National University of Computer & Emerging Sciences, Karachi
FAST School of Computing
Final Examination, Spring 2021 [SOLUTION]
15th June 2021, 09:00 am – 12:00 pm

Course Code: CS-307	Course Name: Computer Networks
Instructor Names: Dr. Sufian Hameed, Dr. Nadeem Kafi, Dr. Hassan Jamil, Dr. Aqsa Aslam, Mr. Shoaib Raza, Mr. Abdullah Zarshaid	
Student Roll No:	Section No:

Instructions:

- Return the question paper.
- **All questions must be answered in answer script and according to the sequence given in the question paper.**
- In case of any ambiguity, you may make an assumption, however, your assumption should not contradict any statement in the question paper.

Time: 120 minutes. **Max Points**: 100

Question 1: Please calculate the LAN and Access link utilization in following scenario. **[10 points]**

a. Average object size is 450 Kilo Bytes
b. Average request rate from the browsers to origin server is 17 requests/seconds
c. Cache Hit ratio is 0.37

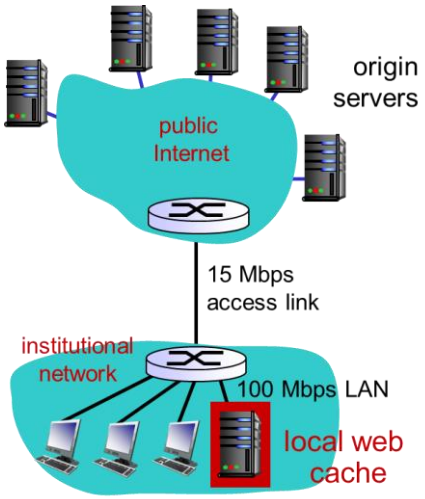


Figure 1

Average Requests/Sec = 17
Avg Size = 450kb * 8 = 3.600 Mbits
Total load = (3.6*17) = 61.2 Mbits/sec
Lan Utilization = 61.2%
Cache hit ratio = 0.37 which would put load of 22.65 Mbits/sec to access link
So it will be 100% utilized and packets will drop due to queuing.

Question 2: Systemslabs.com is registered and hosted with GoDaddy. Both the web server and mail server of Systemslabs are associated with 10.11.21.13 and 10.11.21.14 respectively. The primary authoritative name server of GoDaddy is dns1.GoDaddy.com which is mapped to 192.168.10.1. List down all the resource records (RRs) that will be inserted into the authoritative name server and .com's TLD (top level domain) server. **[10 points]**

Solution:
RR Inserted in Authoritative NS
(Systemslabs.com, 10.11.21.13, A)
(Systemslabs.com, 10.11.21.14, MX)
RR Inserted in TLD
(Systemslab.com, dns1.GoDaddy.com, NS)
(dns1.GoDaddy.com, 192.168.10.1, A)

Question 3: SDN provides a programmable control plane, however, it network infrastructure needs changes as we studied in chapter # 5 of our textbook. Now, answer the following questions. **[10 points]**

a) How the data plane is different while using SDN? Explain.

Two fold: i) data plane is based on SDN controlled switches and ii) uses flow table to forward traffic.

b) What is the key role of OpenFlow in SDN?

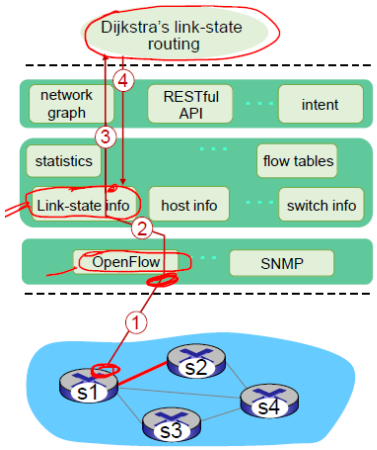
OpenFlow defines the communication protocol between SDN controllers and the data (forwarding) plane. It facilitate SDN controllers to send messages to switches consisting of queries, setting configuration parameters, modify state and even sending packets directly. Similarly, switch can send port and flow table status, or packets for processing at the controller.

c) Setup a flow table entry which prefers traffic from an IP telephone. Make suitable assumptions.

Match plus action type generalized forwarding. IP telephone traffic can be identified using Layer 2 attributes (MAC address or VLAN ID) or Layer 3 attributes (e.g. source or destination IP address).

```
Match [IP Scr=10.20.30.*, optionally IP Dest= 172.16.20.*]
Action [send to controller for type of service setting]
```

d) How SDN controller (explain in a step-by-step way) make use of different network application to provide link state routing in the SND setup? Explain.

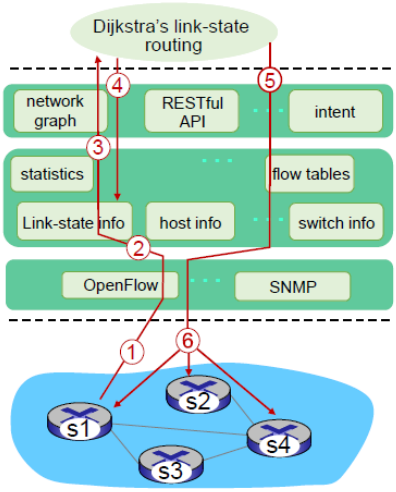


① S1, experiencing link failure uses OpenFlow port status message to notify controller

② SDN controller receives OpenFlow message, updates link status info

③ Dijkstra's routing algorithm application has previously registered to be called when ever link status changes. It is called.

④ Dijkstra's routing algorithm access network graph info, link state info in controller, computes new routes



⑤ link state routing app interacts with flow-table-computation component in SDN controller, which computes new flow tables needed

⑥ controller uses OpenFlow to install new tables in switches that need updating

Question 4: Because of the connection-oriented nature of TCP, a connection setup phase is required at the beginning of each session, as well as a connection tear-down phase at the end of the session. Enumerate the events below in the order they occur as host A opens a TCP connection to host B, transmits data and then closes the connection. Write a 1 next to the event that occurs first and continue like that until all occurring events are enumerated (the first event has been enumerated for you). You may assume that no segments are lost. Also indicate at which host the event happens. Please note that there might be events listed below that are not a part of the above data transfer and hence should not be enumerated. **[10 points]**

Order	Host	Event
8	A	Send an ACK segment
4	A & B	Do the rest of the data exchange
11	A	Close the connection
6	B	Send an ACK segment
5	A	Send a FIN segment
1	A	Send a SYN segment
7	B	Send a FIN segment
		Send a RST segment
2	B	Send a SYN-ACK segment
9	A	Enter the TIME-WAIT state
3	A	Send an ACK+DATA segment
10	B	Close the connection

Question 5: The Transmission Control Protocol uses a method called congestion control to regulate the traffic entering the network. The behavior of TCP congestion control can be represented as a graph in which the x-axis indicates the time, and the y-axis indicates congestion window size. Please use the graph shown below to the answer the following questions. Note that the graph does not explicitly show timeouts, but you should be able to figure out when timeouts happened based on the events shown. **[10 points]**

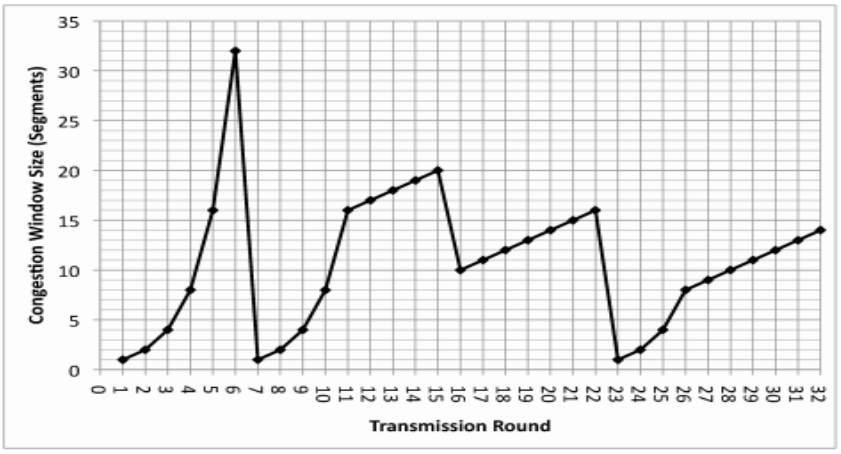


Figure 2

a) **Slow Start:** identify the intervals of time when TCP slow start is operating.

1-6, 7-11, 23-26

b) **Congestion Avoidance:** identify the intervals of time when TCP congestion avoidance is operating.

11-15, 16-22, 26-32

c) **Fast Retransmission**: identify the intervals of time when TCP fast retransmission is used.

15-16

d) **Fast Recovery:** identify the intervals of time when TCP fast recovery is operating.
15-16

Question 6: A provider has been assigned the network **209.118.127.0/23** and wants to divide it among three customers. **Ufone** needs to accommodate up to 250 hosts, **Zong** needs to accommodate up to 48 hosts and **Telenor** needs to accommodate up to 120 hosts. Fill the following table in your answer script with the details of the sub-networks that the provider can create to fit its customers' needs. **[10 points]**

Subnet No.	Network Addr	Netmask	Host Range	No. Of Hosts
Ufone	**209.118.126.0/ 24**	255.255.255.0	**209.118.126.0 --- 209.118.126.255**	254
Zong	**209.118.127.0/25**	255.255.255.128	**209.118.127.0 --- 209.118.127.127**	126
Telenor	**209.118.127.128/25**	255.255.255.128	**209.118.127.128 --- 209.118.127.255**	126

Question 7: Consider the network shown in Figure 3. Suppose AS3 and AS2 are running OSPF for their intra-AS routing protocol. Suppose AS1 and AS4 are running RIP for their intra-AS routing protocol where weight of l1 < l2 both connected to router 1d. Suppose eBGP and iBGP are used for inter-AS routing protocol. Initially suppose there is no physical link between AS2 and AS4. **[10 points]**

There is no physical link between AS2 and AS4 for part (a) and (b)

a) Router 3c learns about prefix x from which routing protocol: OSPF, RIP, eBGP, or iBGP?

3c learn from 4c (AS4)using eBGP.

b) Router 3a learns about x from which routing protocol?

iBGP running on 3c.

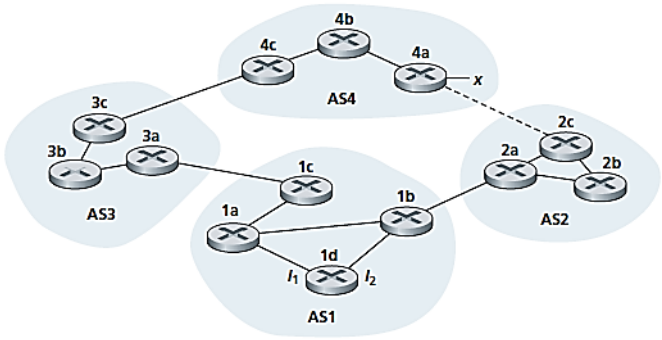


Figure 3

Now suppose that the link between AS2 and AS4 has been restored.

Physical link exists between AS2 and AS4 for part (c) and (d)

c) Router 1c learns about x from which routing protocol?

Learns x from 3a using eBGP. OR Learns x from 1b using iBGP.

d) Router 1d learns about x from which routing protocol?

Learns x from 1b using iBGP. OR Learns x from 1c using iBGP.

Question 8: Consider the following network with the indicated link costs. **[20 points]**

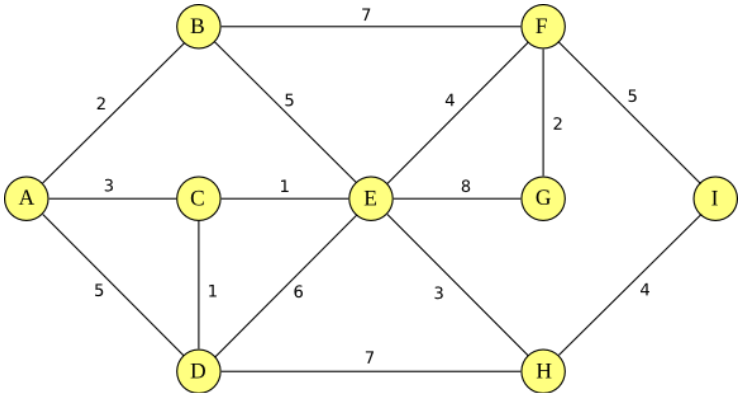


Figure 4

a) Use Dijkstra's shortest-path algorithm to compute the shortest path from A to all network nodes. State of Initial routing table is shown below.

Step	Node (N')	D(B), p(B)	D(E), p(E)	D(F), p(F)	D(C), p(C)	D(G), p(G)	D(I), p(I)	D(D), p(D)	D(H), p(H)
0	A	∞	∞	∞	∞	∞	∞	∞	∞
1	A	2, A	∞	∞	3, A	∞	∞	5, A	∞
2	AB		7, B	9, B	3, A	∞	∞	5, A	∞
3	ABC		4, C	9, B		∞	∞	4, C	∞
4	ABCD		4, C	9, B		∞	∞		11, D
5	ABCDE			8, E		12, E	∞		7, E
6	ABCDEH			9, E		12, E	11, H		
7	ABCDEHF					10, F	11, H		
Converge at this point									

b) Recalculate the routing table for Node A if the link between Node C to Node E is failed.

Step	Node (N')	D(B), p(B)	D(E), p(E)	D(F), p(F)	D(C), p(C)	D(G), p(G)	D(I), p(I)	D(D), p(D)	D(H), p(H)
0	A	∞	∞	∞	∞	∞	∞	∞	∞
1	A	2, A	∞	∞	3, A	∞	∞	5, A	∞
2	AB		7, B	9, B	3, A	∞	∞	5, A	∞
3	ABC		7, B	9, B		∞	∞	4, C	∞
4	ABCD		7, B	9, B		∞	∞		11, D
5	ABCDE			9, B		15, E	∞		11, D
6	ABCDEH			9, B		15, E	15, H		
7	ABCDEHF					11, F	14, F		
Converge at this point									

Question 9: Consider a two LAN connected by a router as shown in Figure 5. **[10 points]**

a) Host A transmits a packet to host D. Which Layer 2 and Layer 3 addresses are contained in the protocol data units that are transmitted from host B to the router?

Answer:

Layer 2 destination address = E6-E9-00-17-BB-4B

Layer 2 source address = 74-29-9C-E8-FF-55

Layer 3 destination address = 222.222.222.221

Layer 3 source address = 111.111.111.111

b) Host A wants to get the MAC address of Host C, which protocol Host A will use to find the C's MAC address? What is the purpose of that protocol?

Answer:

Host A uses ARP to find Host C's MAC address. The purpose of ARP is to obtain a specific MAC address when an IP address is known, by broadcasting an ARP request message to all devices on a particular Ethernet network

c) Host B issues an ARP request because it want to send a packet to Host D. what will happen next?

Answer:

When Host D receive the ARP request, it will send an ARP reply with its MAC address

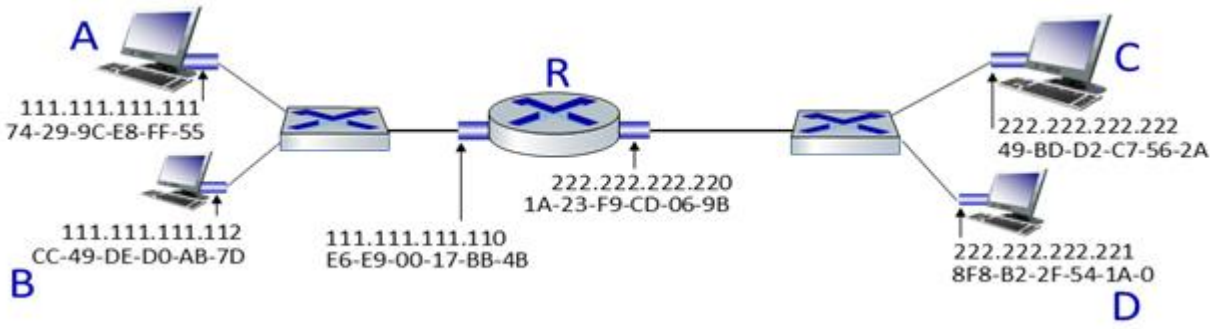


Figure 5

BEST OF LUCK!