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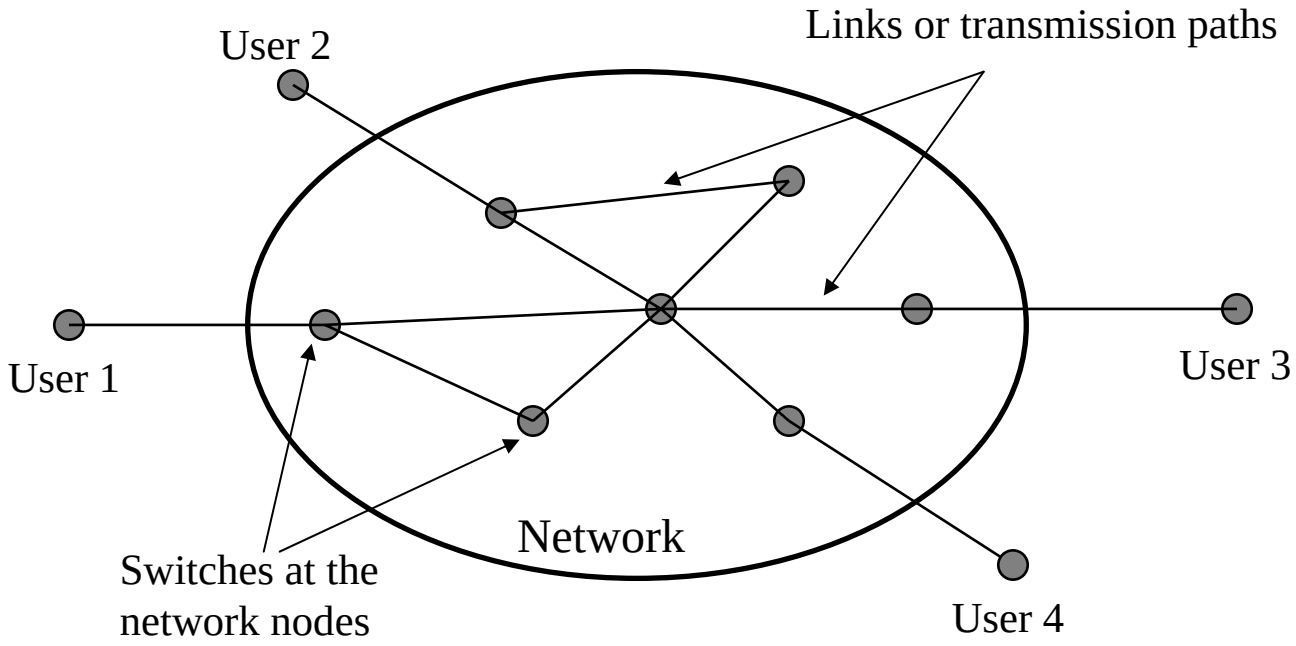
Question 1(a) 10 marks

Simplified Wide Area Network



Functions required:

1. Multiplexing
   A high-speed network is only affordable because of the economies of scale achieved by having a large number of users share a common resource. Multiplexing strategies are required to allow sharing of the expensive network links such as co-ax and fibre.

2. Switching
   This activity routes the data through appropriate network links.

3. Error Control
   Strategies are required to detect and in some cases correct transmission errors.

4. Flow Control
   This is a set of strategies to limit the maximum data rate from any one source to prevent the network being overwhelmed.

5. Congestion Control
   These is a strategy to prevent individual switches or nodes in the network from being overwhelmed.

6. Resource Allocation
   This ensure that network resources are allocated for each data transmission and assigns a priority to data from different sources in many cases.

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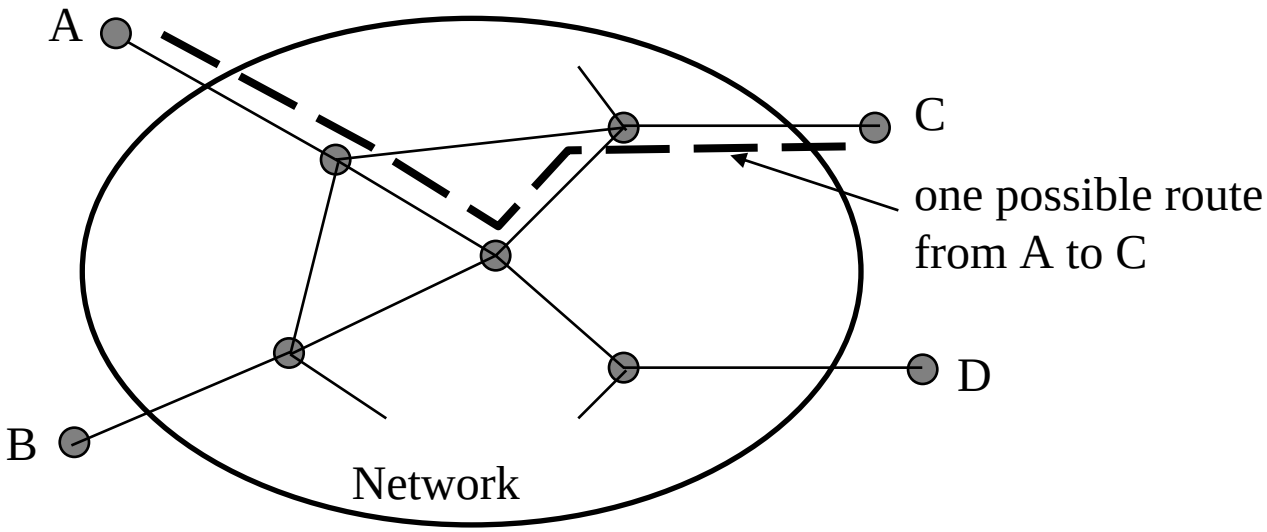
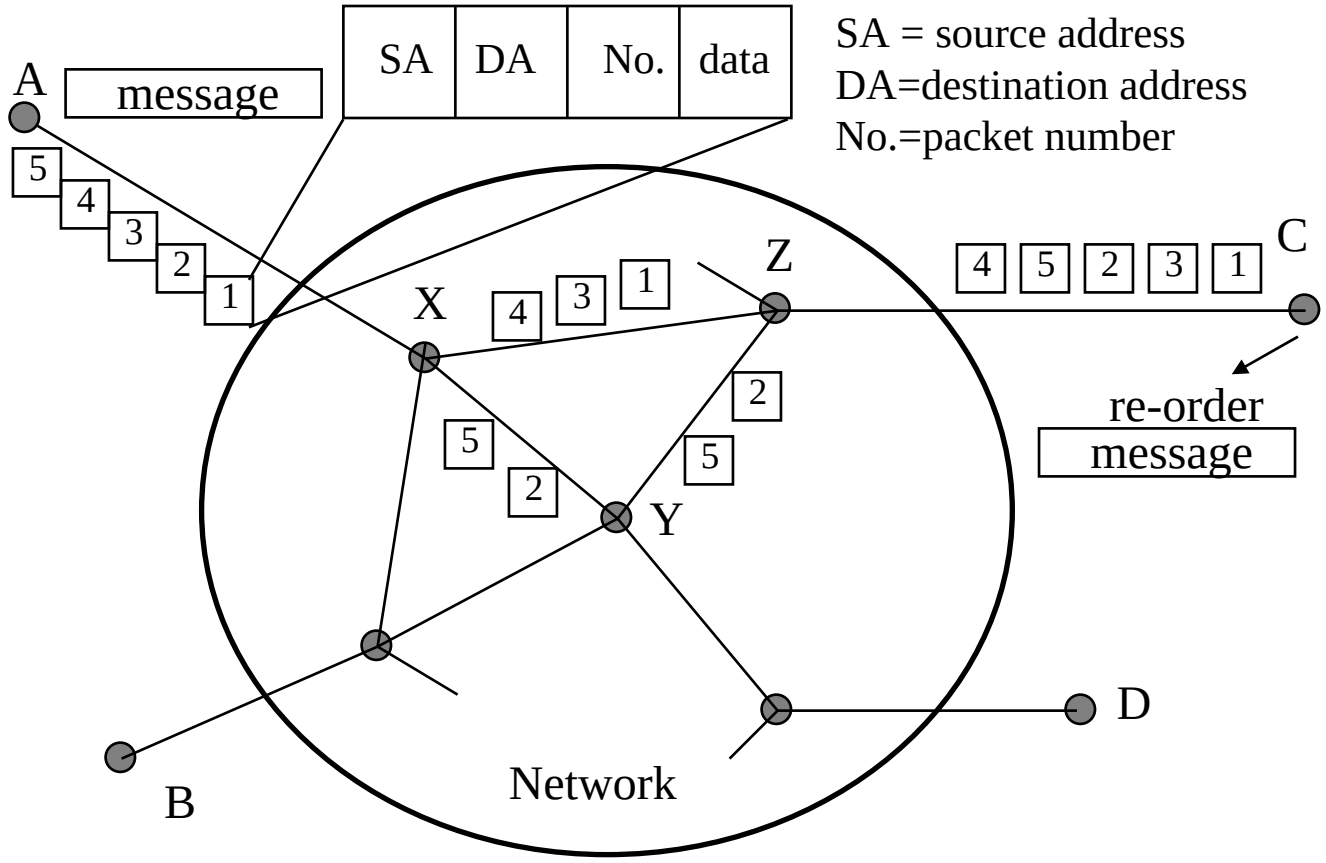
Question 1(b) 10 marks

Circuit Switching



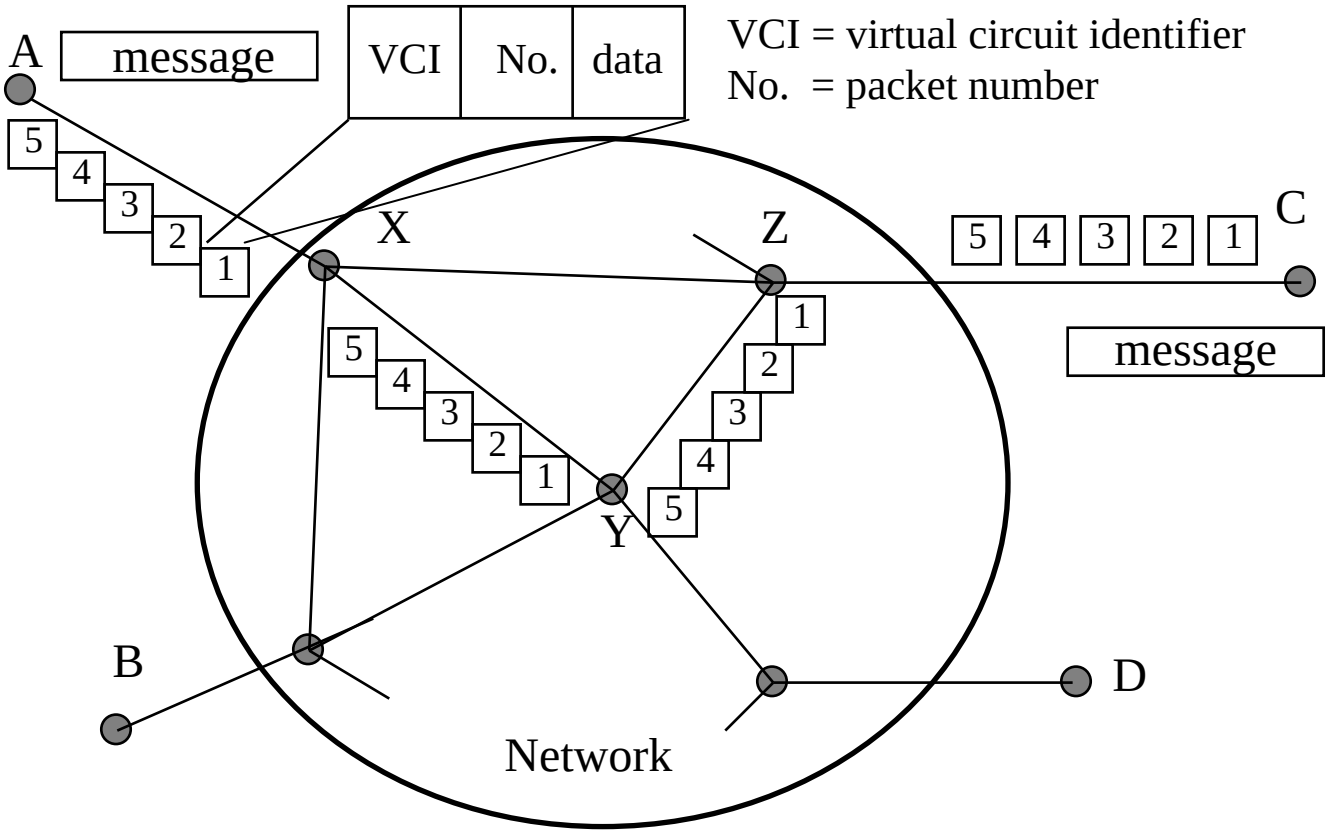
Transmission from A to C - route determined before transmission; each link dedicated to transmission; A and C get full benefit of network but links unavailable to other users during transmission.

Packet Switching - Datagram



Question 1(b) continued

Packet switching – virtual circuit



In packet switching datagram the message is broken into small packets each labelled with source and destination addresses and the intermediate network nodes make a Decision about the best route for each packet as it arrives. The network resources (links and switches) are shared among many users or applications. Unfortunately, The different paths mean that the packets may need to be reordered before arriving at the final destination.

In packet switching virtual circuit, the best route is chosen for all the packets at the start and this route is labelled with a virtual channel/virtual circuit identifier which is them attached to all packets. This combines the advantages of circuit and packet switching while ensuring that the packets arrive in the correct sequence (assuming no errors have occurred).

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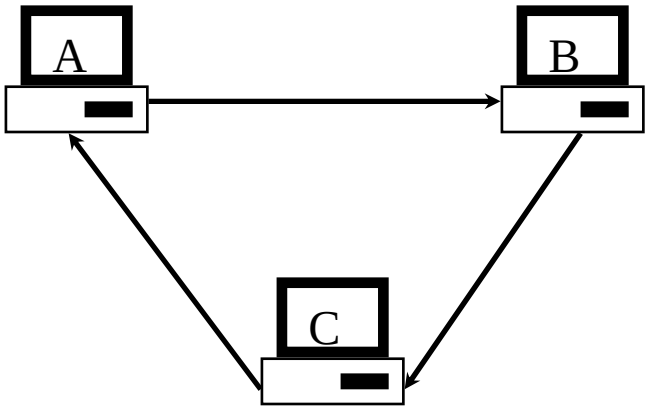
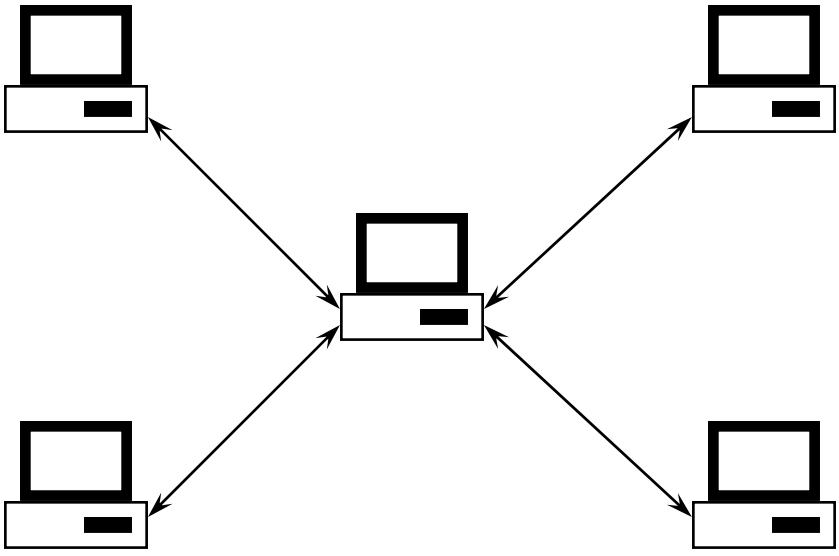
Question 2(a) 10 marks

Local Area Network Topologies

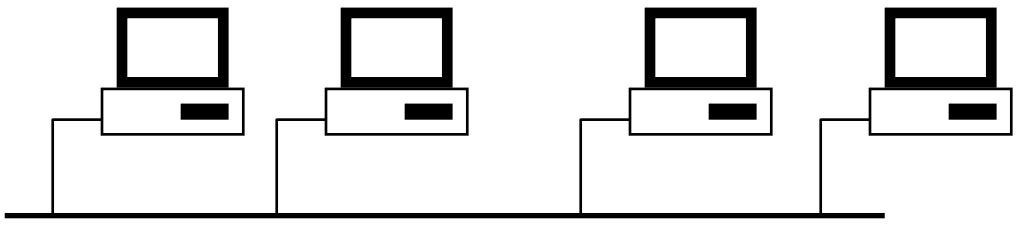
The ring topology



The Star Topology



Passive bus



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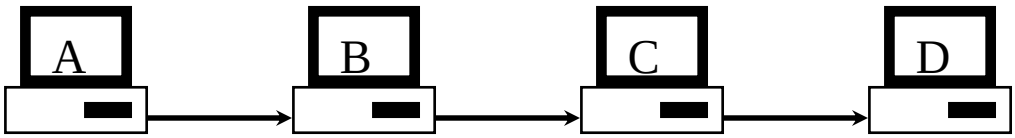
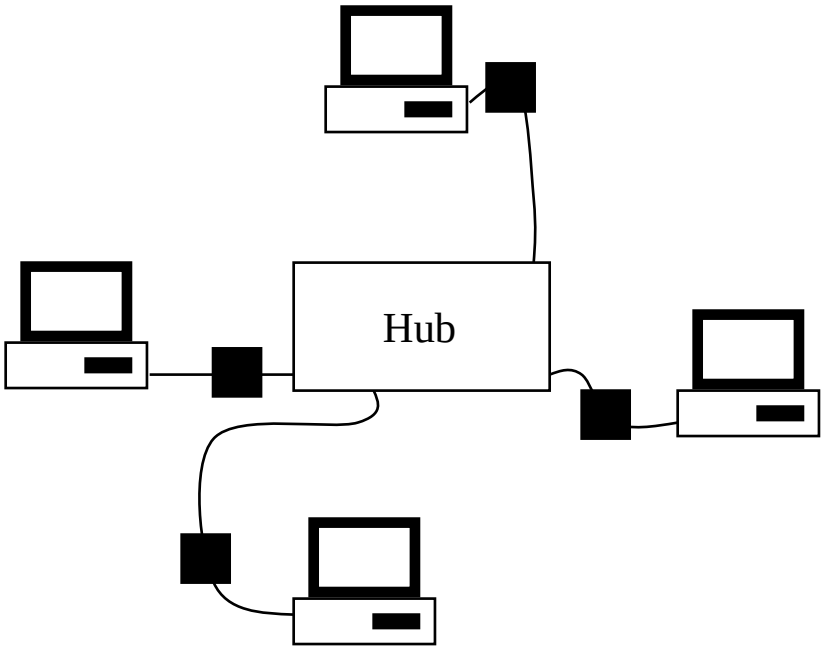
Question 2(a) continued

Active Bus



Physical and Logical Layout



Media Access Unit (MAU)

In terms of physical layout, hub systems make the network look like a star topology. But, because of the way the hub functions, the logical connection between the computers in still that of a bus topology.

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Question 2(b)

(i) 6 marks CSMA/CD operation Ethernet, CSMA/CD

One of the original LAN standards was Ethernet developed by Xerox, Intel and DEC. Thisuses an access technique known as CSMA/CD (Carrier Sense Multiple Access with Collision Detection). This gave rise to an IEEE standard for CSMA/CD systems known as IEEE 802.3. These are generally referred to as Ethernet systems.

Carrier Sense Multiple Access/Collision Detect

In this system if a node wants to transmit a message the following sequence of events occur:

1. Listen to the signal on the medium (carrier sense).
2. If there is another node already transmitting then wait until this stops.
3. When the medium is free begin transmitting the frame.
4. While transmitting continue to monitor the medium to determine if another node has started a transmission or has detected a collision.
5. If no collision has occurred continue to transmit the frame and monitor the medium.
6. If a collision has occurred discontinue the transmission and wait a certain time before trying again (this is determined by the truncated binary exponential back-off algorithm).

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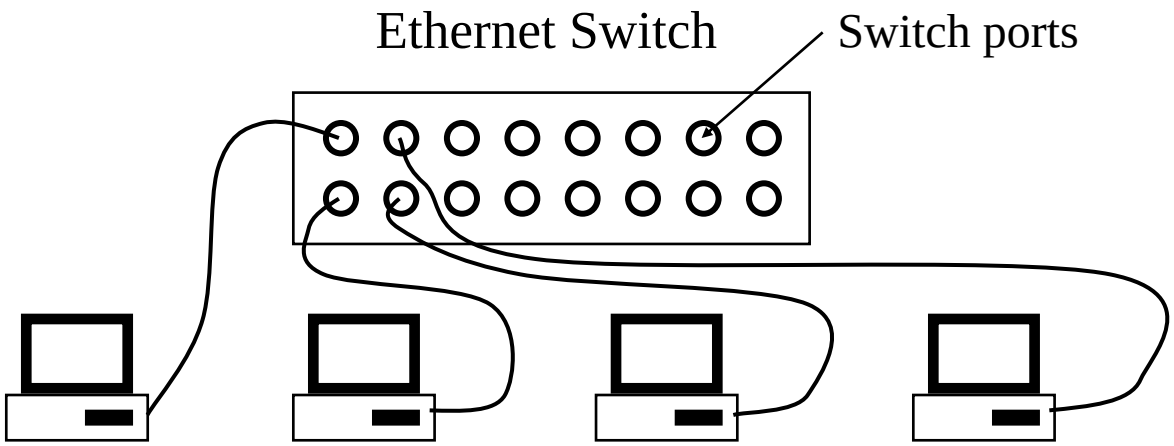
Question 2(b) continued

(ii) 4 marks Switched-based LANs

Modern Ethernet systems are based on the use of switches instead of hubs. Each computer is attached to one port of the switch.



When an Ethernet switch receives a frame from a computer on one of its ports, it looks at the destination address of the packet and then it only forwards the packet on to the port that is connected to the destination computer. It uses a look up table for this task. The advantage of this system is that only data which is meant for a given computer is sent to it and the lines to each computer behave as individual isolated lines so that no packet collisions can occur (and thus the CSMA/CD algorithm is no longer needed). Data packets can thus be simultaneously sent between many different computers on the network and the performance is greatly enhanced compared to the hub-based systems. But, the switch has to be fast.

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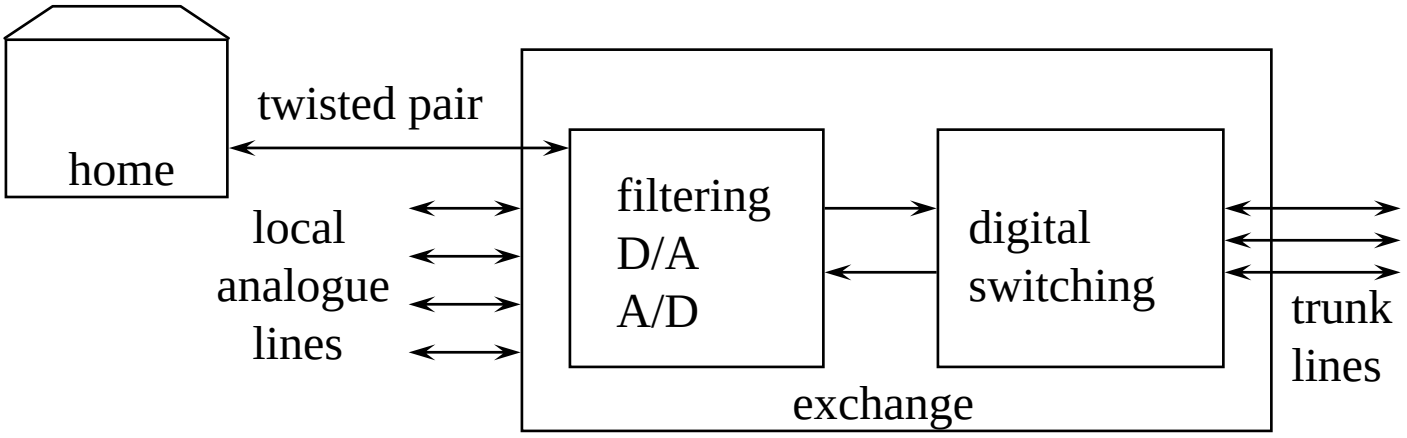
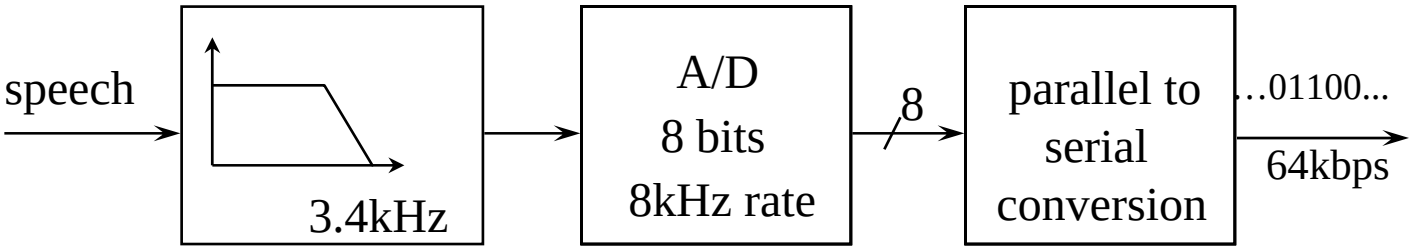
Question 3(a)

(i) 7 marks The exchange/customer interface for a voice channel

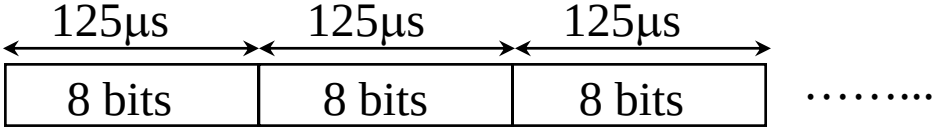


To convert an analogue speech signal to digital it is first band-limited with a filter, and then sampled, quantized and digitized using an analogue-to-digital converter (A/D). The signals are band-limited to 3.4kHz, and sampled at the rate of 8kHz (twice the maximum frequency allowing a 600Hz guardband) to a resolution of 8 bits.



The Pulse Code Modulation (PCM) scheme illustrated above gives a serial data rate of 64kbps for a single speech channel. This is the basic data rate in a PSTN system. Other rates are multiples of this.

A sampling rate of 8kHz gives 125μs between samples



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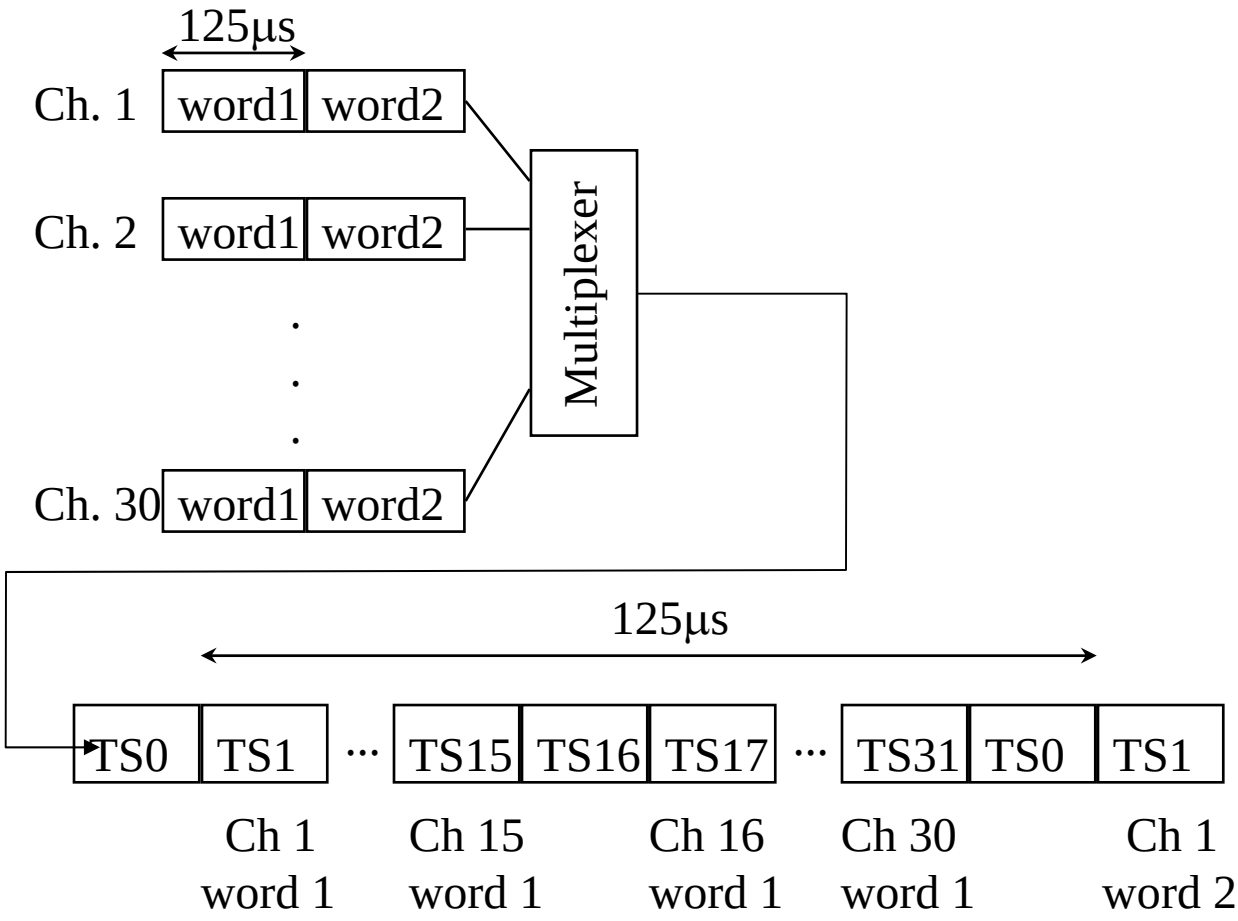
Question 3(a) continued

(ii) 4 marks First level of multiplexing in Europe



Time Slots TS0 and TS16 are used to provide frame and synchronisation data. Even if there is no data on an input channel for a particular time slot this "empty frame" is sent to the output – this is an inefficient use of the output link. Consecutive digital words from each channel must be transmitted at the sampling rate i.e. 8kHz so that they will be received with a constant interval of 125µs to ensure that the voice sounds natural.
Data rate on trunk line (in Europe) = 8000 x 8 x 32 = 2.048Mbps.

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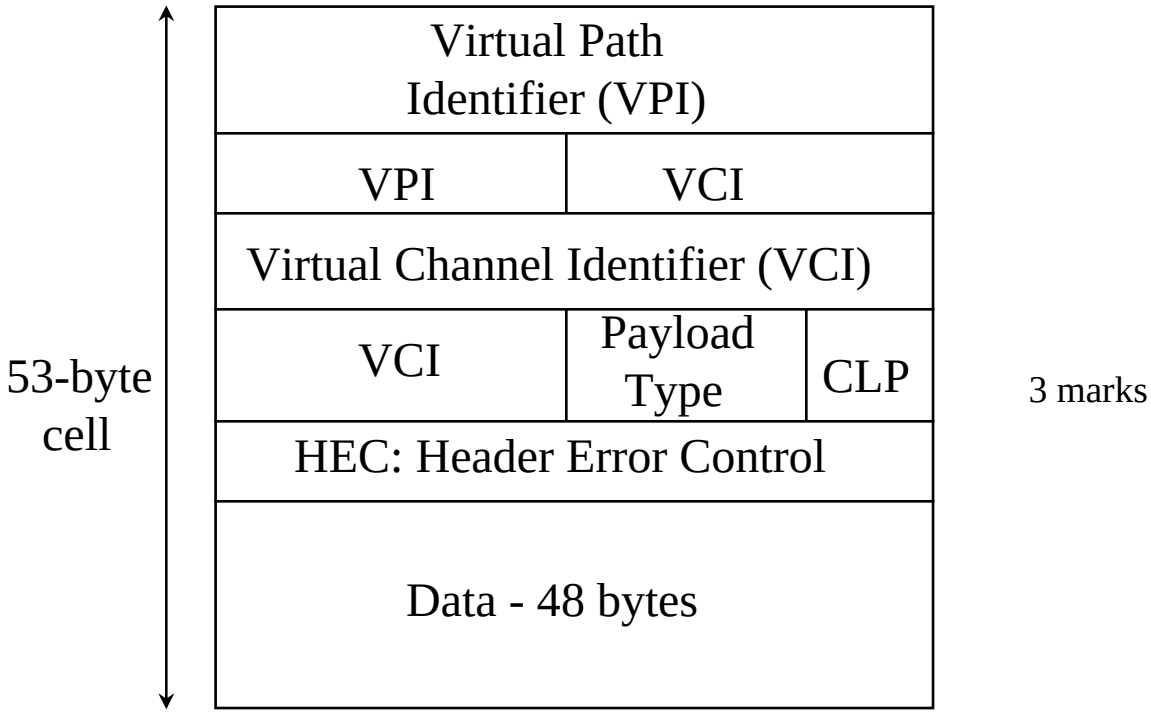
Question 3(b)

(i) 3 marks ATM Cell format (network/network interface)



3 marks

GFC: VPI/VCI: Routing
Payload Type: Indicates the type of data contained in the data field – e.g. control or user data
CLP: Cell Loss Priority: Indicates if a cell may be deleted in case of congestion

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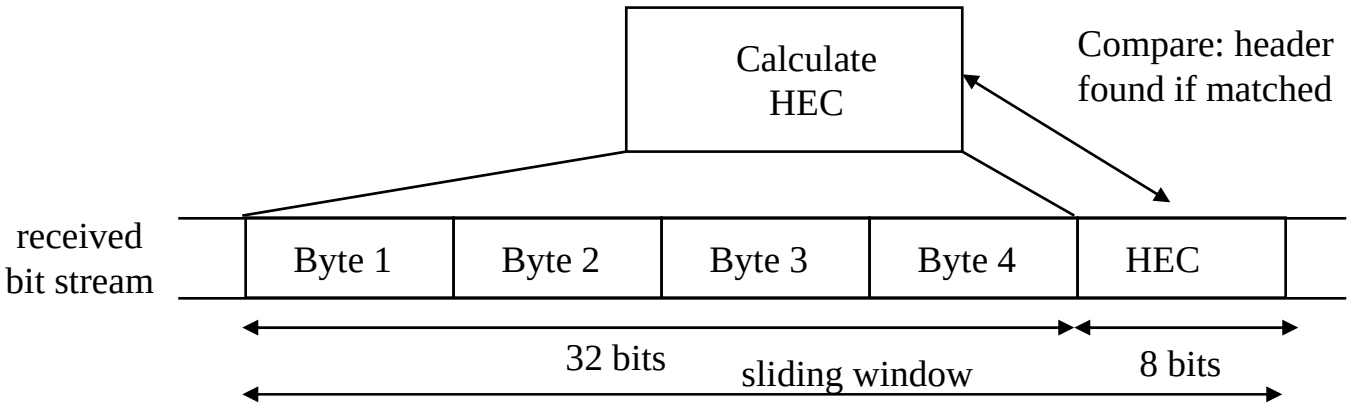
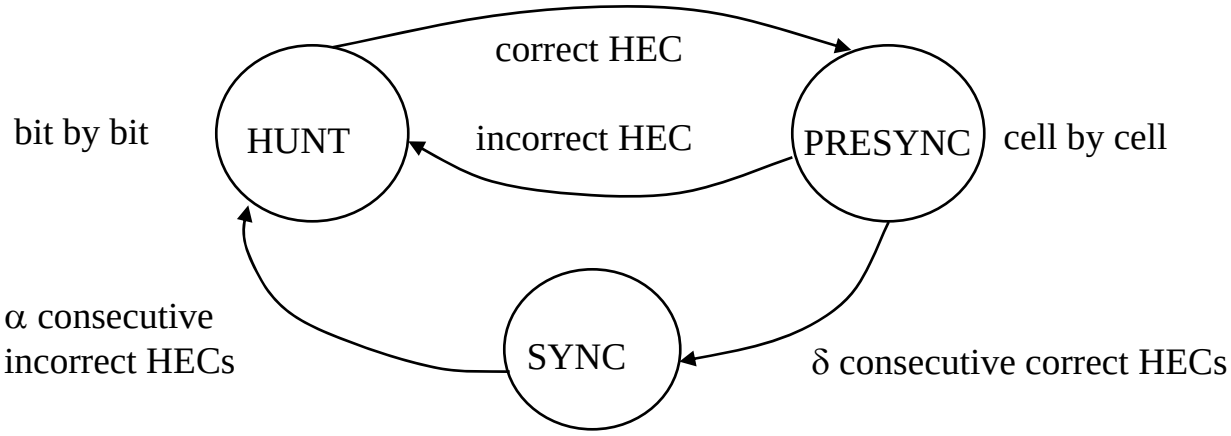
Question 3(b) continued

(ii) 3 marks Finding ATM Cell Boundaries



The HEC is used to determine where an ATM cell starts. The receiver uses a 40 bit sliding window and assumes that the first 32 bits are the first 4 bytes of the ATM header and the next 8 bits are the header error control (HEC). For no errors, the HEC should give a known pattern. If this is achieved then the receiver has found the cell boundaries, if not it moves the sliding window and tries again. Once the cell boundaries have been found, succeeding cell boundaries are determined by counting bits.

(iii) 3 marks ATM Synchronization



α and δ are numbers chosen to give the best performance – usually less than 10.

Synchronisation is based on the HEC. The receiving node alternates between HUNT, PRESYNC and SYNC states. The receiver is considered to be synchronized if it has received δ consecutive cells with no HEC errors. It is considered to have lost synchronization if α consecutive HECs have errors and it then enters a HUNT stage.