Exam Information Cover Sheet

COMP3331/9331— Computer tions

Term 2, 2021

Practice Final Examination

Instructions:

1. TIME ALLOWED: **2 hours and 10 minutes (Reading Time)**.

2. TOTAL MARKS AVAILABLE: **40 marks worth 40% of the total marks for the course. You must score at least 16 marks on the exam to pass the course.**

3. MARKS AVAILABLE FOR EACH QUESTION ARE SHOWN IN THE EXAM. YOU MUST ANSWER ALL QUESTIONS. THERE ARE A TOTAL OF 29 QUESTIONS.

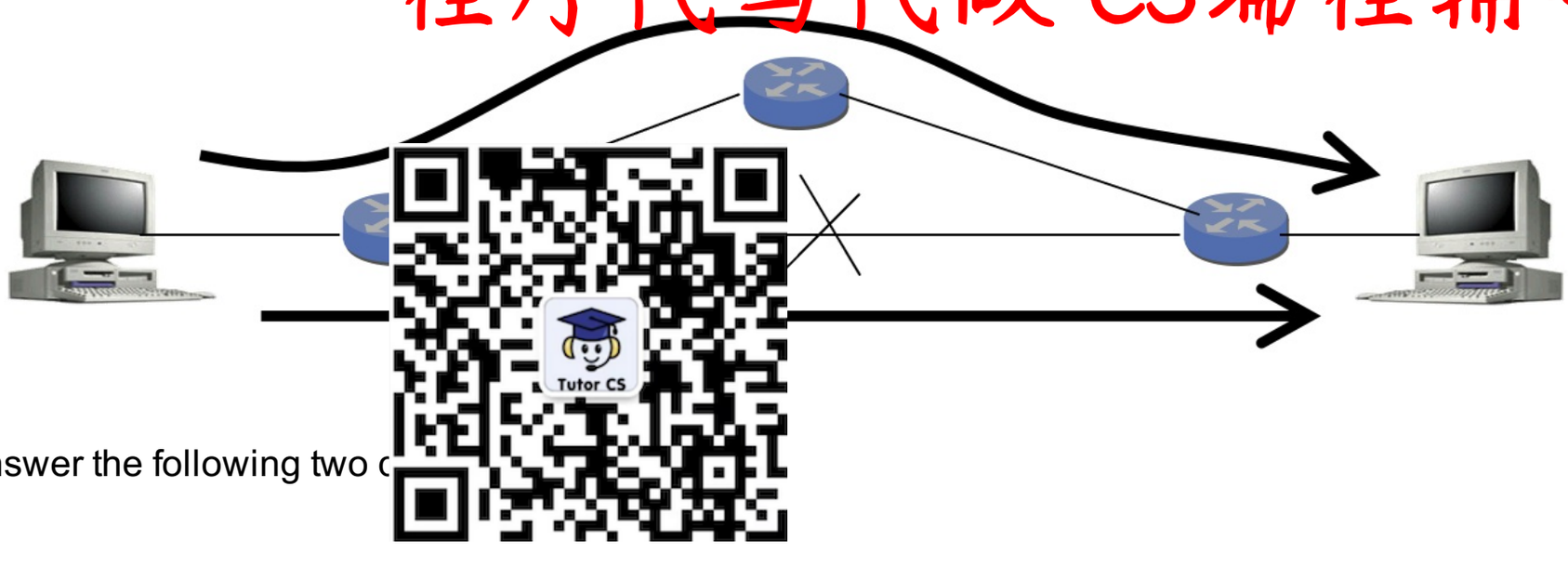
4. STUDENTS ARE ADVISED TO READ THE EXAMINATION QUESTION BEFORE ATTEMPTING TO ANSWER THE QUESTION.

5. THIS EXAM CANNOT BE COPIED, FORWARDED, OR SHARED IN ANY WAY.

6. STUDENTS ARE REMINDED OF THE UNSW RULES REGARDING ACADEMIC INTEGRITY AND PLAGIARISM.

7. YOUR WORK WILL BE SAVED PERIODICALLY THROUGHOUT THE EXAM AND WILL BE AUTOMATICALLY SUBMITTED PROVIDED YOU ARE CONNECTED TO THE INTERNET.

Suppose two hosts have a long-lived TCP session over a path with a 100 msec round-trip time (RTT). Then, a link fails, causing the traffic to flow over a longer path with a 500 msec RTT. This scenario is depicted in the figure below. The original path is the straight path at the bottom. The new path is at the top.



Answer the following two q

1 TCP Path Change Q1

Suppose the router on the left recognises the failure immediately and starts forwarding data packets over the new path, without losing any packets. (Assume also that the router on the right recognises the failure immediately and starts directing ACKs over the new path, without losing any ACK packets.) Why might the TCP sender retransmit some of the data packets anyway?

Fill in your answer here

TCP bases its retransmission timeout (RTO) on an estimate of the round-trip time between the sending and receiving hosts. In this example, the estimate is 100 msec before the failure. As this connection has been active for some time, the estimate should pretty accurate and close to 100 msec. The DevRTT should be a very low value, and the RTO will thus be very similar to the RTT estimate. When the failure occurs, the increase in round-trip time implies that the ACK packets will not arrive before the RTO expires, causing the sender to presume the data packets have been lost, leading to retransmissions, despite the fact that no packets were actually lost.

Maximum marks: 1.5

2 TCP Path Change Q2

Suppose instead that the routers do not switch to the new paths all that quickly, and the data packets (and ACK packets) in flight are all lost. What new congestion window size does the TCP sender use? Explain your answer.

Fill in your answer here

The TCP sender's adjustment ow depends on how the packet losses were detected. If a triple-duplicate- stion window would be divided in half. However, in this case, all pac no ACKs are received, forcing the sender to detect the loss via a timeout. ection leads the sender to set the congestion window to 1 (i.e., 1 MSS).

Maximum marks: 1.5

3 TCP SYN

Why does a TCP sender use a very large retransmission timeout (e.g. several seconds) for the SYN segment? Answer in 2 sentences at most.

Fill in your answer here

The TCP sender does not have any initial estimate of the round-trip time (RTT). Starting with a conservative retransmissio ral seconds prevents the excessive retransmissions that would O that is smaller than the actual RTT.

Maximum marks: 1

4 TCP 3 Way Handshake

Why is it necessary to have a 3 way handshake for connection establishment in TCP? Why is a 2 way handshake not sufficient?

Fill in your answer here

Maximum marks: 2

TCP is a bi-directional communication protocol, which means either end ought to be able to send data reliably. Both parties need to establish an Initial Sequence Number (ISN), and both parties need to acknowledge the other's ISN. Thus a two-way handshake is required in each direction as follows:
1) Alice picks an ISN and SYNchronises it with Bob.
2) Bob ACKnowledges the ISN.
3) Bob picks an ISN and SYNchronises it with Alice.
4) Alice ACKnowledges the ISN.
Steps 2 and 3 can be combined in a SYN-ACK segment, which reduces this to a 3 way handshake.
A two way handshake would only allow one party to establish an ISN, and the other party to acknowledge it. Which means only one party can send data.

Assume that the SendBase for a TCP Reno sender is currently 4000. The TCP sender has sent four TCP segments with sequence numbers 4000, 4500, 5500 and 7000. The sender then receives a segment with an acknowledgement number 7500 and a receive window 6000. The congestion window, CongWin, is set to 10000 bytes after this ACK is processed. Answer the first three questions assuming that this ACK is processed and no further ACKs are received.

5 TCP Sequence Q1

What is the value of SendBase? Only enter the numeric value in the space provided. 7500

Maximum marks: 0.75

The sender has received an AC[illegible]er would have moved the base of the window up to that point. Thus S[illegible]

6

TCP Sequence Q2

How many bytes in total are sent in the four TCP segments? Only enter the numeric value in the space provided: [ ] (3500).

Maximum marks: 0.75

The first segment carries 500 [illegible]ent carries 1000 bytes, the third one carries 1500 bytes and the last segment ca[illegible]e total data in the four segments is 3500 bytes.

7

TCP Sequence Q3

What is the last byte (number) that the TCP sender can send with certainty that the receiver's buffer will not overflow? Assume that the sender always has data to send. Explain your answer in 1-2 sentence.

Fill in your answer here

The window size is set to the minimum of the congestion window and receive window. Hence, the window size will be 6000 bytes. Since current SendBase is 7500, this implies that the last byte we can send with certainty is 13499.

Maximum marks: 1

8

TCP Sequence Q4

Now assume that the sender receives three more TCP segments, such that all three segments have TCP acknowledgement number 7500.

Answer the this question and the next question assuming that all three ACKs are processed and no further ACKs are received.

What is the value of CongWin a

Fill in your answer here

Since the sender receives th CongWin is reduced to half the current value (current value = 10000 bytes

Maximum marks: 1

9 TCP Sequence Q5

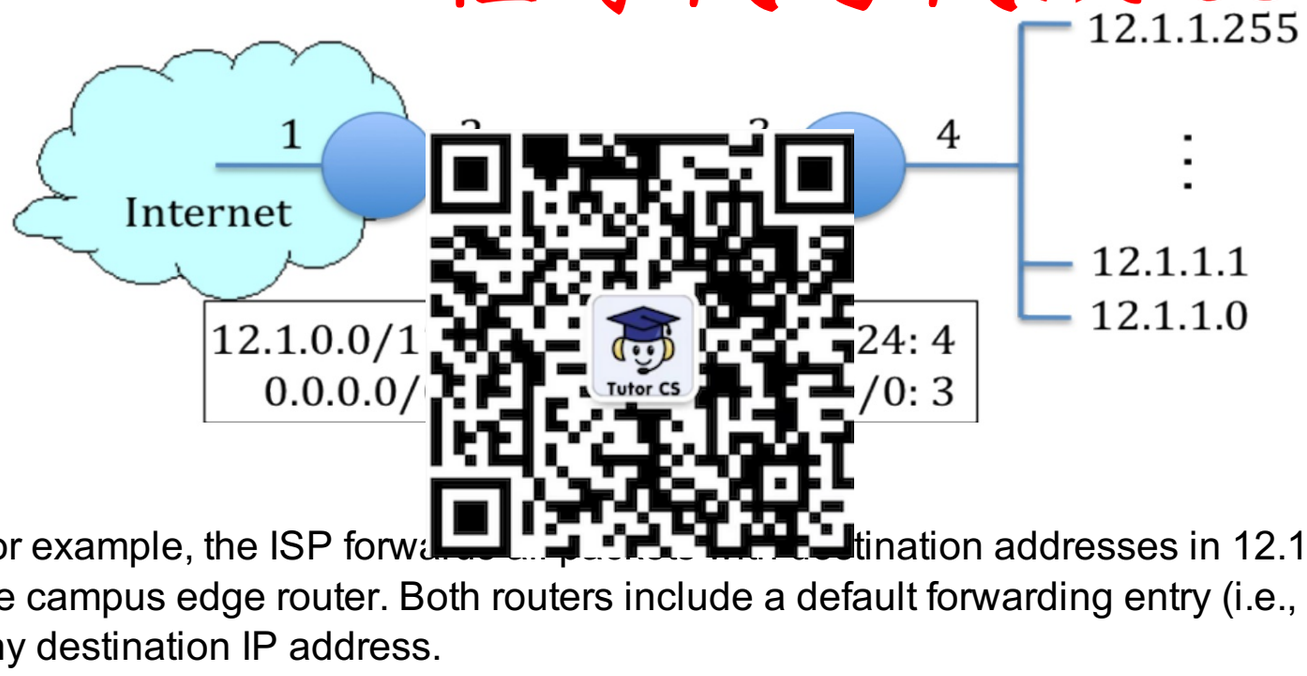
What is the sequence number of the next segment that will be transmitted by the sender? Explain your answer in 1 sentence.

Fill in your answer here

Since the sender received thre 00, it will now retransmit the segment with sequence number 7500.

Maximum marks: 1

A small university campus is assigned a large address block 12.1.0.0/17, but is only using a portion of these addresses (in 12.1.1.0/24) to number its computers. The campus uses a single Internet Service Provider (ISP) to reach the rest of the Internet. The picture below shows the forwarding tables on the ISP's router (on the left) and the campus edge router (on the right).



For example, the ISP forwards datagrams with destination addresses in 12.1.0.0/17 to link #2 toward the campus edge router. Both routers include a default forwarding entry (i.e., 0.0.0.0/0) that can match any destination IP address.

Answer the following 4 questions:

10

IP Addressing Q1

How many IP addresses does the campus "own" in its 12.1.0.0/17 block? You can represent your answer as a power of two.

Fill in your answer here

The 17-bit subnet mask leave[illegible]addresses within the block. As such, the block contains 2^15 or 32,768 addr[illegible]

Maximum marks: 0.5

11

IP Addressing Q2

What are the smallest and largest IP addresses that the campus "owns"? Do these addresses have special meaning and if so what do they signify?

Fill in your answer here

The smallest IP address w usually referred to as the network address (i.e. to refer to the entire ne ess would be 12.1.127.255 and it is the broadcast address for the

Maximum marks: 1

12

IP Addressing Q3

Suppose the ISP router receives a packet from the Internet with destination IP address 12.1.20.12. What path does this packet follow (indicate the path using link numbers from the above figure)? What is the ultimate outcome for this packet?

Fill in your answer here

The packet flows over the p ..... It keeps looping. Match the destination IP with the forwarding table
The looping packet is event TTL equals to zero.

Maximum marks: 1.5

13

IP Addressing Q4

Suppose the ISP router receives a packet from the Internet with destination IP address 12.1.1.1? What path does this packet follow (indicate the path using link numbers from the figure above)?

Fill in your answer here

The packet flows over the path 1 -> 2 -> 3 -> 4

Maximum marks: 1.5

14

NAT

When an IP datagram containing a transport segment is going from a private network onto the public Internet through a Network Address Translation (NAT) router, which of the following network and transport layer header fields might the router change? You can select multiple options.

Select one or more alternatives

- Protocol field in IP header
- Source IP address ✔
- IP checksum ✔
- Destination IP address
- Transport checksum ✔
- Source port number ✔
- None of the provided choices
- Destination port number

Maximum marks: 1

A NAT router would modify the source IP, source destination, and the transport and IP checksums for outgoing datagrams.

15

DV MCQ

Which of the following statements about distance vector routing are true? Multiple statements may be true.

Select one alternative:

- Every router in the network knows the entire network topology.
- Poison reverse may not al… infinity problem. ✔
- None of the other choices a…
- The distance vector sent b… ted to all other routers in the network.
- A reduction in the cost of a link connected to a router will always trigger a distance vector update to be sent from this router.

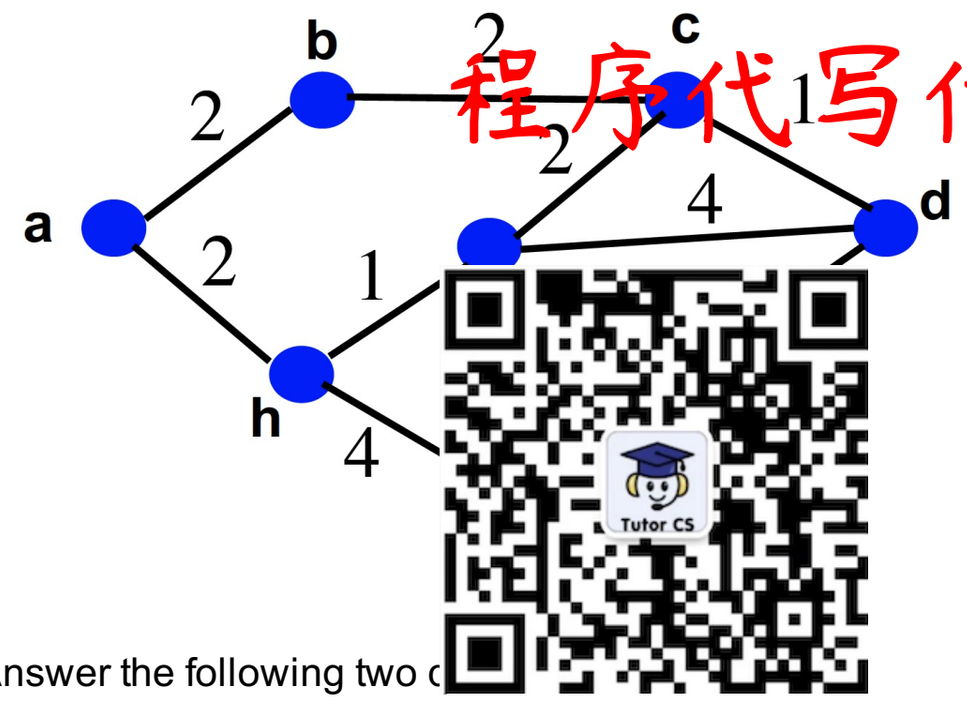
Maximum marks: 1

In DV, routers do not have knowledge of the entire topology, just their direct neighbours.

A reduction in the cost of a link will always trigger the execution of the DV algorithm at the node. However, a DV update will only be sent if there is a change in the DV as a result of this execution, which may not always be the case.

A DV from a node is only sent to its direct neighbours. These neighbours do not propagate the DV further. So the correct answer is that Poison Reverse may not always solve county to infinity problem. An example was shown in the lecture.

Consider the 8-node network shown in the figure below with link costs as shown. Note that each link shown in this network is bidirectional and has the same cost in either direction.



Answer the following two q

16

Dijkstra

Execute Dijkstra's algorithm at Node **a** to determine the shortest path from Node **a** to every other node in the network. You will have to draw an appropriately sized table using the table option in the menu at the top of the text area below (similar to the one shown in the lecture notes on Dijkstra's algorithm) You are required to show all steps.

Fill in your answer here

Format

Step	N	D(b), p(b)	D(c), p(c)	D(d), p(d)	D(e), p(e)	D(f), p(f)	D(g), p(g)	D(h), p(h)
0	a	2, a			-	-	-	2, a
1	ab				-	-	-	2, a
2	abh				-	6, h	3, h	
3	abhg		4, b	7, g	-	6, h		
4	abhgc			5, c	-	6, h		
5	abhgcd				7, d	6, h		
6	abhgcdf				7, d			
7	abhgcdfe							

Since there is a tie at step 1, either b or h could be chosen as the node to be added to N. The other node would be added in Step 2. In the answer provided b is added first, followed by h. However, you could have added h first, followed by b. The end result would still be the same.

Words: 0

Maximum marks: 4

17 Forwarding Table

Based on the execution of the Dijkstra's algorithm in the above question, draw the forwarding table for node **a**, which contains the outgoing link for reaching every other node in the network. A link between two nodes x and y should be denoted as (x, y).

Fill in your answer here

Destination	
b	
c	
d	
e	
f	
g	
h	

Maximum marks: 1.5

18

CRC Q1

Assume that the data bits D being transmitted over a link are 100010 and that CRC is being used to provide error detection. Suppose that a generator, G = 111 is being used and known to both the sender and receiver.

1) What are the CRC bits (R) as computed (and included with the message) by the sender? You are not required to show your calculati in the space provided. (11)

2) Continuing with the previous ne sender transmits <D, R>. Neglect any other headers. Assume that 2nd, 3rd ence are flipped as the frame is transmitted through the link. Will the receiver be able to

Select an alternative

- True
- False ✔

Maximum marks: 1.5

1) R = 11 (NOTE: you cannot add leading or trailing zeros, so 011 or 110 are not valid answers)

```
    110101                    110101
111√10001000              111√10001011
   111                       111
   110                       110
   111                       111
   100                       111
   111                       111
    11                        0 ← perfectly divided
```

The computation on the left which shows how R is computed by the sender. The computation on the right side shows you that if there are no errors while transmission, then dividing <D, R> by G will result in a zero remainder at the receiver.

2) False.

```
     100101
111√11111011
   111
   110
   111
    111
    111
     0 ← perfectly divided, CRC returns 'no error detected'
```

The computation is for the case when the ordering is left to right (i.e. 2nd, 3rd and 4th bits are counted from the left). I have not shown the computation if you count the order right to left but the answer would still be the same - False.

19 # CRC Q2

Now assume that the data bits D are the same as the previous two questions (100010) but that a generator G = 1111 is used.

1) What will be the CRC bits (R) as computed (and included with the message) by the sender? You are not required to show your calculations. Simply note down R in the space provided.

(000)

2) Continuing with the previous ... he sender transmits <D, R>. Neglect any other headers. Assume that 2nd, 3rd ... ence are flipped as the frame is transmitted through the link. Will the receiver be able to ...

Select an alternative

- True ✔
- False

Maximum marks: 1.5

1) R = 000. (NOTE: There MUST be 3 zeros in your answer, so 0 or 00 or 0000 are not valid answers)

```
      110000                    110000
1111√100010000            1111√100010000
      1111                      1111
      1111                      1111
      1111                      1111
      00000                     00000 ← perfectly divided
```

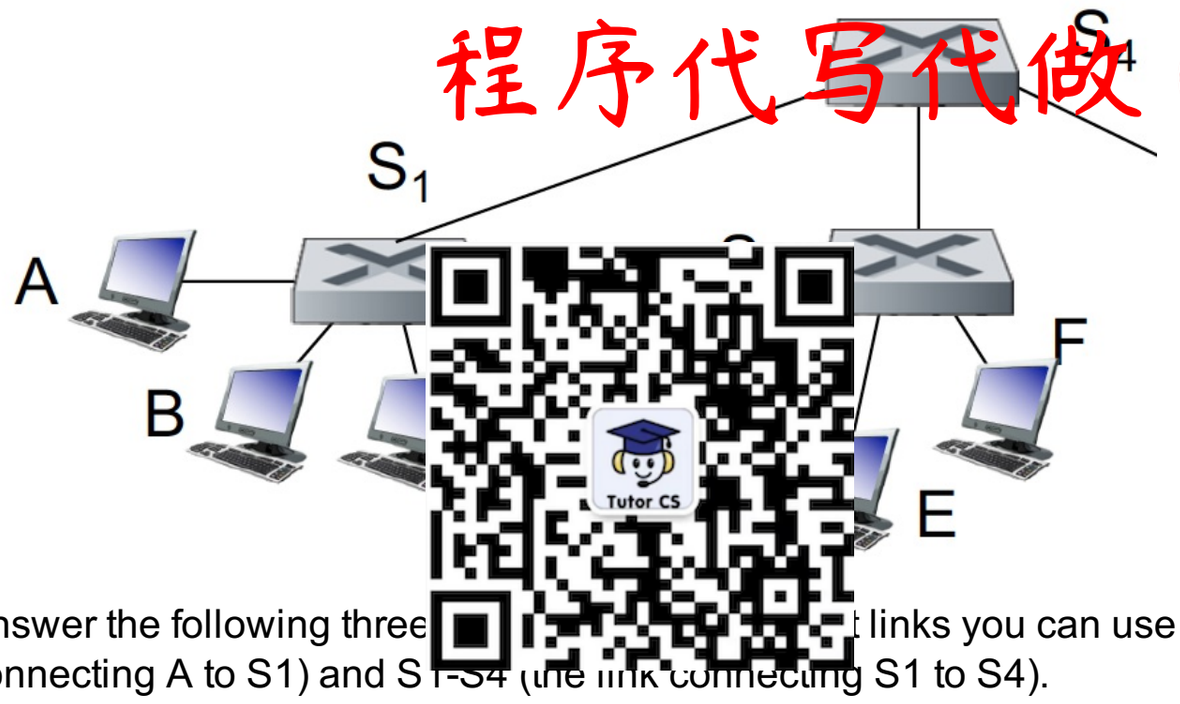
The computation on the left shows how R is computed by the sender. The computation on the right shows the corresponding computation at the receiver assuming there are no errors in transmitting <D, R>

2)

```
       100011
1111√111110000
      1111
       01000
       1111
        1110
        1111
         001 ← not perfectly divided, CRC returns 'error detected'
```

The computation shown is for the case when the ordering is left to right (i.e. 2nd, 3rd and 4th bits are counted from the left). I have not shown the computation if you count the order right to left but the answer would still be the same - True.

Consider the network shown in the figure below. You may assume that all switch tables are empty at the start.



Answer the following three [illegible] links you can use notations such as A-S1 (the link connecting A to S1) and S1-S4 (the link connecting S1 to S4).

20

Switch Q1

Assume that host A sends a frame to Host F. Indicated all links in the network that this frame is transmitted on and explain why.

Fill in your answer here

The frame is first sent on the link A-S1. When it arrives at S1 since the switch table is empty, the frame will be broadcast by S1 on all othe S1-S4.

When the frame reaches S4, empty, S4 would send it to all other links, i.e., S4-S2.

When the frame arrives at S2 empty, the frame will be broadcast by S2 on all other links: S2-D, S2-E, and S2-F.

Maximum marks: 1.5

21

Switch Q2

Assume that host F now sends a frame to Host A. Indicated all links in the network that this frame is transmitted on and explain why.

Fill in your answer here

The frame would be transmitted on F-S2. When the frame reaches S2, it would now have learnt that host A is reachable along the link S2-S4 y forward the frame on this link (i.e., S2-S4).
When the frame reaches S4, S host A is reachable along the link S4-S1. So S4 would selectively forward the frame o
When the frame reaches S1, S host A is reachable along the link S1-A. So S1 would selectively forward the frame o

Maximum marks: 1.5

22

ARP

Suppose Host C wants to send an IP datagram to Host F. Assume that Host C only knows the IP address of Host F but does not know its MAC address. Describe how Host C proceeds to send the IP datagram (i.e., outline the sequence of events leading to transmission of this datagram).

Fill in your answer here

Host C will first send an ARP q MAC address that corresponds to F's IP address. This query will be sent to switch S1 which will se . Switches S4 and S2 will do the same. So all hosts will receive this query. Only Host F will respon containing its own MAC Address. When Host C receives this MAC address, it will encapsulate the rnet frame with F's MAC address as the destination and transmit the frame to Switch S1. Depending ies of the switches this frame will either get selectively forwarded towards F or broadcast.

Maximum marks: 1.5

Consider the wireless network composed of four nodes in the figure below, which has a linear topology deployed along a highway. The distance between neighbouring nodes is equal. Assume all nodes are using 802.11 MAC with RTS/CTS enabled. The radio range for each node is fixed, and this radio range is slightly longer than the inter-node distance, i.e., each node can reach only its left and right neighbours. Assume that if there are two simultaneous transmissions within the radio range of the receiver, both transmissions will be unsuccessful.

Answer the following three

23 # WiFi Q1

Assume that node A is currently sending a data frame (not an ACK, an RTS, or a CTS) to node B. Node C wants to send a packet to node D. Assume that node C (and only C) ignores the 802.11 MAC standard and sends the packet. Would C's packet arrive successfully at D? Would A's packet arrive successfully at B? Explain your reasoning.

Fill in your answer here

C's packet would indeed arri ce D cannot hear A's transmission. Hence, there is no interference from the pe r (i.e. D). However, A's packet would not arrive successfully at B, since there ue to interference from C's transmission.

Maximum marks: 1

24 WiFi Q2

Consider the same situation as in the previous questions except that all nodes are using the 802.11 MAC. Will C start transmission while A is sending the data packet? Why or why not? If not, how does C know that A is transmitting a data frame?

Fill in your answer here

C will not transmit while A is tr[illegible]use C would have overhead the CTS frame sent by B (in response to the RTS reque[illegible]me will contain the duration of time for which the ongoing transmission betweer[illegible]s, C will know when A is transmitting

Maximum marks: 1

25 **WiFi Q3**

Is there any way for C to know when A's transmission will end? Explain.

Fill in your answer here

Same reason as stated in the answer to the previous question. The CTS contains the time and hence, C will know when A's transmission will end. C will also receive the ACK from B to signal the end of transmission from A.

Maximum marks: 1

26

Keys

Suppose *N* people want to communicate with each of *N* - 1 other people using symmetric key encryption. All communication between any two people, *i* and *j*, is visible to all other people in this group of *N*, and no other person in this group should be able to decode their communication. How many keys are required in the system as a whole?

Now suppose that public key encryption is used. How many keys are required in this case?

Provide a short explanation for your answer in the space below.

Fill in your answer here

Symmetric Key Encryption:
A symmetric key would be required for every pair of people. So Person 1 would require (N-1) keys to communicate with others. Person 2 would require (N-2), Person 3 would require (N-3) and so on. Thus total keys required = (N-1) + (N -2) + (N-3) .... + 1 = N(N-1)/2.

Public Key Encryption:
Each person would only require a public, private key pair. So the total keys required = N pairs of public, private key pairs.

Maximum marks: 2

27 **CA**

What is the role of a Certification Authority (CA) in Public Key Infrastructure (PKI)?
Select one alternative:

- Issues a session key to both end parties for communication
- Guarantee that the public k is authenticated by issuing a digital certificate ✔
- Maintain private keys of all
- CA's are not used in PKI

Maximum marks: 1

The role of the CA is to certify the public keys of users who register with it. The CA does so by adding a digital signature (signed by the CA's private key) to the public key of the user. Others can verify the certificate by applying the CA's public key.

28

Email

SuperMail wants every email to be authenticated and protected from modification or tampering while it is in transit from the sender to the receiver. Suppose Alice is sending an email M to Bob. Assume that a SuperMail employee proposes the following solution: Alice's software should encrypt M using Bob's public key. In other words, Alice's software should send E_{KB+} (M) to Bob. Can you comment on whether the employee's solution meets the requirement stated above. Justify your answer.

Fill in your answer here

Encryption does not provide au ne other than Alice can send the exact same message to Bob Bob won't be he sender was..

Maximum marks: 1

29

Putting it together

You walk into a room, connect your laptop to an Ethernet outlet, and type in your web browser a URL of a web page. List all the messages/packets that you expect your laptop to send or receive until you download the web page. Assume that your laptop is configured with the IP address of a local DNS server, as well as the IP address of a default gateway (a router through which traffic from your laptop will exit the local IP subnet).

Fill in your answer here

Format | B I U x_2 | Ω | Σ

Since your computer's ARP ca[illegible]our computer will use ARP protocol to get the MAC addresses of the first-hop rout[illegible]rver.
Your computer will first query [illegible]find the IP address of the Web page you would like to download.
Once your computer has the IP address of the Web page, then it will establish a TCP connection and send out a HTTP request via the first hop router (assuming the Web server does not reside inside the local network). The HTTP request message will be encapsulated in a TCP segment, and then further encapsulated in an IP datagram and then an Ethernet frame.
Your computer sends the Ethernet frame destined to the first-hop router. Once the router receives the frame, it passes the encapsulated IP datagram up to the IP layer, checks its routing table, and then sends the IP datagram encapsulated in an Ethernet frame to the next-hop (the interface corresponding to the next-hop in the routing table). Then the IP datagram will be routed through the Internet until they reach the Web server.
The server hosting the Web page will send back the Web page to your computer via HTTP response messages. Those messages will be encapsulated in TCP segments and then further into IP datagrams and link layer frames. Those IP datagrams follow the routes (as per the routing algorithms used) and finally reach your first-hop router, and then the router will forward them to your computer by encapsulating them into Ethernet frames.

Words: 0

Maximum marks: 3