**A1.** Describe Pulse Amplitude Modulation (PAM).

**[2 marks]**

**A2.** There are two standards for multiplexing digital speech channels.
Draw and label fully a diagram showing the multiplexed frame for
*either* (a) the American T1 standard
*or* (b) the European (ITU) E1 standard. **[2 marks]**

**A3.** When the T1 or E1 streams are further aggregated, the various data streams are not necessarily in synchronism with one another. Give the term that is used to describe the resultant digital multiplexed hierarchy. What mechanism is used to overcome the slight variations that exist in the timing of these streams? **[2 marks]**

**A4.** What is the basic unit of transmission in the synchronous digital hierarchy (SDH)?

**[1 mark]**

**A5.** Define what is meant by i) a *tributary unit*, and
ii) a *virtual container*? **[2 marks]**

**A6.** Illustrate how an E1 connection at 2Mbps may be derived from an E4 link running at approximately 140Mbps, using an *add-drop multiplexer* **[2 marks]**

**A7.** Using diagrams, show what is meant by i) *simplex*,
ii) *duplex*? **[2 marks]**

**A8.** Show the format of an ASCII character encoded for asynchronous transmission.
Label the various parts of the waveform. **[2 marks]**

**A9.** Given a bit sequence 101101 and corresponding bit-clock, draw the corresponding waveforms for i) NRZ, ii) RZ, iii) BI-ϕ-L, iv) BI-ϕ-M, and v) NRZI. **[5 marks]**

**A10.** What are the two principal strategies for error control that may be used to overcome transmission errors? **[2 marks]**

**A11.** Draw a schematic circuit showing how an even parity check bit might be derived for the 7 data bits of an ASCII character. **[2 marks]**

**A12.** Describe how frame synchronization may be achieved in bit oriented synchronous data transmission.
What is bit stuffing? When is it used and why? **[2 marks]**

**A13.** Give two specific aspects in which a UART differs from a USRT. **[2 marks]**

**A14.** Given the divisor/generator $G(x) = 1101$ and a message $M(x) = 111001$, derive the quotient $(M(x) \times 2^3)/G(x)$ and remainder $R(x)$, assuming modulo 2 arithmetic.
Thus show the data message together with the redundancy check bits formed as a complete message. **[3 marks]**

**A15.** Given a set of characters $\{a, b, c, d, e, f, g\}$ with respective source probabilities

$$P(a) = P(b) = 1/4,\ P(c) = P(d) = P(e) = 1/8,\ P(f) = P(g) = 1/16$$

derive a binary Huffman code which gives optimally efficient encoding of the source. (Assume that the source symbols appear independently of one another.) **[3 marks]**

**A16.** Shannon defined a quantity called the *source entropy* which measures the expected average rate of information from a source.
Give Shannon's equation and calculate the entropy for the source in Question A15.
What are the units of entropy? **[3 marks]**

**A17.** Group 3 facsimile uses an encoding scheme referred to as a *modified Huffman* code.
Explain i) why is it called this,
ii) what are make-up codes, and
iii) what are termination-codes. **[2 marks]**

**A18.** A data communications link may be described as being *best effort* or *connectionless*. What is meant by this?
**[2 marks]**

**A19.** How does *explicit* idle RQ error control differ from *implicit* idle RQ?
Which is more efficient and why? **[2 marks]**

**A20.** A 200 km long communications link operates at 10 Mbps, with a frame size of 1250 octets and idle RQ protocol. Calculate the link utilization assuming a propagation velocity of $2\times10^8$ metres/sec and a negligible error rate. Express the link utilization as a percentage. **[3 marks]**

**A21**. How does *continuous RQ* differ from *idle RQ*?
What two resources does *continuous RQ* specifically require? **[2 marks]**

**A22.** What is meant by *flow control*?
Give the names of two established flow control methods. **[2 marks]**

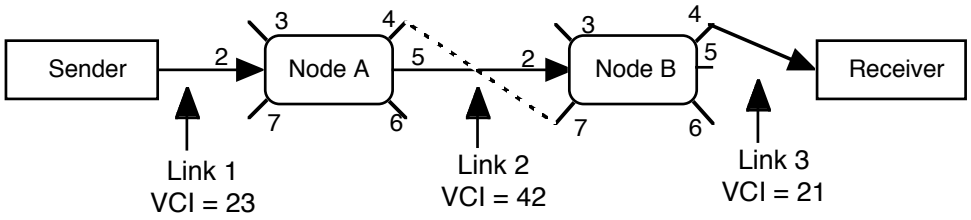
**B23.** A station receives an LLC frame with one of several possible DSAP values.
Explain how the DSAP value is used to control the subsequent processing. **[3 marks]**

**B24.** Although the IEEE 802.3 and Ethernet standards are very similar, they are quite different in how they carry messages for other protocols (IP, AppleTalk, etc). What is this difference? **[2 marks]**

**B25.** Ethernet (or IEEE 802.3), Token Bus (IEEE 802.4) and FDDI all provide a preamble at the start of each data or MAC frame. IEEE 802.5 Token Ring does not include a preamble—why is it different from the other networks? **[2 marks]**

**B26.** Explain why the token rotation time for a token bus network is usually much greater than that for a token ring network where the physical data rate, physical network size and number of stations are all similar. **[2 marks]**

**B27.** Two users communicate through a virtual circuit as shown. The ports of each node are numbered as in the figure (with the same values for both input and output). Although only a few physical links are shown, you should assume that all of the ports on the two nodes connect to other hosts or nodes.




(a) What routing table entries are needed in Nodes A and B to maintain the virtual circuit (sender to receiver) as shown by the *solid* lines in the figure? **[4 marks]**

| | Input Line/ Port | Input VCI | Output Line/Port | Output VCI |
|---|---|---|---|---|
| Node A | | | | |
| Node B | | | | |

(b) The connection from node A to B is changed to that shown by the *dotted* line. What are the new routing tables? **[4 marks]**

**B28.** While bridges can interconnect different types of IEEE networks, some features of 802.4 and 802.5 are difficult to handle over 802.3 networks. What are these features? **[3 marks]**

**B29.** (a) What is the significance of each combination of the "Address Recognised" and "Frame Copied" bits of the IEEE 802.5 Token Ring frame? **[4 marks]**

(b) Give one other use for the Address Recognised bits. **[1 mark]**

**B30.** Explain why a network using datagrams must handle out-of-order packet arrival, whereas one using virtual circuits can expect in-order packet delivery. **[4 marks]**

**B31.** Give two reasons why local area networks usually discard failing messages while wide-area networks often retry them. **[2 marks]**

**B32.** (a) Why does the performance of an Aloha network deteriorate at high loadings? **[2 marks]**

(b) Why does changing Aloha to "slotted Aloha" improve the performance? **[2 marks]**

(c) Most networks control which station can transmit at a particular time, for example by requiring a station to obtain a token before it can transmit. What form of control is provided in Aloha and slotted Aloha protocols? **[1 mark]**

**B33.** How should a token bus station remove itself from the network? **[4 marks]**

**B34.** Explain how routing decisions for data messages differ in a network using datagrams, as compared with one using virtual circuits. **[4 marks]**

**B35.** (a) State three user advantages in using ISDN as opposed to traditional communications techniques.

**[3 marks]**

(b) Protocols such as X.21 and X.25 use “in-band” signalling, whereas ISDN uses “out-of-band” signalling. Briefly contrast the two methods and state why out-of-band signalling might be preferred. **[3 marks]**

**A1**. You read that "*Ethernet is a very inefficient network because so much data is lost from data collisions*". Argue against this statement. **[4 marks]**

**A2**. A slotted ring network has a length of 2 km, a data rate of 10 Mbps and 200 repeaters (or stations), each of which contributes a latency of one bit. Assume a cable propagation velocity of 200 m/$\mu$s and ignore any special monitor latencies.

(a) What is the total ring latency? **[4 marks]**

(b) Each slot has a total length of 40 bits, consisting of one source address byte, one destination address byte, two data bytes, and control bits. How many slots are on the ring? (*The size of a slot is made slightly larger than usual to ease calculation.*) **[3 marks]**

**A3.** Give two reasons why local area networks usually discard failing messages while wide-area networks often retry them. **[2 marks]**

**A4.** Although the IEEE 802.3 and Ethernet standards are very similar, they are quite different in how they carry messages for other protocols (IP, AppleTalk, etc). What is this difference? **[3 marks]**

**A5.** Two stations on a 10BASE5 IEEE802.3 LAN are exchanging messages (requests and responses), with negligible separation between a request and its response and between one response and the next request. There is negligible other traffic. A "request" has 80 information bytes. (*Assume that an 802.3 message has an overhead of 40 octets in inter-record gap, preamble, addresses, FCS, etc and that there are negligible other delays.*)

(a) What sized *data block* should be transferred in the response message to ensure that user information (the data within the response) is transferred at $^2/_3$ the network rate

**[4 marks]**

(b) Show that the maximum possible user data rate is about $^{15}/_{16}$ of the network rate. (You may leave the answer as an unsimplified fraction.) **[4 marks]**

**A6.** While bridges can interconnect different types of IEEE networks, some features of 802.4 and 802.5 are difficult to handle over 802.3 networks. What are these features?

**[3 marks]**

**A7.**(a) What is the "chip rate" in a spread spectrum system?

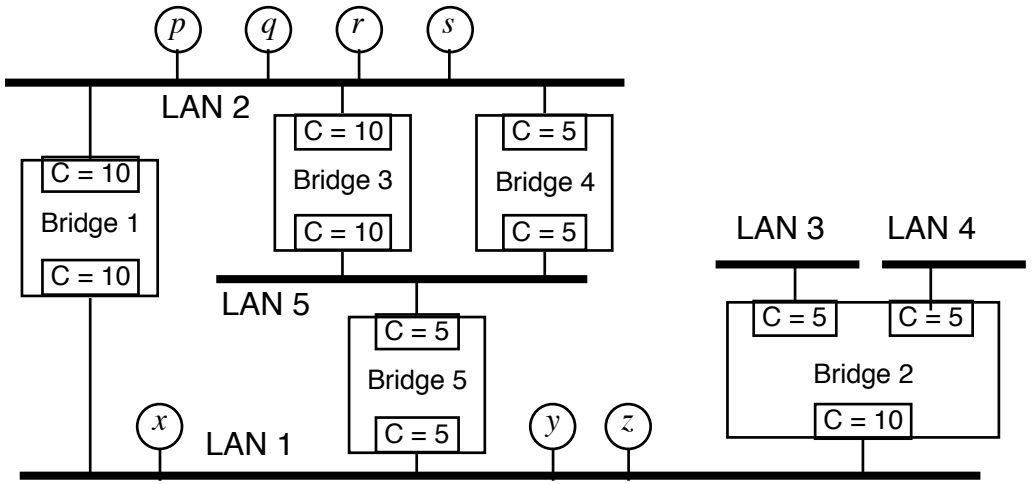
**[2 marks]**

(b) Name one type of spread spectrum and explain how it spreads the signal over the available bandwidth.

**[4 marks]**

**A8.** A station receives an LLC frame with one of several possible DSAP values. Explain how the DSAP value is used to control the subsequent processing. **[3 marks]**

**A9.** The diagram shows a system of several LANs interconnected with transparent bridges. The bridges have names such as "Bridge 4", which are used as the unique identifiers for the spanning tree algorithm. Each connection of a bridge to a LAN has an associated cost as shown, for example "C = 5". Two of the LANs are shown with connected stations or nodes (such as "*p*" and "*x*"). For all except part (a), assume that a network spanning tree has been built.
*Answers to parts (b), (c) and (d) must include explanations or reasons.*




(a) Assuming for this part that only Bridge 1 is operating, explain what messages are on what LANs in response to each of the messages in the following sequence.
In each case state what, if anything, the bridge learns about the network (the answer may be "nothing") Assume that the bridge has no initial knowledge. Information learned from one message may be used in handling later messages. **[6 marks]**

| *source* | *dest* | *message is on LAN(s)* | *information learned by "Bridge 1"* |
|---|---|---|---|
| $x$ | $y$ | | |
| $p$ | $x$ | | |
| $z$ | $y$ | | |
| $z$ | $x$ | | |
| $p$ | $z$ | | |
| $s$ | $p$ | | |

(b) Which bridge will become the root bridge of the full network? **[2 marks]**

(c) Which will be the preferred connection between LAN 2 and LAN 5? **[2 marks]**

(d) How is LAN 5 connected to the rest of the network?. **[4 marks]**

**B10.** Describe how "NEXT" cancellation may be achieved.
What does "NEXT" stand for? **[2 marks]**

**B11.** For a given modulation scheme, $E_{b/N_0}$ denotes the ratio of the *energy per bit* to the *level of thermal noise per Hz* required to achieve some minimum error rate.
Give an expression for $E_{b/N_0}$ in terms of the signalling rate and temperature.
How is $E_{b/N_0}$ affected by temperature, i.e., will it increase or decrease with increasing temperature? **[2 marks]**

**B12.**(a) Two standards exist for multiplexing multiple speech channels.
Draw diagrams showing the multiplexed frame for the American T1 standard and the European (ITU) E1 standard. Label your diagram fully. **[2 marks]**

(b) When the T1 or E1 streams are further aggregated, the various data streams are not necessarily in synchronism with one another.
• Give the term that is used to describe the resultant digital multiplexed hierarchy.
• What mechanism is used to overcome the slight variations that exist in the timing of these streams?

**[2 marks]**

**B13.** Depict the waveform for an asynchronous ASCII encoded character.
Label the constituent parts of the waveform. **[2 marks]**

**B14.** Given a bit sequence 101100 and corresponding bit-clock, draw corresponding waveforms for i) NRZ, ii) RZ, iii) BI-φ-L, iv) BI-φ-M, and v) NRZI? **[5 marks]**
(*The vertical lines may help you define bit boundaries*.)

**B15.** Given the divisor/generator $G(x) = 1101$ and a message $M(x) = 111001$, derive the quotient $(M(x)\times 2^3)/G(x)$ and remainder $R(x)$, assuming modulo 2 arithmetic.
Thus show the data message together with the redundancy check bits formed as a complete message.

**[4 marks]**

**B16.** What are the two principal categories of error control used to overcome transmission errors? **[2 marks]**

**B17.** In 1948 Shannon proposed a refined version of Hartley's measure (1928) of information content. Give Shannon's equation and explain all terms. **[2 marks]**

**B18.** The characters $\{a, b, c, d, e, f, g\}$ issue from a source with probabilities:
$P(a) = 0.24$, $P(b) = 0.26$, $P(c) = 0.13$, $P(d) = 0.14$, $P(e) = 0.05$, $P(f) = 0.06$, $P(g) = 0.12$.
Derive a binary Huffman code which gives optimally efficient encoding for the source.
**[4 marks]**

**B19.** Group 3 facsimile uses an encoding scheme referred to as a *modified Huffman code*. Describe what is meant by:
- make-up codes, and
- termination-codes.

**[2 marks]**

**B20.** A data communications link may be characterised as being a *best effort* or *connectionless* link. What is meant by each of these terms? **[2 marks]**

**B21.**(a) How does *explicit* idle RQ error control differ from *implicit* idle RQ?
Which is more efficient and why? **[2 marks]**

(b) How does *continuous RQ* differ from *idle RQ*?
What two resources does *continuous RQ* require? **[2 marks]**

**B22.** Information frames of length 100 bits are to be transmitted over the following links using idle RQ and with a propagation velocity of $2 \times 10^8$m/sec.
Determine the link efficiency (utilisation) for each of the following:

(a) a 10km link with a BER of $10^{-4}$ and a transmission rate of 9600bps **[3 marks]**

(b) a 500m link with a BER of $10^{-6}$ and a transmission rate of 10Mbps **[3 marks]**

**B23.** Information frames of 1000 bits are to be transmitted over a 4000km link at a data rate of 2Mbps. Assuming a propagation velocity of $2 \times 10^8$m/sec, and a BER of $10^{-4}$, determine the link efficiency for each of the following. Specifically show the effect of bit errors for each of the results obtained.

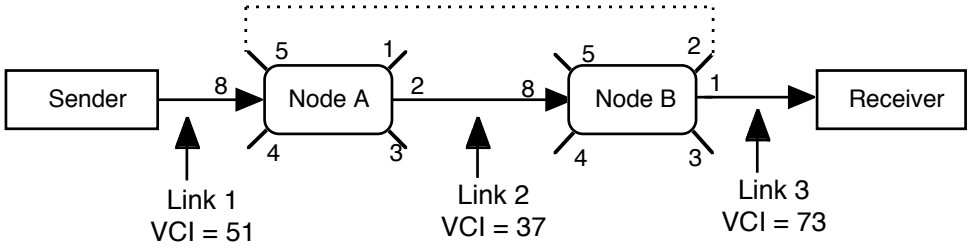
(a) Selective retransmission and a send window of 7. **[3 marks]**

(b) Go-back-N and a send window of 127. **[3 marks]**

**B24.** Use a Hamming code to encode the message 10110100101.
- How many bit errors can be detected in the encoded message?
- How many can be corrected? **[3 marks]**

**A1.** A student thinks that in a token ring it is best to receive the entire token and examine it before either forwarding it to the next station or seizing it to allow this station to send. Comment on this choice. **[2 marks]**

**A2.** Two users communicate through a virtual circuit as shown. The ports of each node are numbered as in the figure (with the same values for both input and output). Although only a few physical links are shown, you should assume that all of the ports on the two nodes connect to other hosts or nodes.




(a) What routing table entries are needed in Nodes A and B to maintain the virtual circuit (sender to receiver) as shown by the *solid* lines in the figure? **[4 marks]**

| | Input Line/ Port | Input VCI | Output Line/Port | Output VCI |
|---|---|---|---|---|
| Node A | | | | |
| Node B | | | | |

(b) The connection from node A to B is changed to that shown by the *dotted* line. What are the routing tables for the *reverse* circuit, from right to left? **[4 marks]**

**A3.** Explain how routing decisions for data messages differ in a network using datagrams, as compared with one using virtual circuits. **[4 marks]**

**A4.** A token bus network is running with active stations whose addresses are A = 759, B = 113, C = 149 and D = 472.
A station E with address 262 enters the network in response to a message from one of the active stations. **[5 marks]**

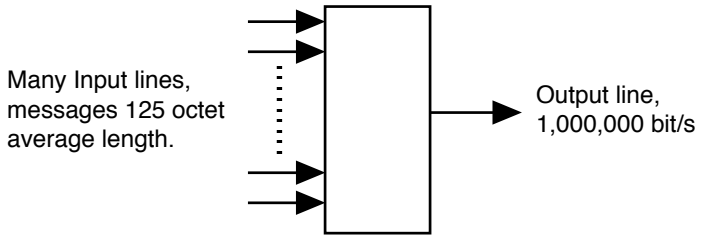
| | | Dest Addr | Source Addr | Message Type | Other Data |
|---|---|---|---|---|---|
| (i) | E responds to what message? | | | | |
| (ii) | E responds with what message? | | | | |
| (iii) | E receives the Token message | | | Token | |

(iv) What changes would result if E had the address 103?. **[2 marks]**

**A5.** How does a repeater differ from a bridge? **[2 marks]**

**A6.** In a token ring the station which raises the priority of a token is responsible for lowering the token priority. Why must the priority be lowered, rather than just leaving it at the higher value? **[2 marks]**

**A7.** A communications multiplexer is concentrating many lines into a single output line with a capacity of 1,000,000 bit/s. All of the messages or packets may be assumed to have an exponentially distributed length, with an average of 125 octets.




Complete the following table

| Total packets/second | 500 | 800 | 900 | 750 | 1000 |
|---|---|---|---|---|---|
| utilisation $\rho$ | | | | | |
| Average packets in multiplexer | | | | | |

**[4 marks]**

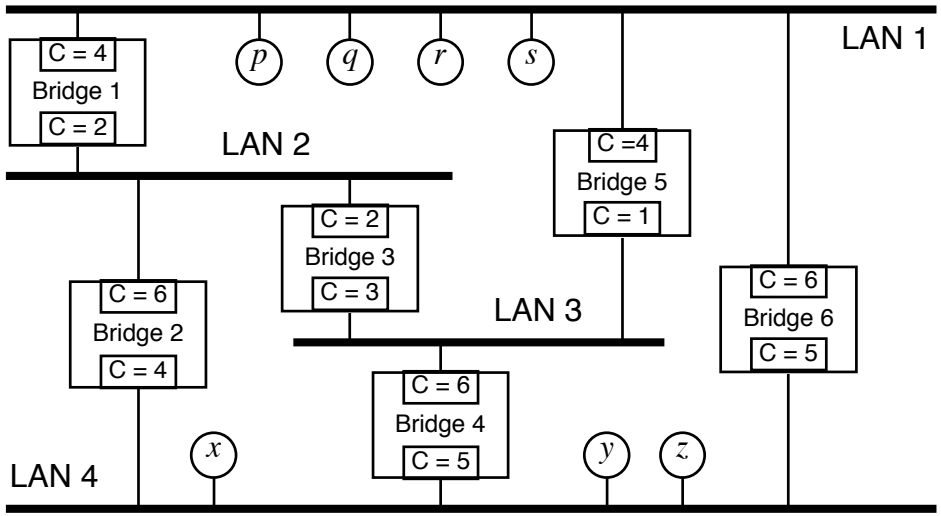
**A8.** With regard to network management, explain each of the following terms, briefly describing their function and importance.

(i) MIB **[2 marks]**

(i) SNMP get request **[2 marks]**

(i) SNMP set request **[2 marks]**

**A9.** The diagram shows a system of several LANs interconnected with transparent bridges. The bridges have names such as "Bridge 4", which are used as the unique identifiers for the spanning tree algorithm. Each bridge port has an associated cost as shown, for example "C = 5". Two of the LANs are shown with connected stations or nodes (such as "*p*" and "*x*").

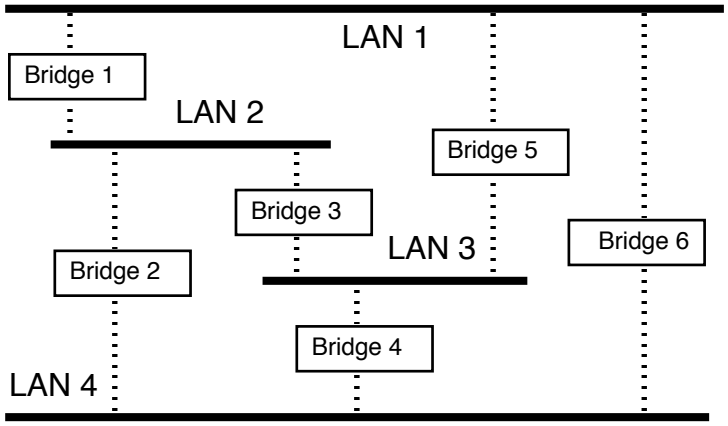


(a) Assuming for this part that *only Bridge 6 is operating*, explain what messages are on what LANs in response to each of the messages in the following sequence.
In each case state what, if anything, the bridge learns about the network (the answer may be "nothing"). The bridge has no initial knowledge. Information learned from one message may be used in handling later messages. **[6 marks]**

| *source* → *dest* | *message is on LAN(s)* | *information learned by "Bridge 6"* |
|---|---|---|
| $p \rightarrow r$ | | |
| $x \rightarrow q$ | | |
| $r \rightarrow s$ | | |
| $r \rightarrow p$ | | |
| $x \rightarrow p$ | | |
| $z \rightarrow x$ | | |

(b) Assuming that a network spanning tree has been built, which bridge will become the root bridge of the full network, and why? **[2 marks]**

(c) The diagram shows the network with only the LANs, bridges and possible connections. Mark the connections which are enabled to form the spanning tree.
(*Or you may mark the connections which are disabled, as long as the result is clear.*)
**[4 marks]**




**A10.** A CSMA/CD network such as IEEE 802.3 employs a technique called "truncated binary exponential backoff".
Why is binary exponential backoff used and how does it achieve its result?
*You do not have to explain its operation in great detail.* **[3 marks]**

**B11.** What are the three lowest levels of the ISO reference model? **[1 mark]**

**B12.** What do i) the V-series recommendations, and
ii) the X-series recommendations pertain to, respectively? **[2 marks]**

**B13.** A 3 kHz bandwidth voice channel is found to have a 30db signal-to-noise level. What is the channel's capacity, and the units for capacity? **[2 marks]**

**B14.** Describe what is meant by Frequency Shift Keying (FSK). Sketch and label a graph to illustrate the spectral bandwidth requirements of a binary FSK modulated signal.
**[2 marks]**

**B15**. Describe what is meant by companding?
Give an example of where is it used. **[2 marks]**

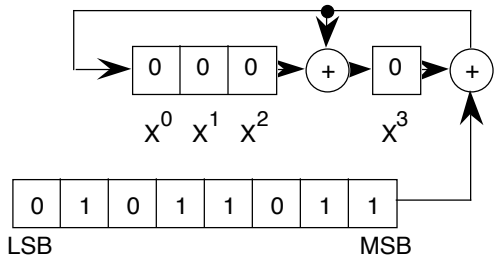
**B16**. When T1 or E1 streams are aggregated, the various data streams might be not absolutely in synchronism with one another. Give the term that is used to describe the resultant digital multiplexed hierarchy. **[1 mark]**

**B17**. Given a bit sequence `100110` and corresponding bit-clock, draw corresponding waveforms for i) NRZ, ii) RZ, iii) BI-ϕ-L, and iv) BI-ϕ-M? **[4 marks]**

**B18**. What are the two principal categories of error control used to overcome transmission errors? **[2 marks]**

**B19**. Use a Hamming code to encode the message 11010110011. How many bit errors can be detected in the encoded message? How many can be corrected? **[4 marks]**

**B20**. The following simplified schematic shows an encoder with CRC register, encoding the binary message 11011010.




Complete the top 4 lines of the following table, where each row corresponds to the contents of the message and CRC registers respectively at bit-time intervals. The first line of the table shows the initial contents of the registers. **[4 marks]**

**B21**. Information frames of length 100 bits are to be transmitted over a 10 km link with a BER of $10^{-4}$ and a transmission rate of 9600 bps using idle RQ.
Assuming a propagation velocity of $2 \times 10^8$ m/sec, determine the link efficiency (utilisation) for the link. **[4 marks]**

**B22**. In 1948 Shannon proposed a refinement of Hartley's information measure (1928).
Give Shannon's equation and explain all terms. **[2 marks]**

**B23**. The characters {a, b, c, d} issue from a source with probabilities:

$$P(a) = 0.5,\ P(b) = 0.25,\ P(c) = 0.125,\ P(d) = 0.125\ .$$

Compute the first order Shannon entropy (information rate) for the source.
What are its units? **[4 marks]**

**B24**. Though Shannon's information measure is based on a probabilistic model, Cherry outlined an alternative interpretation of Shannon's definition.
Briefly describe this alternative interpretation. **[2 marks]**

**B25**. T-complexity theory provides a formal definition of a strings complexity.
What are the units of this measure?
What does it stand for? **[2 marks]**

**B26**. Derive the binary variable-length T-code graph containing the maximal-length string: 1001011. What is the T-complexity of this string? **[4 marks]**

**B27**. What does UART stand for? What does USRT stand for? List two specific ways in which a UART differs from a USRT? **[3 marks]**

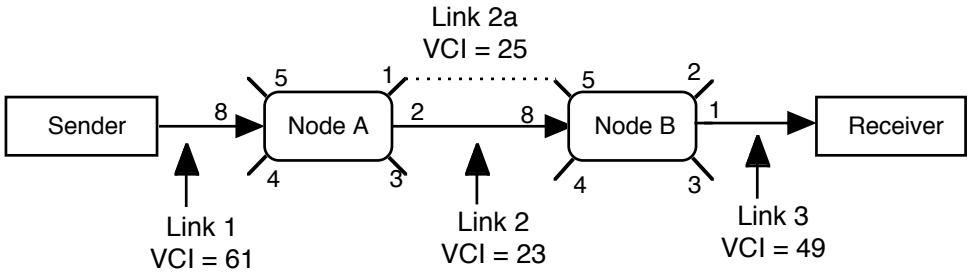
**B28**. How does *explicit* idle RQ differ from *implicit* idle RQ?
Which is more efficient and why? **[2 marks]**

**B29**. What additional resources does *continuous RQ* require over *idle RQ* **[2 marks]**

**B30**. What is meant by *flow control*? **[1 mark]**

**1.** A student thinks that in a token ring it is best to receive the entire token and examine it before either forwarding it to the next station or seizing it to allow this station to send. Comment on this choice. **[3 marks]**

**2.** Two users communicate through a virtual circuit as shown. The ports of each node are numbered as in the figure (with the same values for both input and output). Although only a few physical links are shown, you should assume that all of the ports on the two nodes connect to other hosts or nodes.




(a) What routing table entries are needed in Nodes A and B to maintain the virtual circuit (sender to receiver) as shown by the *solid* lines in the figure? **[4 marks]**

| | Input Line/ Port | Input VCI | Output Line/Port | Output VCI |
|---|---|---|---|---|
| Node A | | | | |
| Node B | | | | |

(b) The connection from node A to B is changed to that shown by the *dotted* line. What are the routing tables for the *reverse* circuit, from right to left? **[4 marks]**

**3.** Explain how routing decisions for data messages differ in a network using datagrams, as compared with one using virtual circuits. **[4 marks]**

**4.** A token bus network is running with active stations whose addresses are

$A = 505$, $B = 623$, $C = 338$ and $D = 795$.

A station $E$ with address 484 enters the network in response to a message from one of the active stations. Complete the following table. **[5 marks]**

| | | Dest Addr | Source Addr | Message Type | Other Data |
|---|---|---|---|---|---|
| (i) | E responds to what message? | | | | |
| (ii) | E responds with what message? | | | | |
| (iii) | E receives the Token message | | | Token | |

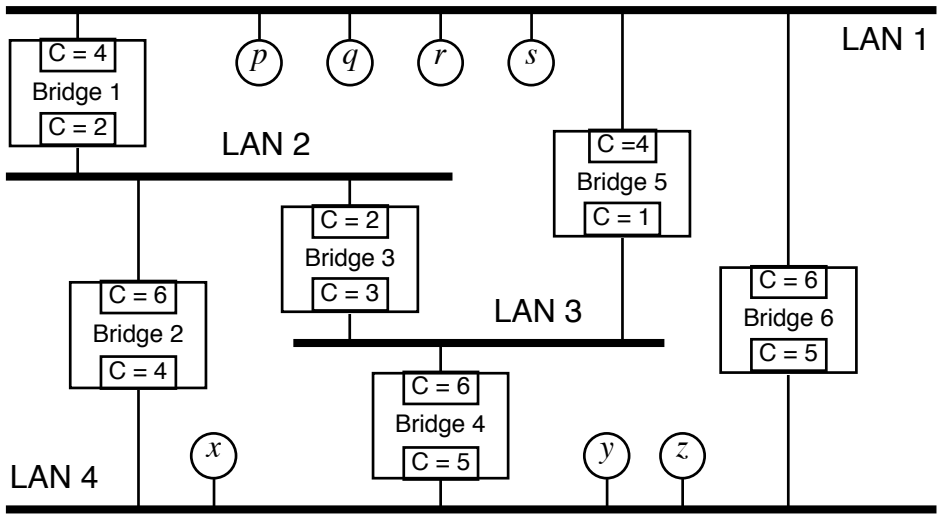
(iv) What changes would result if E had the address 103?. **[2 marks]**

**5.** How does a repeater differ from a bridge? **[2 marks]**

**6.** The diagram shows a system of several LANs interconnected with transparent bridges.

The bridges have names such as "Bridge 4", which are used as the unique identifiers for the spanning tree algorithm.

Each bridge port has an associated cost as shown, for example "C = 5". Two of the LANs are shown with connected stations or nodes (such as "*p*" and "*x*").

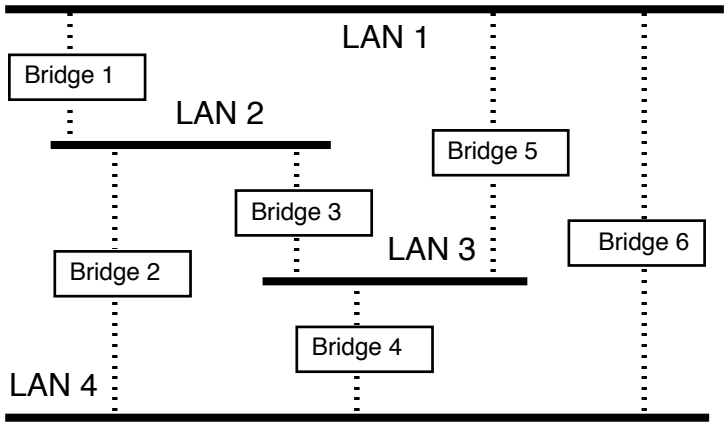


(a) Assuming for this part that *only Bridge 6 is operating*, explain what messages are on what LANs in response to each of the messages in the following sequence.
In each case state what, if anything, the bridge learns about the network (the answer may be "nothing"). The bridge has no initial knowledge. Information learned from one message may be used in handling later messages. **[6 marks]**

| *source* → *dest* | *message is on LAN(s)* | *information learned by "Bridge 6"* |
|---|---|---|
| $p \rightarrow r$ | | |
| $x \rightarrow q$ | | |
| $r \rightarrow s$ | | |
| $r \rightarrow p$ | | |
| $x \rightarrow p$ | | |
| $z \rightarrow x$ | | |

(b) Assuming that a network spanning tree has been built, which bridge will become the root bridge of the full network, and why? **[2 marks]**

(c) The diagram shows the network with only the LANs, bridges and possible connections. Mark the connections which are enabled to form the spanning tree.
(*Or you may mark the connections which are disabled, as long as the result is clear.*)**[4 marks]**




**7.** In a token ring the station which raises the priority of a token is responsible for lowering the token priority. Why must the priority be lowered, rather than just leaving it at the higher value? **[2 marks]**

**8.** What are the two principal categories of error control used to overcome transmission errors? **[2 marks]**

**9.** A CSMA/CD network such as IEEE 802.3 or Ethernet employs a technique called "truncated binary exponential backoff".
Why is binary exponential backoff used and how does it achieve its result?
*You do not have to explain its operation in great detail.* **[3 marks]**

**10**. A (7,4) Hamming code uses *odd* parity for each of its parity groups. The received codeword is 0000000.

(i) Correct the error (if any) in the received word and extract the corrected data bits (deleting the parity bits). You must state the bit order. **[4 marks]**

(ii) As in this example, odd parity is sometimes preferred to even parity for a Hamming code. Suggest a reason for this preference. **[1 mark]**

**11**.(a) Give *three* reasons why it may take more than 8 seconds to send a 100 megabyte file over a 100 megabit ($10^8$) per second link. **[3 marks]**

(b) Give some way of reducing each reason, if possible. **[3 marks]**

**12**. You read that "*Ethernet is a very inefficient network because so much data is lost from data collisions*". Argue against this statement. **[3 marks]**

**13.** Two stations on a 10BASE5 IEEE802.3 LAN are exchanging messages (requests and responses), with negligible separation between a request and its response and between one response and the next request. There is negligible other traffic. A "request" has 80 information bytes. (*Assume that an 802.3 message has an overhead of 40 octets in inter-record gap, preamble, addresses, FCS, etc and that there are negligible other delays.*) The term "rate" means the number of bytes transferred per second, or possibly transferred per second.

(a) What sized *data block* should be transferred in the response message to ensure that user information (the data within the response) is transferred at $^{2}/_{3}$ the network rate. **[4 marks]**

(b) Show that the maximum possible user data rate is about $^{15}/_{16}$ of the network rate. (You may leave the answer as an unsimplified fraction.) **[4 marks]**

**14.** Give two reasons why local area networks usually discard failing messages while wide-area networks often retry them. **[2 marks]**

**15.** Networks are sometimes subject to "deadlock".

(a) What are the two types of deadlock? **[2 marks]**

(b) Give one way of preventing deadlock. **[2 marks]**

(c) If a deadlock does occur, give one way by which it may be broken. **[2 marks]**

**16.** Headers in TCP and IP contain various fields, some of which are in the following table. Mark each field as being part of its appropriate header and briefly indicate its function. **[8 marks]**

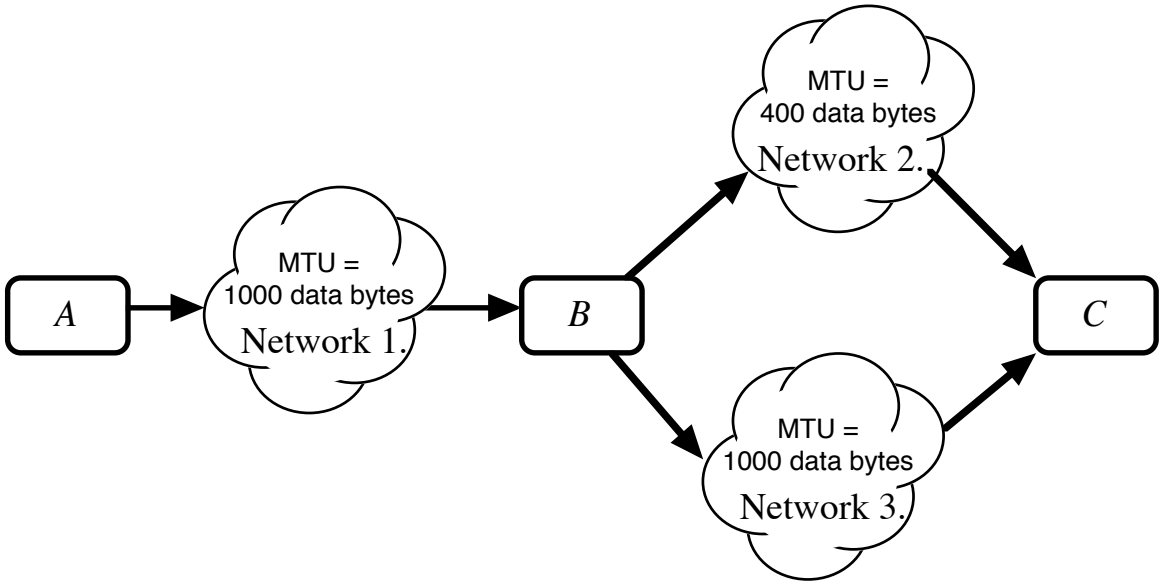
| Field | IP | TCP | Function |
|---|---|---|---|
| Time to live | | | |
| checksum | | | |
| fragment offset | | | |
| version | | | |
| source address | | | |
| destination port | | | |
| sequence number | | | |
| urgent pointer | | | |

**17.**(a) Describe a "two-way" handshake. **[3 marks]**

(b) Describe a "three-way" handshake. **[6 marks]**

(c) What is the problem of a two-way handshake which is solved by a three-way handshake?. **[2 marks]**

**18.** Suppose a router at *A* in the figure receives an IP packet with 4000 data bytes, fragments the packet and routes the fragments to *B* via network 1.
*B* in turn routes all fragments except the second one to *C* via network 3, but sends the second fragment to *C* via Network 2.




Show the fragments that *C* receives and give relevant values in the fragment headers.
*You must place your own appropriate headings on the columns.*
*The table may have more rows than you need for all of the fragments.*
*The precise fragment order at C does not matter, but packets sent over a path must remain in the order of sending.*

| Fragment | | | | |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |