483/1	848. ttl=1		
	9 6.176826		92.168.1		ICMP				to live exceed		sit)	
	10 6.188629 11 6.202957	192.168.1.102 1 24.218.0.153 1	28.59.23 92.168.1		ICMP	98 Echo (ping) 70 Time to live	request 1	d=0x03	100, seq=20739/1	849, ttl=2 ed in tran	sit)	
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	13 6.234505	24.128.190.197 1	92.168.1	.102	ICMP	70 Time to-live	e exceeded	(Time	to live exceed	ed in tran	sit)	Ŧ
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2. A look at the captured trace

Packets: 380 Displayed: 380 Marked: 0 Load time: 0:00.006

🔵 Frame (frame), 98 bytes

In the trace, you should be able to see the series of ICMP Echo Requests sent by the client computer and the ICMP TTL-exceeded messages returned to the computer by the intermediate routers.

Profile Default

- 1. Select the first ICMP Echo Request message sent by the client computer, and expand the Internet Protocol part of the packet in the packet details window, as shown in the figure below. You should see something similar to the image above. What is the IP address of the client?
- 2. Within the IP packet header, what is the value in the upper layer protocol field? What is the purpose of this field?
- 3. Has this IP datagram been fragmented? Explain how you determined whether or not the datagram has been fragmented.

Next, sort the traced packets according to IP source address by clicking on the *Source* column header; a small downward pointing arrow should appear next to the word *Source*. If the arrow points up, click on the *Source* column header again. Select the first **ICMP Echo Request message** sent by the client computer, and expand the Internet Protocol portion in the "details of selected packet header" window. In the "listing of captured packets" window, you should see all of the subsequent ICMP messages (perhaps with additional interspersed packets sent by other protocols running on the computer) below this first ICMP. Use the down arrow to move through the ICMP messages sent by the computer.

- 4. Which fields in the IP datagram *always* change from one datagram to the next within this series of ICMP messages sent by your computer? Why must those fields change?
- 5. Describe the pattern you see in the values in the Identification field of the IP datagram.

Fragmentation

Sort the packet listing according to time by clicking on the *Time* column.

- 6. Find the first ICMP Echo Request message that was sent by the computer after the *Packet Size* was changed to 2000. How many datagrams has that message been fragmented across?
- 7. What information in the IP header indicates that the datagram been fragmented? What information in the IP header indicates whether this is the first fragment versus a latter fragment?
- 8. Now look at the second fragment of the IP datagram. What information in the IP header indicates that this is not the first datagram fragment? Are there more fragments? How can you tell?

Now find the first ICMP Echo Request message that was sent by the computer after the *Packet Size* was changed to 3500.

- 9. How many fragments were created from the original datagram?
- 10. What fields change in the IP header among the fragments?