CS 348: Computer Networks	**End-semester Exam**	**April 15, 2024**
Spring 2023-24, IIT Dharwad	Total Marks: 68	09:30 AM to 12:30 PM

Name: ____ **Roll No.** __________________________

Instructions

- One or more option(s) may be correct for all MCQs. Full marks will be awarded only if all correct options are selected. No partial marks will be awarded in such questions.
- This is a question paper-cum-answer sheet, which must be submitted to the invigilator at the end of the exam. Answers are only to be written in the space provided.
- Extra sheets may be used for rough work, which need not be submitted.
- No notes, books, cheat-sheet, calculator, etc. are allowed in this exam.
- Answers must be written using pen, and not using pencil.

Q1. [*1 mark*] A DHCP server can return:

a. MAC Address of the first-hop router for client device
b. MAC address of the DNS server
c. Network mask of the parent subnet

Ans. c

Q2. [*1 mark*] Which of the following quality-of-service guarantees are part of the Internet's best-effort service model?

a. Guaranteed delivery from sending host to receiving host.
b. A guaranteed minimum bandwidth is provided to a source-to-destination flow of packets
c. Guaranteed delivery time from sending host to receiving host.
d. In-order datagram payload delivery to the transport layer of those datagrams arriving to the receiving host.
e. None of the above.

Ans. e

Q3. [*1 mark*] Suppose a datagram is switched through the switching fabric and arrives to its appropriate output to find that there are no free buffers. In this case:

a. The packet will be sent back to the input port.
b. The packet will either be dropped or another packet will be removed (lost) from the buffer to make room for this packet, depending on policy. But the packet will definitely not be be sent back to the input port.
c. The packet will be dropped (lost).
d. Another packet will be removed (lost) from the buffer to make room for this packet.

Ans. b

Q4. [*1 mark*] What is meant by Head of the Line (HOL) blocking?

a. In a block error code, the first bytes of the code indicate the type of coding being used.
b. A queued datagram receiving service at the front of a queue prevents other datagrams in queue from receiving service.
c. A queued datagram waiting for service at the front of a queue prevents other datagrams in queue from moving forward in the queue.

Ans. c

Q5. [*1 mark*] A user accesses www.amazon.com first from the Firefox web browser, and then from the Google Chrome web browser. Both web browsers are part of the same desktop. Amazon.com uses HTTP cookies.

Will Amazon.com store a single cookie or two different cookies for the above website access?

Ans. Two different cookies one for each browser, as HTTP cookies tag the user history to each web browser, and not to the IP address of the user's network interface.

Q6. [*1 mark*] A web cache server may act as a web client. True or false.

Ans. True, especially in the event that it doesn't have a given web page cached, and fetches it from the original web server.

Q7. [*1 mark*] A student visited the website whatismyipaddress.com[1] once from a Lab 401 desktop and then from a Lab 402 desktop. Will the IP addresses displayed by the website on both occasions be the same or different?

Ans. Same, as the website displays the IP address of our border/gateway/NAT router, and not our local IP address.

Q8. [*1 mark*] The checksum computed at the network and transport layers are redundant. True or False.

Ans. False, since the transport layer checksum is computed over complete segment (which is payload of datagram), whereas network layer checksum is computed only over the datagram header.

Q9. [*1 mark*] In CSMA/CD, after the fourth collision, what is the probability that a node chooses to wait 2048 bit times?

Ans. After the 4th collision, the node chooses from {0, 1, 2,…, 15}. The probability that it chooses 4 is 1/16.

Q10. [*1 mark*] If all the links in the Internet were to provide reliable delivery service, the TCP reliable delivery service would be redundant. True or False.

Ans. False, since TCP reliable delivery service may still be needed for:

- Reordering packets at the destination
- Recovering from routing loops
- Recovering from equipment failures
- Buffer overflows

Q11. [*1 mark*] The count to infinity problem manifests in link state routing. True or False.

Ans. False, since it only manifests in distance vector routing.

[1] A website that displays the client's public IP Address.

Q12. [*1 mark*] Check all the statements below about where (in the network) the network layer is implemented that are true.

a. The network layer is implemented in wired Internet-connected devices, but not wireless Internet-connected devices.
b. The network layer is implemented in Ethernet switches in a local area network.
c. The network layer is implemented in routers in the network core.
d. The network layer is implemented in hosts at the network's edge.

Ans. c, d

Q13. [*1 mark*] We've seen that there are two approaches towards implementing the network control plane - a per-router control-plane approach and a software-defined networking (SDN) control-plane approach. Which of the following actions occur in a per-router control-plane approach?

a. Routers send information about their incoming and outgoing links to other routers in the network.
b. A control agent in router receives a complete forwarding table, which it installs and uses to locally control datagram forwarding.
c. A router exchanges messages with another router, indicating the cost for it (the sending router) to reach a destination host.
d. All routers in the network send information about their incoming and outgoing links to a logically centralized controller.

Ans. a, c

Q14. [*1 mark*] Which of the following statement(s) characterize(s) an IP subnet?

a. A set of devices all manufactured by the same equipment maker/vendor.
b. A set of device interfaces that can physically reach each other without passing through an intervening router.
c. A set of devices that have a common set of leading high order bits in their IP address.
d. A set of devices that always have a common first 16 bits in their IP address.

Ans. b, c

Q15. [*1 mark*] Which of the following fields occur ONLY in the IPv6 datagram header (i.e., appear in the IPv6 header but not in the IPv4 header)?

a. The flow label field.
b. The time-to-live (or hop limit) field.
c. The upper layer protocol (or next header) field.
d. The header checksum field.
e. The header length field.
f. 128-bit source and destination IP addresses.
g. The options field.
h. The IP version number field.

Ans. a, f

Q16. [*1 mark*] ______ refers to determining the route taken by packets from source to destination, and is implemented in the _____ plane.

Ans. Routing, Control

Q17. [*1 mark*] ___________ refers to moving packets from a router's input to appropriate router output, and is implemented in the ________ plane.

Ans. Forwarding, Data

Q18. [*1 mark*] Which of the following statements is true about both Pure Aloha, and CSMA (both with and without collision detection?

a. Pure Aloha and CSMA can achieve 100% utilization, in the case that there is only one node that always has frames to send
b. There can be times when the channel is idle, when a node has a frame to send, but is prevented from doing so by the medium access protocol.
c. There can be simultaneous transmissions resulting in collisions.
d. Pure Aloha and CSMA can achieve 100% channel utilization, in the case that all nodes always have frames to send.

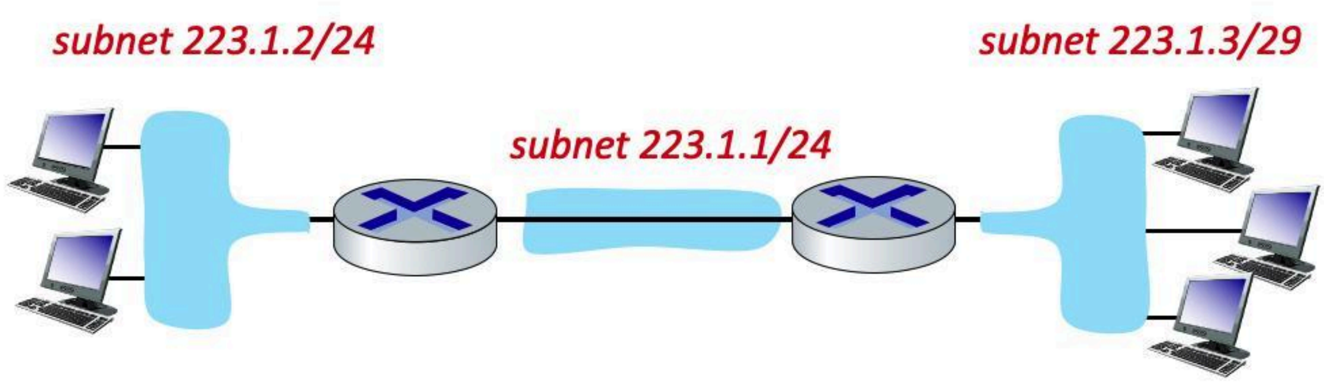
Ans. a, c

Q19. [*1 mark*] Consider the following multiple access protocols that we've studied: (1) TDMA, and FDMA (2) CSMA (3) Aloha, and (4) polling. For which of these protocols is there a maximum amount of time that a node knows that it will have to wait until it can successfully gain access to the channel?

a. CSMA and CSMA/CD
b. TDMA and FDMA
c. Aloha
d. Polling

Ans. b, d

Q20. [*1 mark*] Consider the three subnets in the diagram below.



Which of the following addresses cannot be used by an interface in the 223.1.3/29 network?

a. 223.1.3.16
b. 223.1.3.2
c. 223.1.3.6
d. 223.1.2.6
e. 223.1.3.28

Ans. a, d, e

Q21. [*1 mark*] What are the principal components of the IPv4 protocol (check all that apply)?

a. Routing algorithms and protocols like OSPF and BGP.
b. ICMP (Internet Control Message Protocol)
c. IPv4 addressing conventions.
d. IPv4 datagram format.
e. Packet handling conventions at routers (e.g., segmentation/reassembly)
f. SDN controller protocols.

Ans. c, d, e

Q22. [*1 mark*] For each of the actions below, select those actions below that are primarily in the network-layer data plane.

a. Looking up address bits in an arriving datagram header in the forwarding table.
b. Monitoring and managing the configuration and performance of a network device.
c. Moving an arriving datagram from a router's input port to output port.
d. Computing the contents of the forwarding table.
e. Dropping a datagram due to a congested (full) output buffer.

Ans. a, c, e

Q23. [*1 mark*] Which of the following network devices can be thought of as a "middlebox"?

a. HTTP load balancer
b. WiFi base station
c. SDN controller
d. IP router
e. HTTP cache
f. Network Address Translation box

Ans. a, e, f

Q24. [*1 mark*] Which of the statements below about ICMP are true?

a. ICMP is used by hosts and routers to communicate network-level information.
b. ICMP messages are carried in UDP segments using port number 86.
c. ICMP messages are carried directly in IP datagrams rather than as payload in UDP or TCP segments.
d. ICMP communicates information between hosts and routers by marking bits in the IP header.
e. The TTL-expired message type in ICMP is used by the traceroute program.

Ans. a, c, e

Q25. [*1 mark*] Which of the following statements is true about a two-dimensional parity check (2D-parity) computed over a payload?

a. 2D-parity can detect and correct any case of a single bit flip in the payload.
b. 2D-parity can detect any case of a single bit flip in the payload.
c. 2D-parity can detect and correct any case of two bit flips in the payload.
d. 2D-parity can detect any case of two bit flips in the payload.

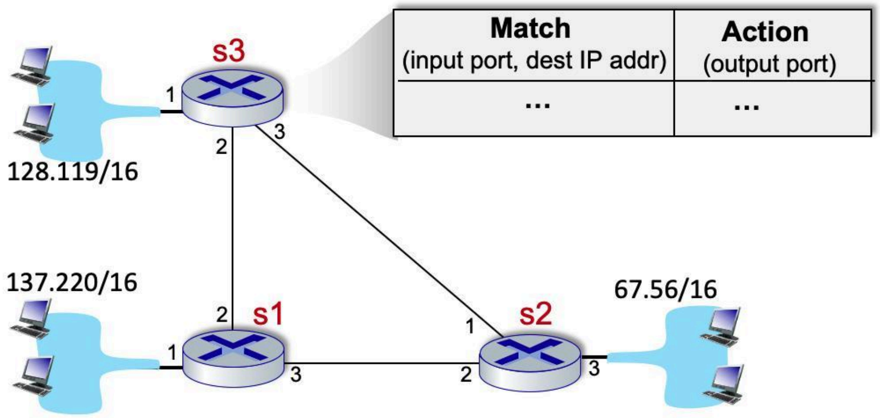
Ans. a, b, d / a, d

Q26. [*1 mark*] Check the one or more of the following statements about the OSPF protocol that are true.

a. OSPF is an intra-domain routing protocol.
b. OSPF implements hierarchical routing
c. The Open Shortest Path First (OSPF) Internet routing protocol implements a Bellman-Ford distance-vector routing algorithm.
d. OSFP uses a Dijkstra-like algorithm to implement least cost path routing.
e. OSPF is an interdomain routing protocol.

Ans. a, b, d

Q27. [*1 mark*] Consider the network below.



We want to specify the match+action rules at s3 so that only the following network-wide behavior is allowed:

a. traffic from 128.119/16 and destined to 137.220/16 is forwarded on the direct link from s3 to s1;
b. traffic from 128.119/16 and destined to 67.56/16 is forwarded on the direct link from s3 to s2;
c. incoming traffic via port 2 or 3, and destined to 128.119/16 is forwarded to 128.119/16 via local port 1.
d. No other forwarding should be allowed. In particular s3 should not forward traffic arriving from 137.220/16 and destined for 67.56/16 and vice versa.

From the list of match+action rules below, select the rules to include in s3's flow table to implement this forwarding behavior. Assume that if a packet arrives and finds no matching rule, it is dropped.

a. Input port:1 ; Dest: 137.220/16 Action: forward(3)
b. Input port: 1; Dest: 67.56/16 Action: forward(2)
c. Input port: 2; Dest: 128.119/16 Action: forward(1)
d. Input port: 3; Dest: 137.220/16 Action: forward(2)
e. Input port: 2; Dest: 67.56/16 Action: forward(3)
f. Input port: 1; Dest: 67.56/16 Action: forward(3)
g. Input port: 3; Dest: 128.119/16 Action: forward(1)
h. Input port:1 ; Dest: 137.220/16 Action: forward(2)

Ans. c, f, g, h

Q28. [*1 mark*] Among the following protocols, terminology or considerations, indicate those that are associated with "routing within a single network (typically owned and operated by one organization)."

a. inter-domain routing
b. intra-domain routing
c. intra-AS routing
d. Driven more by routing policy than end-end routing performance
e. Driven more by performance than by routing policy
f. inter-AS routing
g. BGP
h. OSPF

Ans. b, c, e, g, h

Q29. [*1 mark*] Which of the following fields in the frame/datagram/segment/application-layer message can be matched in OpenFlow 1.0?

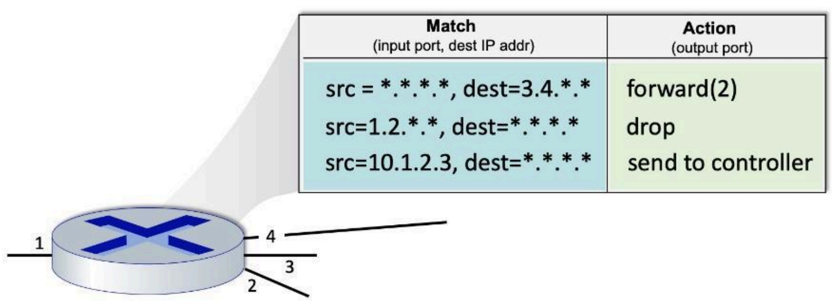
a. IP destination address
b. IP type-of-service field
c. Upper layer protocol field
d. Number of bytes in the datagram
e. Time-to-live field
f. Source and/or destination port number
g. URL in HTTP message
h. IP source address

Ans. a, b, c, f, h

Q30. [*1 mark*] What are the disadvantages of the layered approach to network design?

Ans. One potential drawback of layering is that one layer may duplicate lower-layer functionality. For example, many protocol stacks provide error recovery on both a per-link basis and an end-to-end basis. A second potential drawback is that functionality at one layer may need information (for example, a timestamp value) that is present only in another layer; this violates the goal of separation of layers.

Q31. [*2 marks*] Consider the figure below that shows the generalized forwarding table in a router. Recall that a * represents a wildcard value.



Now consider an arriving datagram with the IP source and destination address fields indicated below.

a. Source: 1.2.56.32 Destination:128.116.40.186	i. send to controller
b. Source: 65.92.15.27 Destination: 3.4.65.76	ii. forward(2)
c. Source: 10.1.2.3 Destination: 7.8.9.2	iii. drop
d. Source: 10.1.34.56 Destination: 54.72.29.90	

For each source/destination IP address pair, indicate which rule is matched. Assume that a rule that is earlier in the table takes priority over a rule that is later in the table and that a datagram that matches none of the table entries is dropped.

Ans. a-iii, b-ii, c-i, d-iii

Q32. [*2 marks*] Name the global governing body for:

a. IP Address allocation
b. MAC Address allocation
c. TCP/IP-related protocol number allocation
d. DNS root server management

Ans.

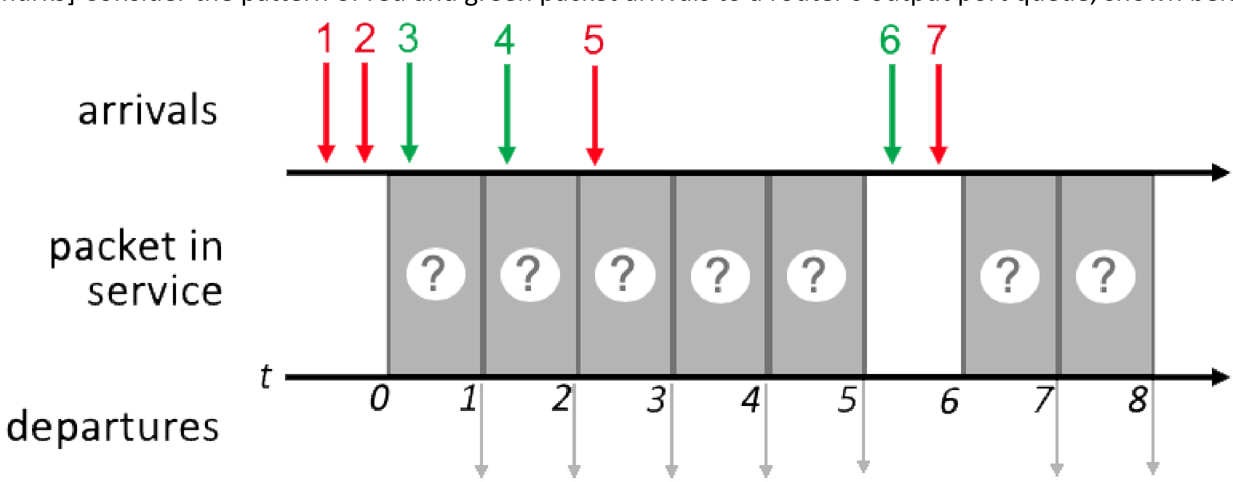
a. ICANN/IANA
b. IEEE
c. ICANN/IANA
d. ICANN/IANA

Q33. [*2 marks*] Consider the Cyclic Redundancy Check (CRC) algorithm. Suppose that the 4-bit generator (G) is 1001, that the data payload (D) is 10011001. What are the corresponding CRC bits (R)?

Ans. To compute the CRC, we begin by taking the value of D, 10011001, and multiplying it by 2^3, giving 10011001000. We then divide this number by the generator bits [G] = 1001, using modulo-2 arithmetic. The final remainder, R, after this division are then the CRC bits. Here is that calculation:

```
             10001000
           ------------
  1001  )  10011001000
           1001
           ----
               1001
               1001
               ----
                000
                000
                ---
                000------->R
```

Q34. [*3 marks*] Consider the pattern of red and green packet arrivals to a router’s output port queue, shown below.



Suppose each packet takes one time slot to be transmitted, and can only begin transmission at the beginning of a time slot after its arrival. Indicate the sequence of departing packet numbers (at t = 1, 2, 3, 4, 5, 7, 8) under

a. FCFS scheduling
b. priority scheduling, where red packets have higher priority.
c. round robin scheduling, where red starts a round if there are both red and green packets ready to transmit after an empty slot.

Give your answer as 7 ordered digits (each corresponding to the packet number of a departing packet), with a single space between each digit, and no spaces before the first or after the last digit, e.g., in a form like 7 6 5 4 3 2 1).

Ans.

a. 1 2 3 4 5 6 7
b. 1 2 3 5 4 7 6
c. 1 3 2 4 5 7 6

Q35. [*4 marks*] Match each of the following fields in the IP header with its description, function or use.

a. Version field	i. This field is used for datagram fragmentation/reassembly.
b. Type-of-service field	ii. This field contains the Internet checksum of this datagram's header fields.
c. Fragmentation offset field	iii. This field contains the IP protocol version number.
d. Time-to-live field	iv. This field indicates the total number of bytes in datagram.
e. Header checksum field	v. This field contains the "protocol number" for the transport-layer protocol to which this datagram's payload will be demultiplexed - UDP or TCP, for example.
f. Upper layer field	vi. The value in this field is decremented at each router; when it reaches zero, the packet must be dropped.
g. Payload/data field	vii. This field contains ECN and differentiated service bits.
h. Datagram length field.	viii. This field contains a UDP or TCP segment, for example.

Ans. a-iii, b-vii, c-i, d-vi, e-ii, f-v, g-viii, h-iv

Q36. [*4 marks*] Match the following.

a. This is a network-layer address.	i. Exclusively true for MAC Addresses
b. This address must be unique among all hosts in a subnet.	ii. Exclusively true for IPv4 Addresses
c. This is a 48-bit address.	iii. Applicable to both MAC and IPv4 Addresses
d. This is a 32-bit address.	iv. Applicable to neither MAC nor IPv4 Addresses
e. This address remains the same as a host moves from one network to another.	
f. This address is allocated by DHCP.	

g. This is a 128-bit address.	
h. This is a link-layer address.	

Ans. a-ii, b-iii, c-i, d-ii, e-i, f-ii, g-iv, h-i

Q37. [*4 marks*] Consider the following forwarding table below.

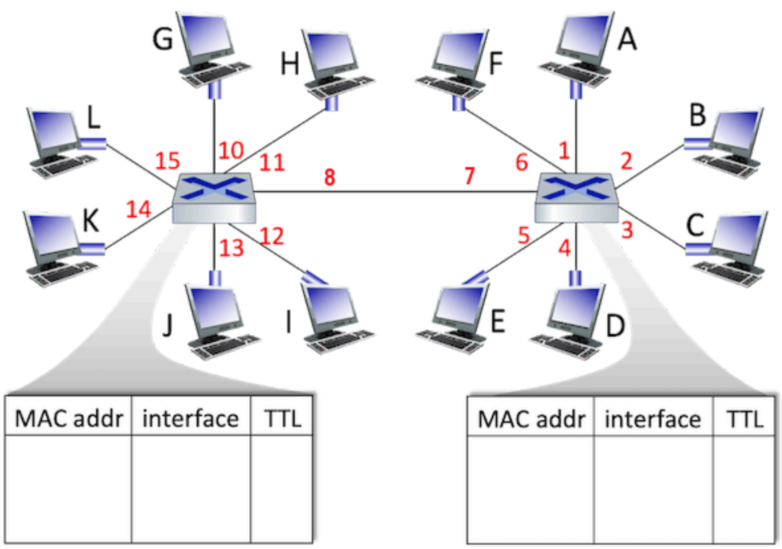
Destination Address Range	Link interface
11001000 00010111 00010*** ********	0
11001000 00010111 00011000 ********	1
11001000 00010111 00011*** ********	2
otherwise	3

Indicate the output link interface to which a datagram with the destination addresses below will be forwarded under longest prefix matching.

a. 11001000 00010111 00010010 10101101	i. 0
b. 11001000 00010111 00011000 00001101	ii. 1
c. 11001000 00010111 00011001 11001101	iii. 2
d. 10001000 11100000 00011000 00001101	iv. 3
e. 11001000 00010111 00011000 11001111	
f. 11001000 00010111 00010001 01010101	
g. 11001000 00010111 00011101 01101101	
h. 11001000 00010111 00010010 10101101	

Ans. a-i, b-ii, c-iii, d-iv, e-ii, f-i, g-iii, h-i

Q38. [*4 marks*] Consider the LAN below consisting of 10 computers connected by two self-learning Ethernet switches. At t=0 the switch table entries for both switches are empty. At t = 1, 2, 3, and 4, a source node sends to a destination node as shown below, and the destination replies immediately (well before the next time step).



Assume that the following transmissions occur (the transmissions in reply occur but are not shown in the list below):

- t=1: A -> B
- t=2: B -> C
- t=3: A -> C
- t=4: C -> E

Show the layer 2 forwarding tables at the left and right switches at t = 2, 3, 4, and 5.

Ans.
At t=2,

- right switch table: (A,1), (B,2)

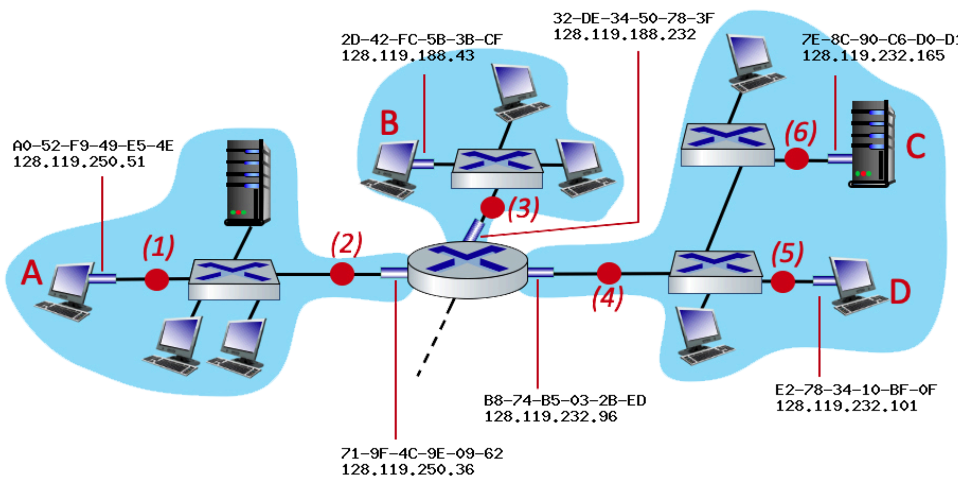
- left switch table: (A,8)

At t=3,
- right switch table: (A,1), (B,2), (C,3)
- left switch table: (A,8), (B,8)

At t=4,
- right switch table: (A,1), (B,2), (C,3)
- left switch table: (A,8), (B,8)

At t=5,
- right switch table: (A,1), (B,2), (C,3), (E,5)
- left switch table: (A,8), (B,8), (C,8)

Q39. [*5 marks*] Consider the figure below. The IP and MAC addresses are shown for nodes A, B, C and D, as well as for the router's interfaces.



Consider an IP datagram being sent from node C to node A.

At point 6:
a. What is the source MAC address?
b. What is the destination MAC address?
c. What is the source IP address?
d. What is the destination IP address?

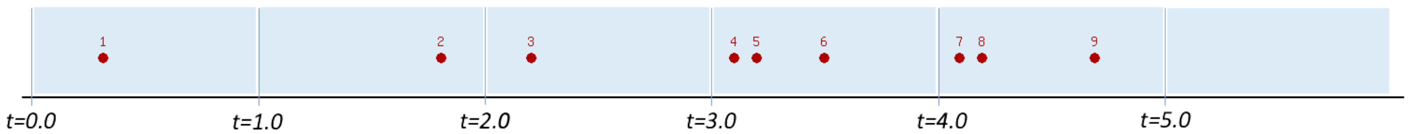
At point 1:
e. What is the source MAC address?
f. What is the destination MAC address?
g. What is the source IP address?
h. What is the destination IP address?

i. Compared to point 4, at point 2, which of the above four values (i.e. source MAC address, destination MAC address, source IP address, and destination IP address) change?

Ans.
a. The source MAC address at point 6 is 7E-8C-90-C6-D0-D1
b. The destination MAC address at point 6 is B8-74-B5-03-2B-ED
c. The source IP address at point 6 is 128.119.232.165
d. The destination IP address at point 6 is 128.119.250.51
e. The source MAC address at point 1 is 71-9F-4C-9E-09-62

f. The destination MAC address at point 1 is A0-52-F9-49-E5-4E
g. The source IP address at point 1 is 128.119.232.165
h. The destination IP address at point 1 is 128.119.250.51
i. Source and destination MAC addresses change. Source and destination IP addresses remain the same.

Q40. [*8 marks*] Consider the figure below, which shows the arrival of 9 messages for transmission at different multiple access wireless nodes at times t = <0.3, 1.8, 2.2, 3.1, 3.2, 3.5, 4.1, 4.2, 4.7> and each transmission requires exactly one time unit.



For each of the following three scenarios:

a. Suppose all nodes are implementing the Aloha protocol.
b. Suppose all nodes are implementing the Slotted Aloha protocol.
c. Suppose all nodes are implementing Carrier Sense Multiple Access (CSMA)[2], but without collision detection.
d. Suppose all nodes are implementing Carrier Sense Multiple Access (CSMA)[2], with collision detection (CSMA/CD)[3].

Answer the following two questions:

i. For each message, indicate the time at which each message transmission begins, or indicate that message transmission does not begin due to a channel that is sensed busy when that message arrives. Separate each value with a comma and no spaces, and if the channel is sensed busy, substitute it with 's'.
ii. Which messages transmit successfully? Write your answer as a comma-separated list with no spaces using the messages' numbers.

Index your answers as a(i), a(ii), b(i), b(ii), c(i), c(ii), d(i), and d(ii).
Assume that nodes attempt to transmit each message only once, and if unsuccessful, they do not attempt to retransmit.

Ans. As per footnote 2, if a node begins transmitting a message at t=2.0 and transmits that message until t=3.0, then any node performing carrier sensing in the interval [2.4, 3.4] will sense the channel busy. Thus, a node with data to send at t=3.4 would sense the channel busy (as interpreted by some of you), or free (as interpreted by the rest of you). I have awarded marks to both interpretations.

The following table provide the transmission interval (which includes the transmission start time) for both interpretations. In addition, the successful transmissions are coloured in green.

Frame Index			1	2	3	4	5	6	7	8	9
Arrival Time			0.3	1.8	2.2	3.1	3.2	3.5	4.1	4.2	4.7
Transmission Interval	(Pure) ALOHA		[0.3-1.3]	[1.8-2.8]	[2.2-3.2]	[3.1-4.1]	[3.2-4.2]	[3.5-4.5]	[4.1-5.1]	[4.2-5.2]	[4.7-5.7]
	Slotted ALOHA		[1-2]	[2-3]	[3-4]	[4-5]	[4-5]	[4-5]	[5-6]	[5-6]	[5-6]
	CSMA	Interpretation 1: [2.4, 3.4]	[0.3-1.3]	[1.8-2.8]	s	s	s	[3.5-4.5]	s	s	s
	CSMA/CD		[0.3-1.3]	[1.8-2.8]	s	s	s	[3.5-4.5]	s	s	s
	CSMA	Interpretation 2: [2.4, 3.4)	[0.3-1.3)	[1.8-2.8)	s	s	[3.2-4.2)	[3.5-4.5)	s	s	s
	CSMA/CD		[0.3-1.3)	[1.8-2.8)	s	s	[3.2-3.9)	[3.5-3.6)	s	s	[4.7-5.7)

[2] Suppose that the time from when a message transmission begins until it is beginning to be received at other nodes is 0.4 time-units. (Thus, if a node begins transmitting a message at t=2.0 and transmits that message until t=3.0, then any node performing carrier sensing in the interval [2.4, 3.4] will sense the channel busy.)

[3] Assume that a node can stop transmission instantaneously when a message collision is detected.