1 IMPORTANT: This question focuses on generic pipelined reliable delivery protocols (GBN and SR) and not specifically on TCP. Keep this in mind when providing your answers.

Assume that we are using 5 bit sequence numbers and the window size is 16. Assume that data only flows in one direction from a sender to a receiver. Supposed that the receiver has received all packets up to and including sequence number 28 and next receives packets with sequence numbers 31, 29 and 0, in that order.

(a) Assume that that a specific implementation of **Go-Back-N** is used that **buffers out-of-order packet at the receiver but still uses cumulative ACKs**. What are the sequence numbers in the ACK(s) sent out by the receiver in response to the above noted packets. Simply enter the answers in the space provided below. No explanation is necessary. 0.5 mark for each answer.

ACK sent in response to packet with sequence number 31 = [ ]

ACK sent in response to packet with sequence number 29 = [ ]

ACK sent in response to packet with sequence number 0 = [ ]

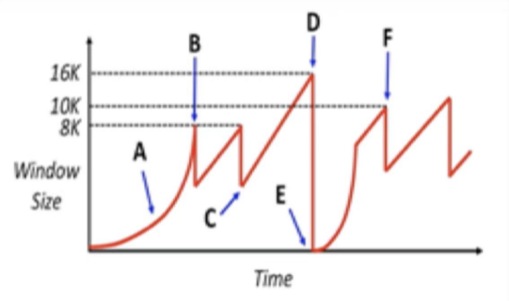
(b) Now assume that instead of Go-Back-N, **Selective Repeat** is used. What are the sequence numbers in the ACK(s) sent out by the receiver in response to the above noted packets. Simply enter the answers in the space provided below. No explanation is necessary. 0.5 mark for each answer.

ACK sent in response to packet with sequence number 31 = [ ]

ACK sent in response to packet with sequence number 29 = [ ]

ACK sent in response to packet with sequence number 0= [ ]

Maximum marks: 3



Consider the graph of the congestion window (**NOT DRAWN TO SCALE**) of a TCP Reno connection where the y-axis describes the TCP window size of the sender (expressed in bytes) and the x-axis denotes time. Assume that the receiver advertised window for flow control is very large.

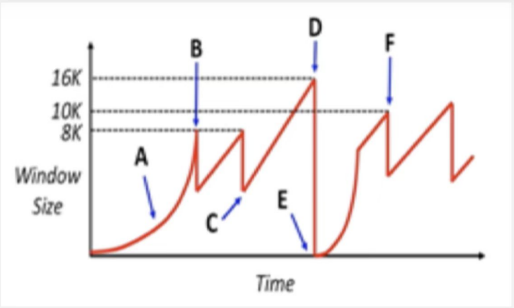
Answer the questions in the right frame.

2

- Assume that the TCP connection has an MSS of 1000 bytes and all packets are 1 MSS. Assume that the the round-trip-time between sender and receiver is 100 milliseconds and fixed. Assume at time 0 the sender attempts to open the connection and it takes 1 round trip time to setup the connection. Assume that the transmission time of packets is negligible. Assume that there is no other traffic on the network. Note that, 1KBytes = 1000 bytes.
  - How much time has progressed between Points E and F? Explain briefly (2 - 3 sentences). (1 mark)

Fill in your answer here Help

Format B I U x_e x^e I_x Ω Σ



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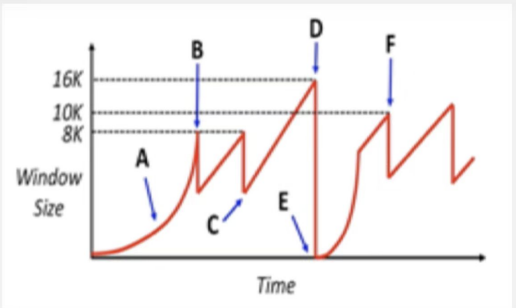
Answer the questions in the right frame.

3

- Assume that the TCP connection has an MSS of 1000 bytes and all packets are 1 MSS. Assume that the the round-trip-time between sender and receiver is 100 milliseconds and fixed. Assume at time 0 the sender attempts to open the connection and it takes 1 round trip time to setup the connection. Assume that the transmission time of packets is negligible. Assume that there is no other traffic on the network. Note that, 1KBytes = 1000 bytes.
  - How much time has progressed till you reach the point B? Explain briefly (2 - 3 sentences). (1 mark)

Fill in your answer here Help

Format



Consider the graph of the congestion window (**NOT DRAWN TO SCALE**) of a TCP Reno connection where the y-axis describes the TCP window size of the sender (expressed in bytes) and the x-axis denotes time. Assume that the receiver advertised window for flow control is very large.

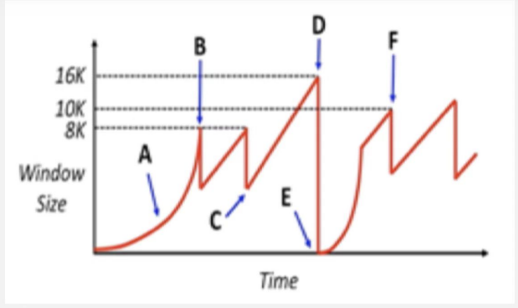
Answer the questions in the right frame.

4

- The window size of the TCP sender decreases at several points in the graph, including those marked by B and D. (1 mark)
  - Name the event at B that occurs that causes the sender to decrease its window?
  - Does the event at B necessarily imply that the network discarded a packet (Yes or No)? Why or why not? (be brief, 2-3 sentences)

Fill in your answer here Help

Format



Consider the graph of the congestion window (**NOT DRAWN TO SCALE**) of a TCP Reno connection where the y-axis describes the TCP window size of the sender (expressed in bytes) and the x-axis denotes time. Assume that the receiver advertised window for flow control is very large.

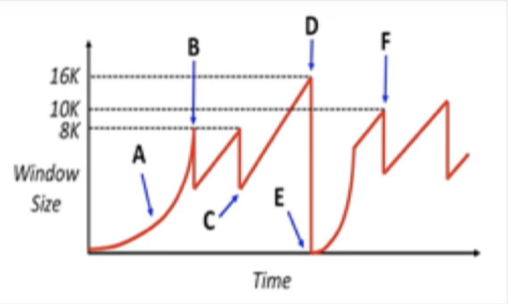
Answer the questions in the right frame.

5

- The window size of the TCP sender decreases at several points in the graph, including those marked by B and D. (1 mark)
  - Name the event at D that occurs that causes the sender to decrease its window.
  - Does the event at D necessarily imply that the network discarded a packet (Yes or No)? Why or why not? (be brief, 2-3 sentences)

Fill in your answer here Help

Format



Consider the graph of the congestion window (**NOT DRAWN TO SCALE**) of a TCP Reno connection where the y-axis describes the TCP window size of the sender (expressed in bytes) and the x-axis denotes time. Assume that the receiver advertised window for flow control is very large.

Answer the questions in the right frame.

6

- Assume that the TCP connection has an MSS of 1000 bytes and all packets are 1 MSS. Assume that the the round-trip-time between sender and receiver is 100 milliseconds and fixed. Assume at time 0 the sender attempts to open the connection and it takes 1 round trip time to setup the connection. Assume that the transmission time of packets is negligible. Assume that there is no other traffic on the network. Note that, 1KBytes = 1000 bytes.
  - How much time has progressed between Points C and D? Explain briefly (2 - 3 sentences). (1 mark)

Fill in your answer here Help

Format

7 Assume that an ISP has 8 subscribers which have been allocated the following IP address blocks:

Organisation 1: 199.14.192.0/24
Organisation 2: 199.14.193.0/24
Organisation 3: 199.14.194.0/24
Organisation 4: 199.14.195.0/24
Organisation 5: 199.14.196.0/24
Organisation 6: 199.14.197.0/24
Organisation 7: 199.14.198.0/24
Organisation 8: 199.14.199.0/24

The ISP would like to aggregate the above blocks into a single address block and advertise this block for the purpose of routing. The advertised IP address block should not contain IP addresses that do not belong to the above 8 blocks of addresses.

Note down the advertised IP address block in the space provided below in the CIDR (a.b.c.d/x) format. No explanation is required.

Maximum marks: 1

8 Consider a router with the following forwarding table.

Network	Interface	Next-hop
101.21.1.0/24	a0	directly connected
101.21.2.0/24	a1	directly connected
101.21.3.0/25	b0	directly connected
101.21.4.0/24	b1	directly connected
101.21.5.0/24	e0	101.21.1.2
101.21.5.64/28	e1	101.21.2.2
101.21.5.64/29	s0	101.21.3.3
101.21.5.64/27	s1	101.21.4.4

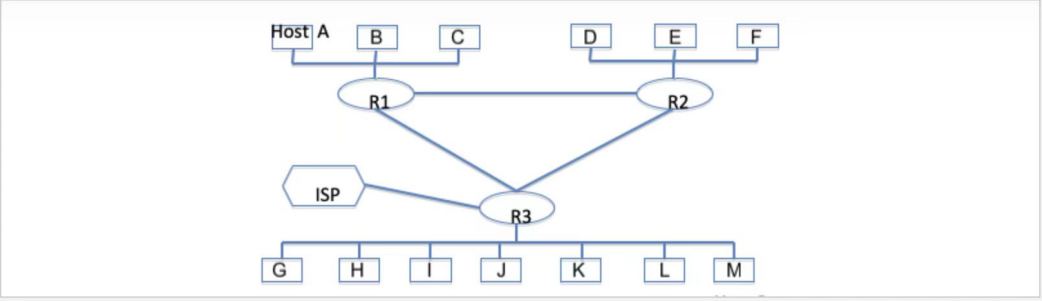
Which interface would an IP datagram with destination address 101.21.5.65 be forwarded to?
Select one alternative:

- ○ s0
- ○ e0
- ○ e1
- ○ s1

Reset

Maximum marks: 1

9



You are given a IP address block 202.203.160.0/25 to assign to hosts and routers in the networks managed by your organisation as shown in the illustration. The number of hosts in the networks are shown e.g., network on the top left has 3 end hosts attached (A to C), network on top right also has 3 end hosts attached (D to F) while the network on the bottom has 7 end hosts (from G to M). Assume that these number of hosts will not change.

Answer the following questions:

a). How many separate networks/subnets are there in the system? (1 mark)

b). Partition the address block efficiently and assign addresses to **ALL** the networks and **EACH** of the interface for routers as well as the end hosts.. Write down the addresses in the CIDR a.b.c.d/x notation. How many addresses are leftover after this assignment? (4 marks)

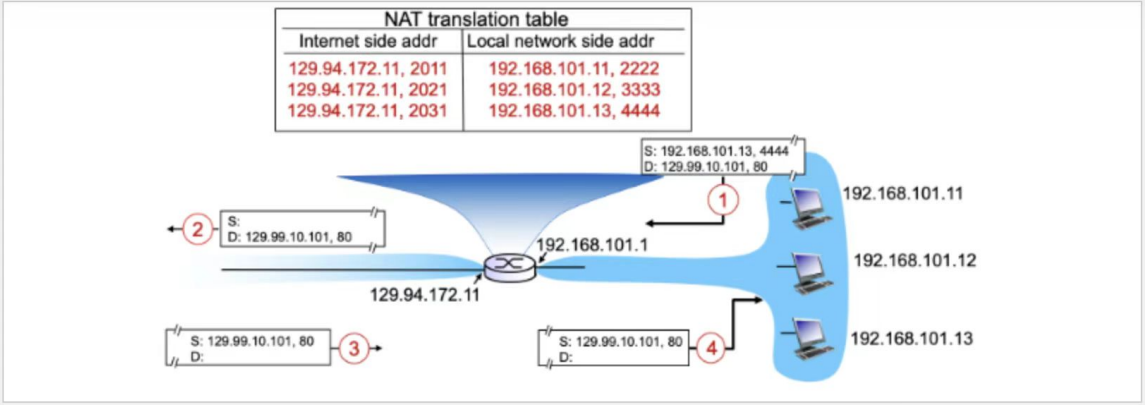
c) Suppose that HOST **A** in the illustration sends a IP datagram to HOST **M** that passes through Routers R1 and R3. Will these routers change any of the fields in the IP datagram's header? If yes, which fields? (1 mark)

Fill in your answer here

Help

Format

10



The figure shows a local (private) network with a NAT router and its translation table. In Step 1, host 192.168.101.13 sends a datagram from its port 4444 to a destination host 129.99.10.101's port 80 (not shown in the figure). The NAT router will modify certain header fields after examining the NAT translation table.

1. In Step 2, the destination IP address and port number of the outgoing datagram are provided. What are the source IP address and port number within this datagram?
   - Source IP address (in a.b.c.d format):
   - Source port number:
2. In Step 3, the destination host 129.99.10.101 will return a datagram from its port 80 back to 192.168.101.13. The source IP address and port number of the returning datagram are provided. What are the destination IP address and port number within this datagram **before it arrives at the NAT router**?
   - Destination IP address (in a.b.c.d format):
   - Destination port number:
3. In Step 4, the NAT router will modify certain header fields of the returning datagram from 129.99.10.101

1. In Step 2, the destination IP address and port number of the outgoing datagram are provided. What are the source IP address and port number within this datagram?
   - Source IP address (in a.b.c.d format):
   - Source port number:
2. In Step 3, the destination host 129.99.10.101 will return a datagram from its port 80 back to 192.168.101.13. The source IP address and port number of the returning datagram are provided. What are the destination IP address and port number within this datagram **before it arrives at the NAT router**?
   - Destination IP address (in a.b.c.d format):
   - Destination port number:
3. In Step 4, the NAT router will modify certain header fields of the returning datagram from 129.99.10.101 before forwarding it to the local network. What are the destination IP address and port number within this datagram?
   - Destination IP address (in a.b.c.d format):
   - Destination port number:

Reset

Maximum marks: 3

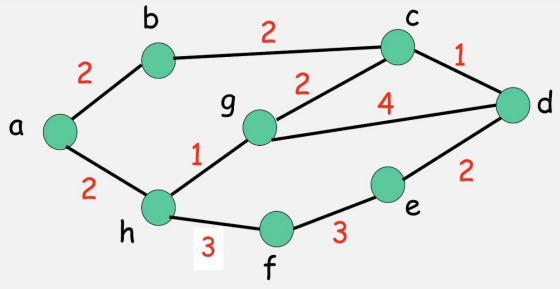
11 An IP datagram which is itself a fragment (of a larger datagram) is of size 1,060 bytes (inclusive of the IP header) and has an offset field of 50. It arrives at a router which has to forward it on an outgoing link with MTU of 740 bytes, and thus needs to create two fragments. What are the offset fields of these two fragments (fill in the values in the provided spaces)? Assume that IP headers are always 20 bytes (i.e. no options are used).

Offset for first fragment: [ ]

Offset for second fragment: [ ]

Maximum marks: 2

请看vcr，例题讲很清楚。



Consider the 8-node topology as shown in the illustration. Note that each link shown in this network is bidirectional and has the same cost in either direction.

Answer the questions at the right.

12 Execute Dijkstra's algorithm at Node **f** to determine the shortest path from Node **f** 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. (3 marks)

Note: There is an option to draw a table in the menu bar at the top in the answer window below.

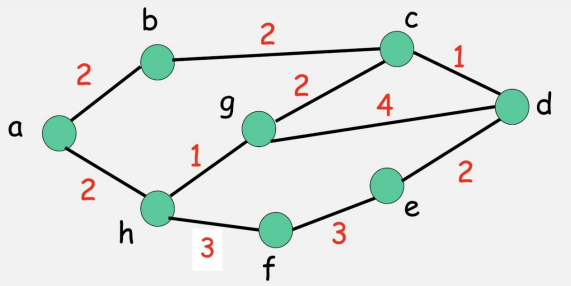
Fill in your answer here Help

Format

请看vcr，例题讲很清楚。

step	N	a	b	c	d	e	g	h
0	f					3, f		3, f
1	fe				5, e			3, f
2	feh	5, h			5, e		4, h	
3	fehg	5, h		6, g	5, e			
4	fehga		7, a	6, g	5, e			
5	fehgad		7, a	6, d				
6	fehgadc		7, a					
7	fehgadcb							
8								

此处填g和d均可



Consider the 8-node topology as shown in the illustration. Note that each link shown in this network is bidirectional and has the same cost in either direction.

Answer the questions at the right.

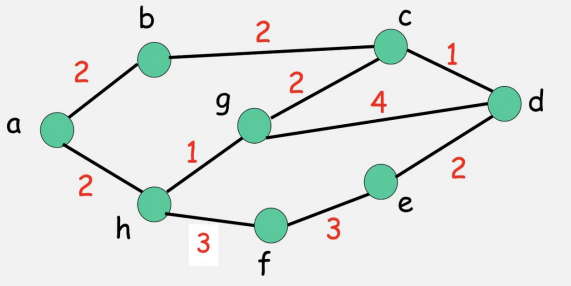
13 Based on the execution of the Dijkstra's algorithm in the previous question, list the forwarding table for node **f**, which contains the outgoing link for reaching every other node in the network. A link between two nodes x and y should be denoted as (x, y). (1 mark)

Fill in your answer here Help

Format

请看vcr，例题讲很清楚。

```
(f, a) - h
(f, b) - h
(f, c) - e
(f, d) - e
(f, e) - e
(f, g) - h
(f, h) - h
```



Consider the 8-node topology as shown in the illustration. Note that each link shown in this network is bidirectional and has the same cost in either direction.

Answer the questions at the right.

14 Suppose that the traffic from **a** to **c** currently traverses the (a,b) edge. The network administrator plans to change the weight of the (b,c) edge to divert the traffic from **a** to **c** onto another path. What is the minimum weight the (b,c) edge would need to force **ALL** of the traffic from **a** to **c** to take a different path? (1 mark)

What is the maximum weight the edge (b,c) could have while still ensuring the traffic from **b** to **c** goes directly over the (b,c) edge and traffic from **a** to **c** does not go over (b,c) edge? (1 mark)

Maximum marks: 2

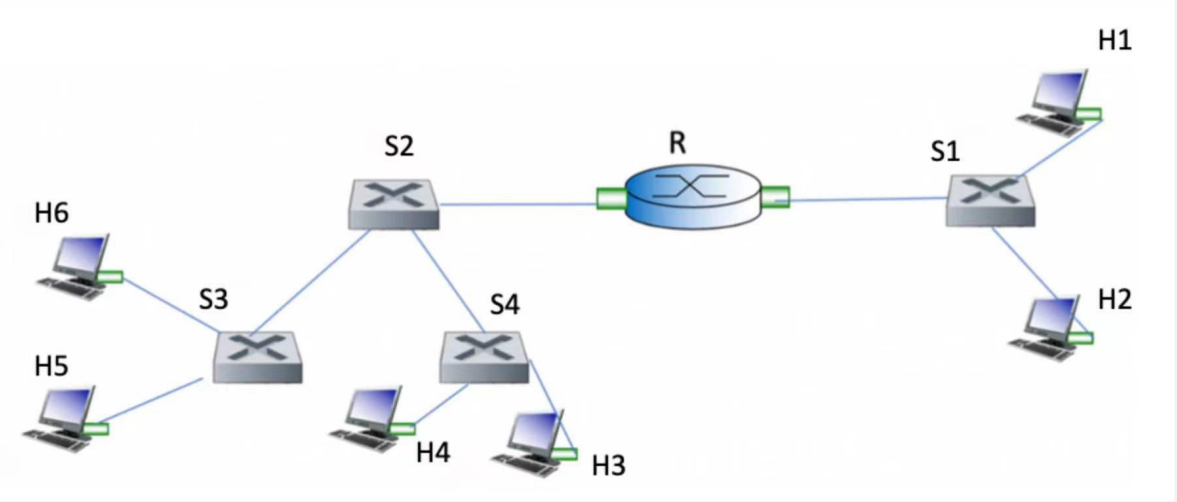
第1问：一定是4，因为要强迫所有的流量走其他路，所以一定是大于，不能代价相等。

其他路的代价是：2+2+1=5，　2+bc > 5，　bc > 3，bc = 4

第2问：6

bc < ba+ah+hg+gc

15 Consider the network shown in the figure below which comprises 6 hosts (H1-H6), 4 Ethernet switches (S1-S4) and a router R. Suppose that the switch tables in all switches are empty and that the router forwarding tables are correctly configured. Once an entry is added to a switch table, you may assume that it persists forever.



Answer the following questions.

(1) Suppose H5 sends a frame to H3. Which switches learn where H5 is? The Ethernet adapters of which hosts other than H3 may receive this frame? Explain your answer. (1.5 marks)

(2) Next, suppose H6 wants to send an IP datagram to H1 and knows H1's IP address. Must H6 also know H1's MAC address to send the datagram to H1? If so, how does H6 get this information? If not, explain why not. (1.5 marks)

(3) When H6 sends the frame encapsulating the datagram from question 2, the Ethernet adapters of which hosts (in the entire network) may receive this frame? Which switches (in the entire network) learn where H6 is? (2

Answer the following questions.

(1) Suppose H5 sends a frame to H3. Which switches learn where H5 is? The Ethernet adapters of which hosts other than H3 may receive this frame? Explain your answer. (1.5 marks)

(2) Next, suppose H6 wants to send an IP datagram to H1 and knows H1's IP address. Must H6 also know H1's MAC address to send the datagram to H1? If so, how does H6 get this information? If not, explain why not. (1.5 marks)

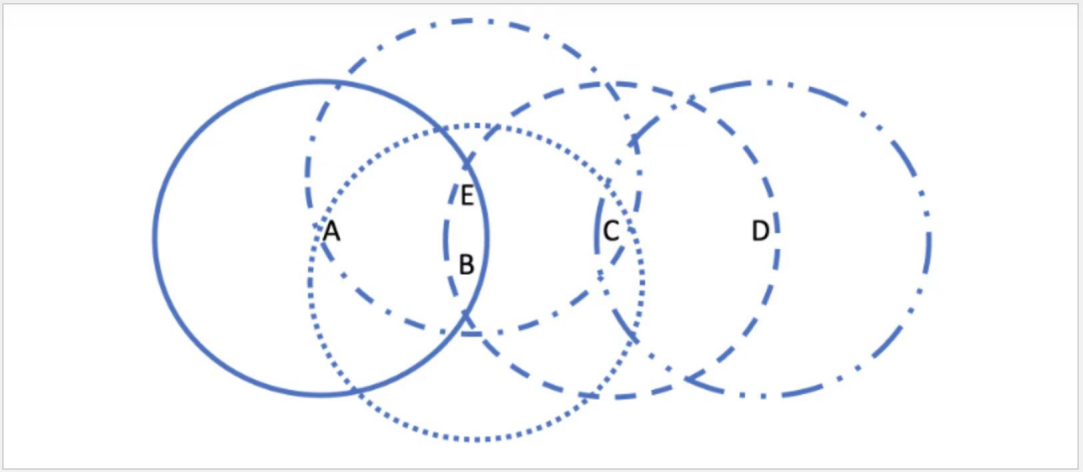
(3) When H6 sends the frame encapsulating the datagram from question 2, the Ethernet adapters of which hosts (in the entire network) may receive this frame? Which switches (in the entire network) learn where H6 is? (2 marks)

Fill in your answer for all 3 questions here

Help

Format

16



Consider the wireless network in the illustration, which is an example of a wireless LAN topology comprised of 5 nodes marked A through E sharing the same frequency. Circles around each node illustrate their transmission range, e.g. A's range is shown by circle drawn in solid line. Assume that the transmissions from two nodes will interfere (or collide) at a location if and only if both nodes transmit at the same time and their transmission ranges overlap.

a) Assume that Node C transmits to Node B. **What are the potential hidden terminals and exposed terminals? (2 marks)**

b) if Node D transmits to Node C, w**hat are the potential hidden terminals and exposed terminals? (1 mark)**

Fill in your answer here Help

17

Suppose we want to transfer **1455** bytes of data from an application running on top of **UDP** between two hosts connected through Ethernet with **100** Mbps capacity. The application header is **20** bytes. UDP header is **8** bytes. IP header is **20** bytes and Ethernet Frame header+trailer are **18** bytes. Assume that the overhead for Ethernet framing happens at the link layer. You can neglect the Inter Frame Gap (if applicable) when calculating the overhead at the Link Layer. Note that Ethernet supports an MTU of **1500** bytes.

a) Calculate the overhead at each layer of the protocol stack in terms of the **percentage of the original data,** if the application layer data is to be transferred to the destination host? (1 mark each)

Application layer overhead: [ ] **%**

Transport layer (UDP) overhead: [ ] **%**

Network layer overhead: [ ] **%**

Link layer overhead: [ ] **%**

b) How many **TOTAL** bytes would appear on the **WIRE** to transfer the original 1455 bytes (Neglect the InterFrame gap) ? (1 mark) [ ]

Maximum marks: 5

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