Homework 2 assignment for ECE671

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.

Problem 1 (5 Points):
Suppose Client A initiates a HTTP session with web server S. At about the same time, Client B also initiates a HTTP session with web server S. Provide possible source and destination port numbers for:

a) The segments sent from A to S.
b) The segments sent from B to S.
c) The segments sent from S to A.
d) The segments sent from S to B.
e) If A and B are different hosts, is it possible that the source port number in the segments from A to S is the same as that from B to S?

Solution:
a) A → S (S)467 (D)80 b) B → S (S)513 (D)80 c) S → A (S)80 (D)467 d) S → B (S)80 (D)513 e) yes, because A and B will have different IP addresses and thus the five tuples will be different and allow the server to differentiate the streams.

Problem 2 (20 Points):
For this problem, consider the network shown in the figure below. Assume that source A and sink A communicate via TCP Tahoe (TCP1), while source B and sink B communicate via TCP Reno (TCP2). At t=650ms a packet loss (detected via triple duplicate ACKs) occurs for TCP2. Similarly, at t= 900 ms a packet loss (detected via triple duplicate ACKs) occurs for TCP1. Use the empty diagram given below to indicate the size of the congestion window over time for both TCP connections.
Solution:
Problem 3 (20 Points):
The figure below gives an example for slotted ALOHA. For this problem you are asked to calculate the efficiency of the protocol in the long-run. i.e., to calculate the fraction of successful slots assuming many nodes, all with many frames to send. You can make the following assumptions:

- There are $N$ nodes with many frames to send, each transmits in slot with probability $p$
- Probability that given node has success in a slot $= p(1-p)^{(N-1)}$
  Probability that any node has a success $= Np(1-p)^{(N-1)}$

<table>
<thead>
<tr>
<th>node</th>
<th>1</th>
<th>1</th>
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<th>1</th>
</tr>
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<tbody>
<tr>
<td>node</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>node</td>
<td>3</td>
<td></td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

| C   | E   | C   | S   | E   | C   | E   | S   | S   |
Problem 4 (20 Points):

a) Are MAC addresses on the ports of Ethernet switches used in Layer 2 frames? Please justify your answer in a few short sentences.

b) As we know by now, two Ethernet switches that support VLANs can be connected by a VLAN trunk. What information is used by a switch that is connected to a VLAN trunk to identify what VLAN arriving packets belong to? How many VLANs can be support in total? Explain your answer!

c) The congestion window size in TCP Cubic is expressed by $W_{cubic} = C(t-K)^3 + W_{max}$. Explain how $K$ (in terms of $C$ and $W_{max}$) can be determined in this case?

d) Briefly describe the principle of three duplicate ACKs used in the case of TCP congestion control. (You can draw a diagram to illustrate an example if you'd like to). Why are three duplicate ACKs used for fast retransmissions?

Solution:

a) No. MAC addresses of the ports in Ethernet switches are never used. Referring to the example of a self-learning Ethernet switch, we see that their use is not required. The switch maintains a table that links its ports to the MAC addresses of the devices that are connected to these ports. With this
information frames can be switched based on the MAC addresses of the end systems.
b) 802.1Q frames that contain a specific VLAN ID are transmitted over VLAN trunks. The VLAN ID field is 12 bits, so $2^{12} = 4096$ VLAN addresses can be supported in total.
c) The goal of the TCP Cubic algorithm is to reach $W_{\max}$ at $t=K$. Right after a loss we have $W_{cubic} = (1-\beta) * W_{\max}$. Thus,

$$(1-\beta) * W_{\max} = C(t-K)^3 + W_{\max},$$

for $t=0$ we get

$$(1-\beta) * W_{\max} = -CK^3 + W_{\max}$$

$K=(\beta * W_{\max}/C)^{1/3}$.
d) Three duplicate ACKs indicate that TCP segments are still reaching the receiver and only one or a small fraction of segments might have been lost. Thus, indication only some very minor congestions.

**Problem 5 (25 Points):**

Consider the network shown above.

a. Consider an ARP request send by node B for node A. Whose IP-to MAC address translation is being queried?
b. What is the destination MAC address on the frame containing the ARP request?
c. After B receives the ARP reply, what is contained in switch 3 switching table?
d. Assign IP addresses to hosts A, B, C, and interfaces 1 and 3 of R1. Note: Each of the subnets should be able to host a maximum of 17 hosts.
e. Now consider the frame containing the B-to-A IP datagram. What are the MAC source and destination address of this frame and the IP source and destination addresses in the encapsulated IP datagram at points (1), (2), and
f. Suppose all switches in the above example are learning switches. Consider the datagram being sent from A to C; neither A nor C have sent any frames or datagrams in the network before. How many of hosts in the network receive the frame containing the datagram sent by this server? Explain your answer briefly.

Solution:

a. The right router interface “3”.
b. Since B doesn’t know which MAC address to send the request to (hence the ARP request), the frame carrying this request has FF:FF:FF:FF:FF:FF (the broadcast) MAC address as destination address.
c. Switch 3 knows that B is reachable via interface 4 (as a result of the ARP request sent by B) and that the router R1 is reachable via interface 5 (as a result of the ARP reply sent by R1)
d. Because each subnet should be able to host a maximum of 17 hosts, five address bits are needed for each subnet. So let’s assign the left subnet XX.YY.ZZ.xx0*****/27, where the XX.YY.ZZ are 8 bit numbers. Each x is a bit and the three *’s correspond to the five address bits for this network. For the right subnet, well use XX.YY.ZZ.xx1*****/27. Any address in the range XX.YY.ZZ.xx000001 to XX.YY.ZZ.xx011110 can be used for A, C, and interface 1. Any address in the range XX.YY.ZZ.xx100001 to XX.YY.ZZ.xx111111 can be used for B and interface 1.
e. (1) MAC-D: AA:10:F3:5C:01:04, MAC-S: 20:FF:3A:BC:01:4E, IP-D: e.g., XX.YY.ZZ.xx000001, IP-S: e.g., XX.YY.ZZ.xx100001
   (3) MAC-D: 10:D4:E1:A8:97:F0, MAC-S: BB:89:34:E7:01:3B, IP-D: e.g., XX.YY.ZZ.xx000001, IP-S: e.g., XX.YY.ZZ.xx100001; (2) same as (1).
f. All hosts that are connected to switches 1 and 2 will receive the frame. That will include interface 1 of R1.

Problem 6 (10 Points):

This problem focuses on the new approach of Software Defined Networking (SDN).

a. Explain what happens when a packet arrives at the switch and no matching flow table for that packet exists on the switch?
b. What information is contained in a flow table entry?
c. Name the header fields that can be used for matching in the case of OpenFlow?
d. What happens if a flow rule times out?
e. What OpenFlow message is used to add a new flow table in a switch? What message does the switch use to let the controller know that it received a packet for which it does not have a matching rule?

Solution:
a. Packet will be sent from the switch to the controller. Controller checks if a new flow table should be installed in the switch after checking the packet. If so, new flow table entry is sent to the switch and the packet is sent to the switch including information on which port of the switch it should be sent out.

<table>
<thead>
<tr>
<th>Match</th>
<th>Action</th>
<th>Counter</th>
<th>Priority</th>
<th>Time-out</th>
</tr>
</thead>
</table>

b.  

c.  

d. It will be removed from the switch. A packet that would have matched that rule will go through the routine described in a).

e. Flow-mod, Packet-in.