Introduction to Computer Networks Final Examination, Fall 2009

1. (5%) Describe how the ping utility works.

   Ping operates by sending Internet Control Message Protocol (ICMP) *echo* request message to the target host and waits for an ICMP *echo* reply message.

2. (10%) Describe how the traceroute utility works.

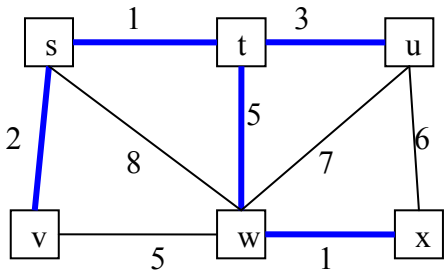
   Source sends series of UDP segments with Unlikely port number to destination. First has TTL =1. Second has TTL=2, etc. When the nth datagram arrives at the nth router. Router discards datagram and sends to source an ICMP "TTL expired" (type 11, code 0) message includes IP address of the router. When the UDP segment eventually arrives at the destination host, the destination returns an ICMP "port unreachable" (type 3, code 3) message. When the source gets this ICMP message, the traceroute utility stops.

3. (20%) Consider a network with six nodes, s, t, u, v, w, and x. The costs of the links are shown in the following matrix. A dash in the matrix indicates that there is no link between the corresponding nodes. Calculate the shortest paths from node s to all other nodes using the Dijkstra's algorithm. Show how the algorithm works using the following table, where N' is the set of nodes to which the least-cost paths from the source node are known, D(t) is the cost of the least-cost path from the source node to node t, and p(t) is the previous node along the current least-cost path from the source node to node t.

	s	t	u	v	w	x
s	-	1	-	2	8	-
t	1	-	3	-	5	-
u	-	3	-	-	7	6
v	2	-	-	-	5	-
w	8	5	7	5	-	1
x	-	-	6	-	1	-

Step	N'	D(t),p(t)	D(u),p(u)	D(v),p(v)	D(w),p(w)	D(x),P(x)
0						
1						
2						
3						
4						

5



Step	N'	D(t),p(t)	D(u),p(u)	D(v),p(v)	D(w),p(w)	D(x),P(x)
0	s	1,s	infinity	2,s	8,s	infinity
1	st		4,t	2,s	6,t	infinity
2	stv		4,t		6,t	infinity
3	stvu				6,t	10,u
4	stvuw					7,w
5	stvuwx					

4. (10%) What information are required in each of the nodes for running the distance-vector routing algorithm?

   For each node x,

   - The cost c(x,v) from x to directly attached neighbor v
   - Node x's distance vector, that is, $D_x = [D_x(y): y \text{ in } N]$ containing x's estimate of its cost to all destinations y in N
   - The distance vector of each of its neighbors, that is, $D_v = [D_v(y): y \text{ in } N]$, for each neighbor v of node x.

5. (5%) Node s has three neighbor nodes t, v, and w. The link costs from node s to nodes t, v, and w are respectively 1, 2, and 8. The minimum costs from node t to node x is 6. The minimum costs from node v to node x is 6. The minimum costs from node w to node x is 1. Calculate the minimum cost from node s to node x using the Bellman-Ford equation.

   $D_s(x) = \min \{1+6, 2+6, 8+1\}=7$

6. (5%) Describe how loops in paths can be detected in BGP.

   Since full AS path information is available from an AS to a destination in BGP, loop detection is simple – if a BGP peer receives a route that contains its own AS number in the AS path, then using that route would result in a loop.

7. (5%) Describe the disadvantages of the slotted ALOHA protocol.

   - collisions, wasting slots

- idle slots, wasting slots
- nodes may be able to detect collision in less than time to transmit packet
- clock synchronization

8. (10%) Describe how address resolution protocol works.
   - A wants to send datagram to B, and B's MAC address not in A's ARP table.
   - A broadcasts ARP query packet, containing B's IP address
     - dest MAC address = FF-FF-FF-FF-FF-FF
     - all machines on LAN receive ARP query
   - B receives ARP packet, replies to A with its (B's) MAC address
     - frame sent to A's MAC address (unicast)
   - A caches (saves) IP-to-MAC address pair in its ARP table until information becomes old (times out)
     - soft state: information that times out (goes away) unless refreshed
9. (5%) Describe how the Exponential Backoff mechanism in the Ethernet protocol works.

   After the *m*th collision, NIC chooses *K* at random from $\{0,1,2,\ldots,2^{m}-1\}$. NIC waits K·512 bit times
10. (5%) What are the rationalities behind the exponential backoff mechanism in the Ethernet protocol?

    Choose a backoff time from a smaller range for a smaller number of colliding adaptors. Choose a backoff time from a larger range for a larger number of colliding adaptors.
11. (20%) Consider a router R with two interfaces, interface1 and interface 2. Subnet 1 is connected to interface 1 and subnet 2 is connected to interface 2. Host A is in subnet 1 and host B is in subnet 2. Suppose that the ARP tables of all interfaces are initially empty. Describe the detailed operations (including network layer, link layer, ARP operations) required for sending a datagram from host A to host B.
    - A creates IP datagram with source A, destination B
    - A finds that the IP address of B is not in the same subnet as A. A determines to send the datagram to interface 1 of router R.
    - A uses ARP to get MAC address of interface 1 of router R
    - A creates link-layer frame with MAC address interface 1 of router R as destination, frame contains A-to-B IP datagram
    - A's NIC sends frame

- R's interface 1 receives frame
- R removes IP datagram from Ethernet frame, sees its destined to B
- R forwards the datagram to interface 2.
- R uses ARP to get B's MAC address
- R creates frame containing A-to-B IP datagram
- R sends the frame to B

12. (10%) Consider the operation of a self-learning switch with six interfaces. Hosts A, B, C, D, E, and F are connected to interface 1, 2, 3, 4, 5, and 6 respectively. The switch table is initially empty. Suppose that (i) host A sends a frame to host C, (ii) host C replies with a frame to host A, (iii) host E sends a frame to host C, (iv) host C replies with a frame to host E. Complete the following switch table.

	MAC address	Interface
host A sends a frame to host C		
host C replies with a frame to host A		
host E sends a frame to host C		
host C replies with a frame to host E		

Event	Switch table entry learned	
	MAC address	Interface
A sends a frame to C	A	1
C replies with a frame to A	C	3
E sends a frame to C	E	5
C replies with a frame to E	none	none