IT301: Data Communication & Computer Network(DCCN)

Class: B. Tech (CS) Sec A
Semester : V
Teacher: Dr. Amritanjali

Week 9 +Week10

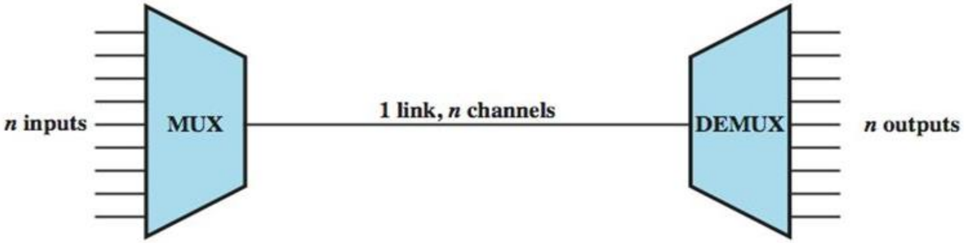
Module 4

Module 4 Topics

- Multiplexing
  - Frequency Division Multiplexing
  - Synchronous Time Division Multiplexing
  - Statistical Time Division Multiplexing
- Switched Communication Networks
  - Circuit Switching
  - Packet Switching

Multiplexing

- Allows to utilize high capacity of the medium by dividing it into multiple transmissions
- To provide dedicated share to medium to different transmissions

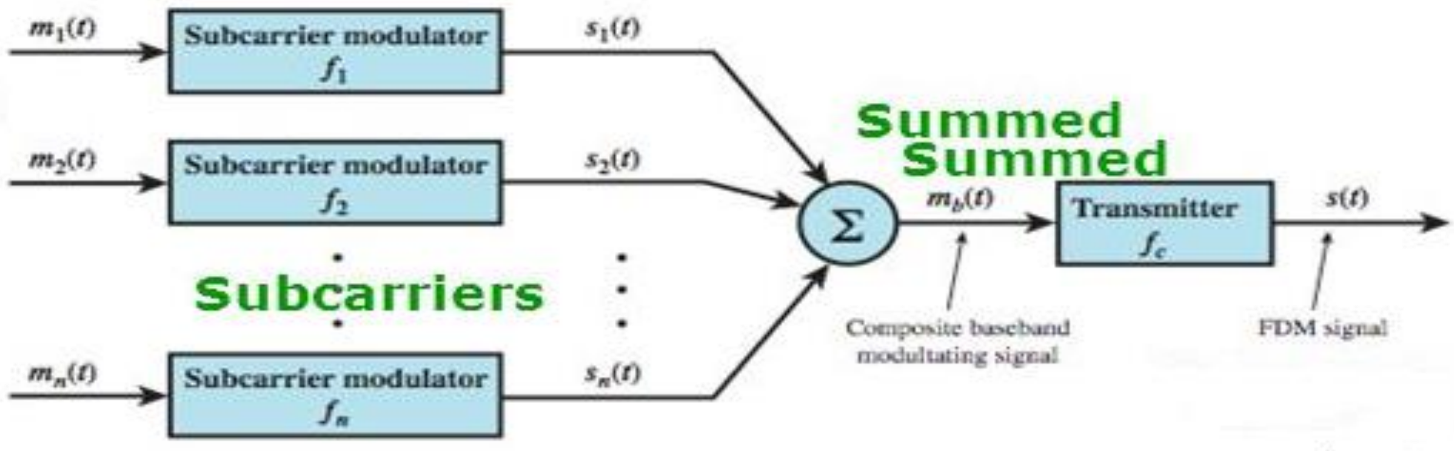


- Common forms of Multiplexing-
  - Frequency Division Multiplexing (FDM)
  - Time Division Multiplexing (TDM)

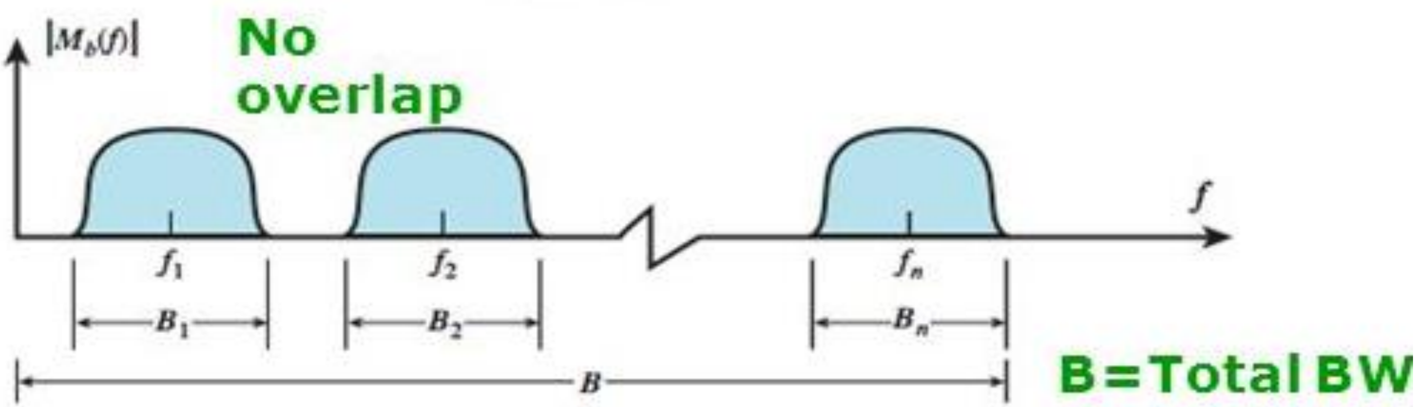
Frequency Division Multiplexing

- It is most popular and is used extensively in radio and TV transmission.
- Bandwidth of a single physical medium is divided into a number of smaller, independent frequency channels.
- Using modulation, independent message signals are translated into different frequency bands.
- At the receiving end the signal is applied to a bank of band-pass filters, which separates individual frequency channels.
- The band pass filter outputs are then demodulated and distributed to different output channels

Transmitter

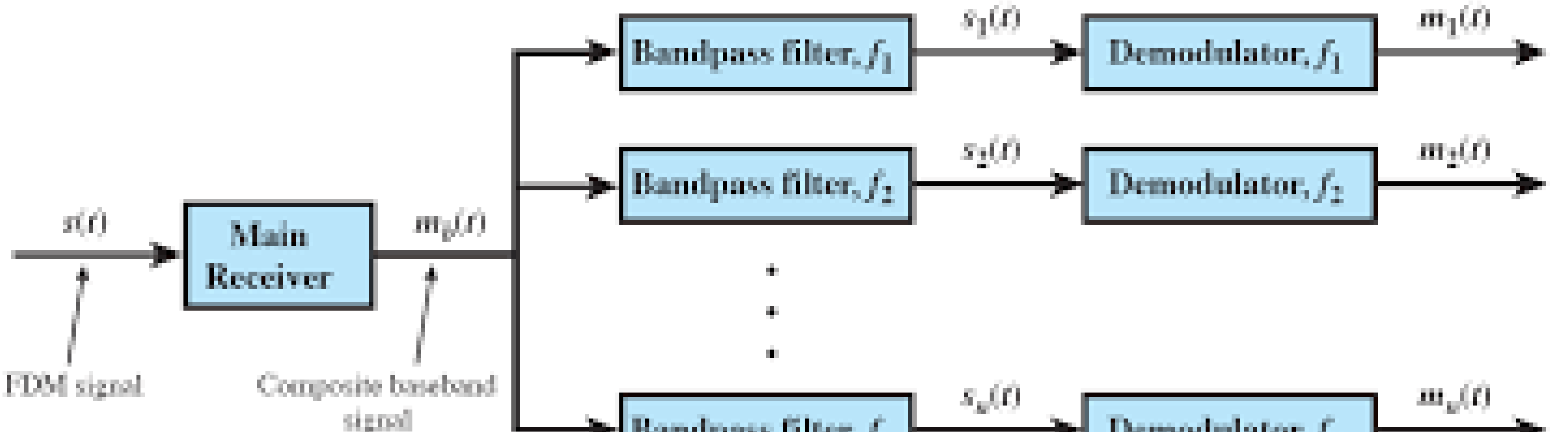


(a) Transmitter



(b) Spectrum of composite baseband modulating signal

Receiver



(c) Receiver

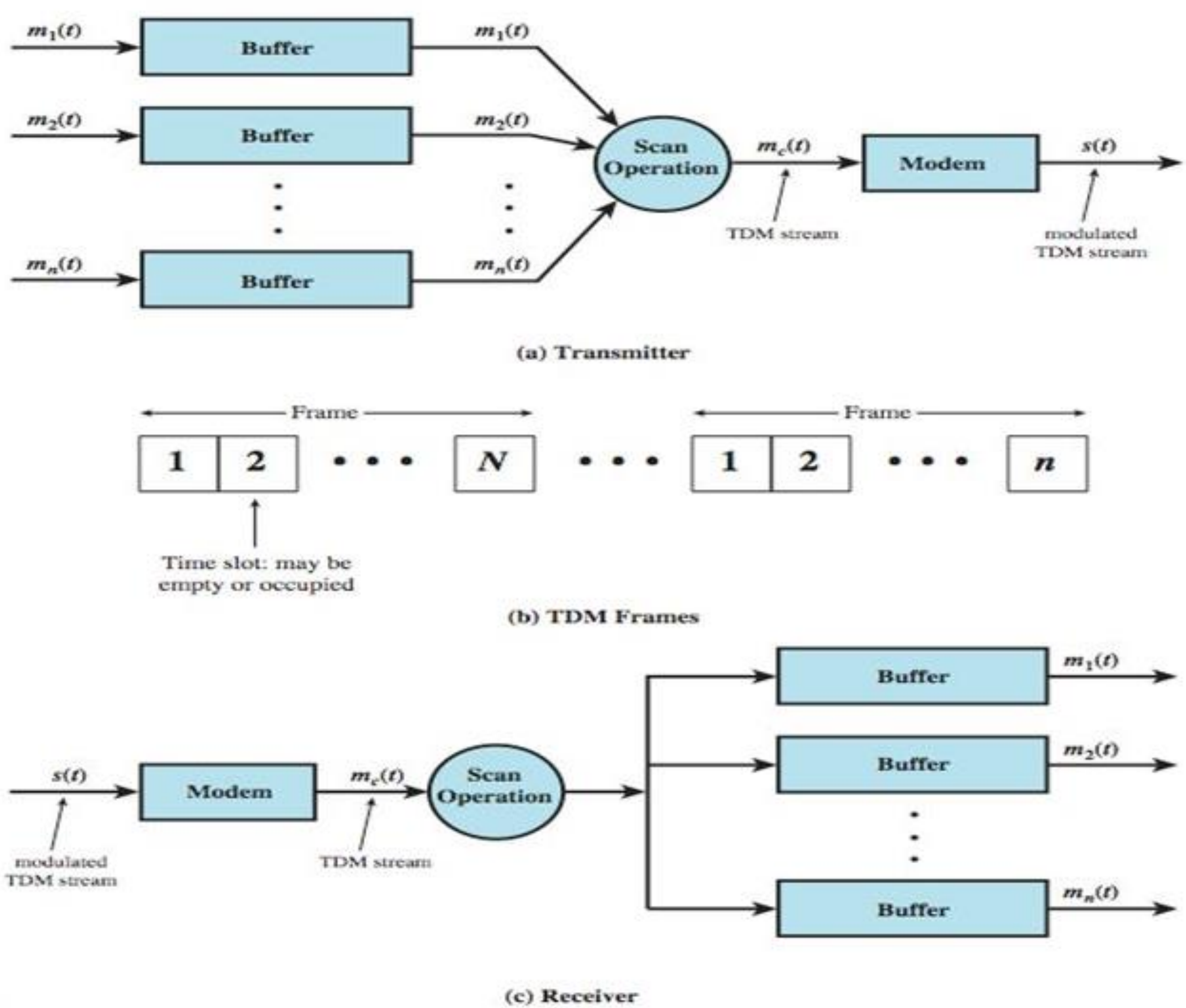
Wavelength Division Multiplexing

- To utilize the high bandwidth of optical fibers, multiple beams of light are transmitted at different frequencies
- This form of FDM is called as wavelength division multiplexing

Time division Multiplexing

- If the data rate of the medium exceeds the data rate of the digital signals to be transmitted, then TDM can be used to send multiple signals
- Signals are interleaved in time
- Interleaving can be done at bit level, byte level or larger blocks of bytes

Synchronous TDM System

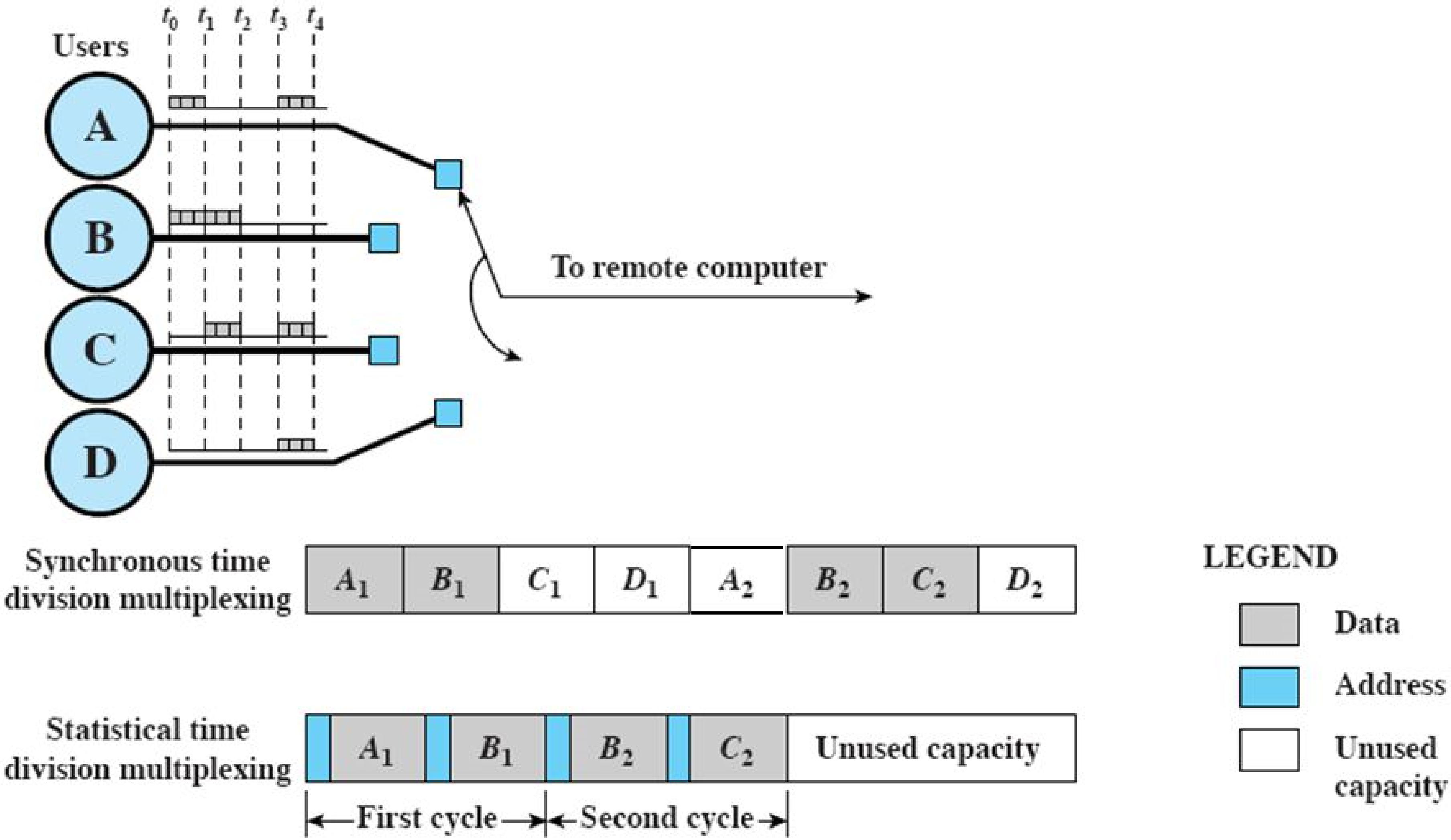


Synchronous TDM

- In **synchronous TDM**, sources are pre-assigned to fixed sources
- Data from each source is temporarily buffered
- Data blocks scanned from buffers are combined to form **frame**, each occupying a separate slot
- Sequence of slots dedicated to one source, from frame to frame, is called as **channel**
- To handle sources at different rates, different number of slots can be allotted to different sources

Statistical TDM

- Assignment of time slots is not fixed
- Slots cab be allocated to any device which has data to be sent
- As all the devices are not transmitting all the time, so the data rate of the multiplexed line can be less than the sum of the data rate of the devices attached
- Hence, for the same data rate of multiplexed line, statistical TDM can support more number of devices than synchronous TDM
- Each slot carries address as well as data
- For variable length slots from multiple sources, length field is also required



Users
t_0 t_1 t_2 t_3 t_4
A
B
C
D
To remote computer
Synchronous time division multiplexing
A_1 B_1 C_1 D_1 A_2 B_2 C_2 D_2
Statistical time division multiplexing
A_1 B_1 B_2 C_2 Unused capacity
First cycle
Second cycle
LEGEND
Data
Address
Unused capacity

TDM of Analog Signals using PCM

Consider following example

- Source 1: Analog, 2 kHz
- Source 2: Analog, 4 kHz
- Source 3: Analog, 2 kHz

Find the required Sampling Rate to use PCM for their digitization

- Source 1: 4 k samples/s
- Source 2: 8 k samples/s
- Source 3: 4 k samples /s

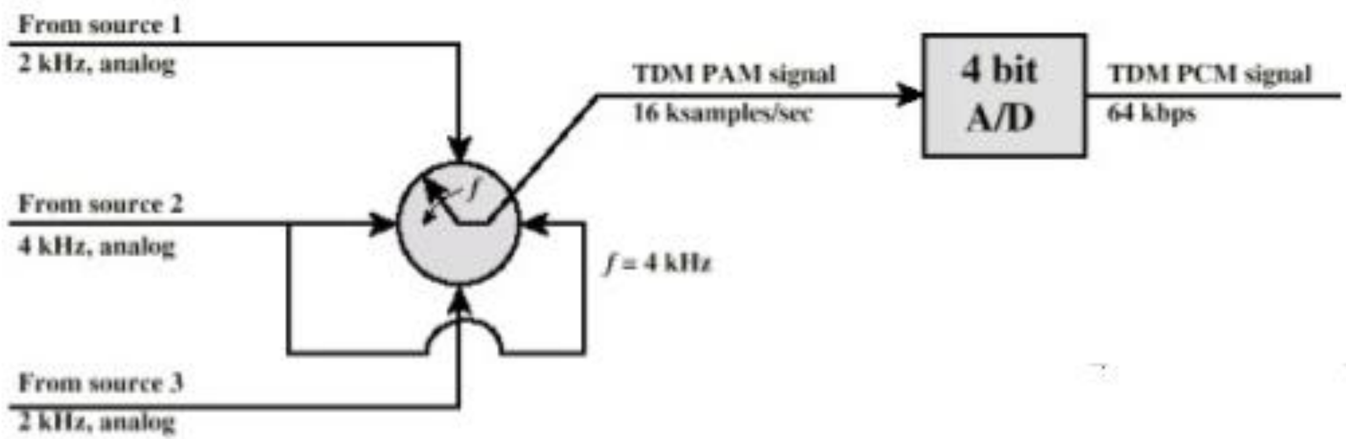
Find Aggregate sampling rate

- Aggregate sampling rate = 16 k samples/s

Find the output bit rate, if sample size is of 4 bit

- Bit rate = 64 kbps

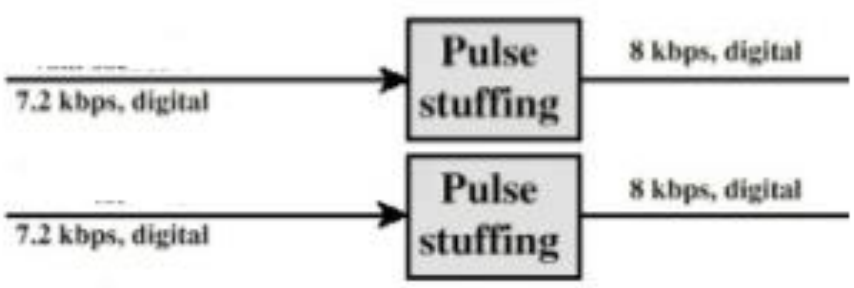
TDM with Analog Signals



TDM of Digital Signals with Pulse Stuffing

- Problems in the implementation of synchronous time division multiplexing
- variation in clocks of different sources with respect to the local clock signal
- Data rates of different sources may be not be related by integral numbers
- Pulse stuffing is done to overcome these problems, owing to the fact that the outgoing data rate of the multiplexer exceeds the sum of the data rate of each of the input streams
- Consider a digital source with data rate of 7.2 kbps can be changed to 8 kbps after pulse stuffing

Pulse Stuffing

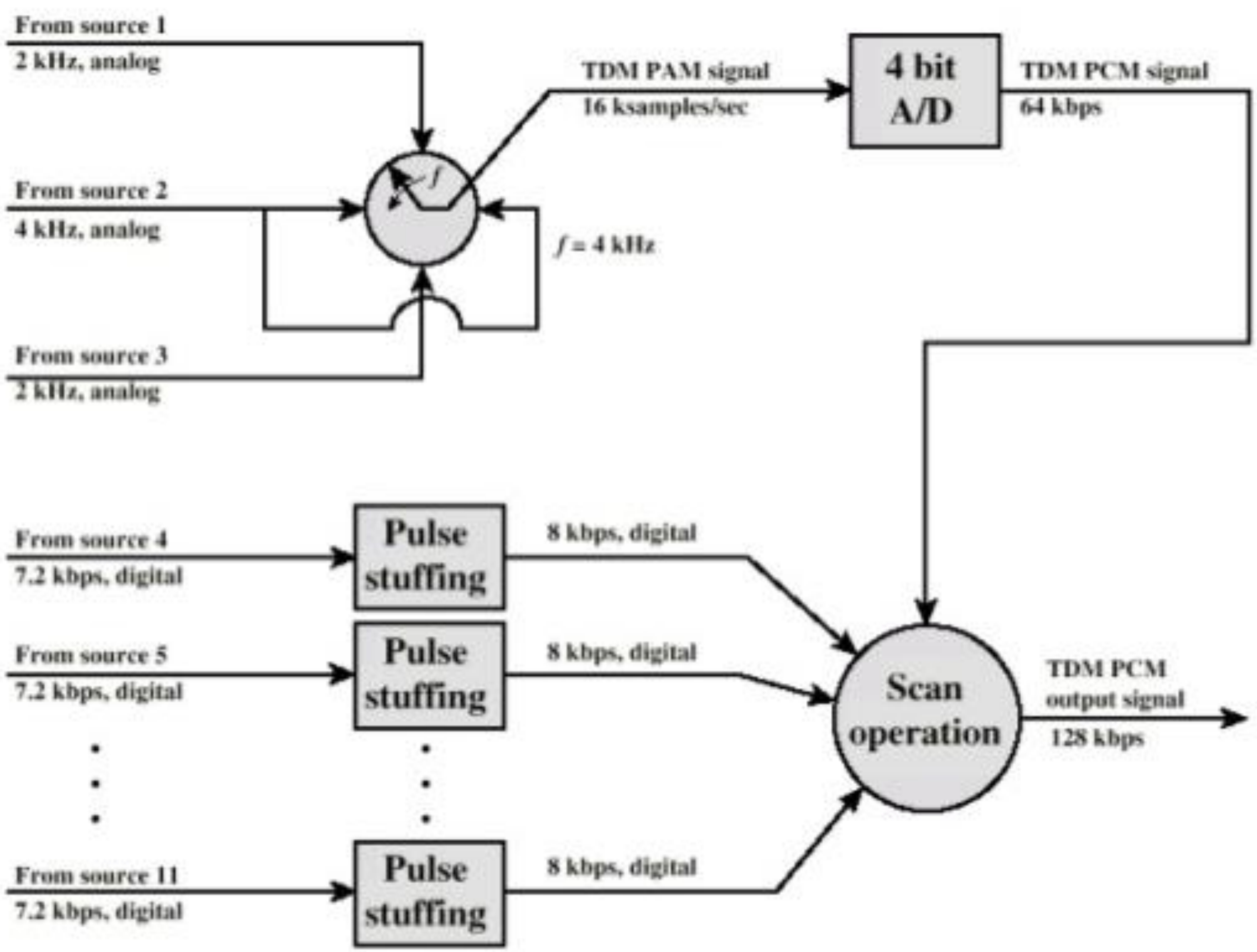


TDM with analog and Digital Sources

Consider following example

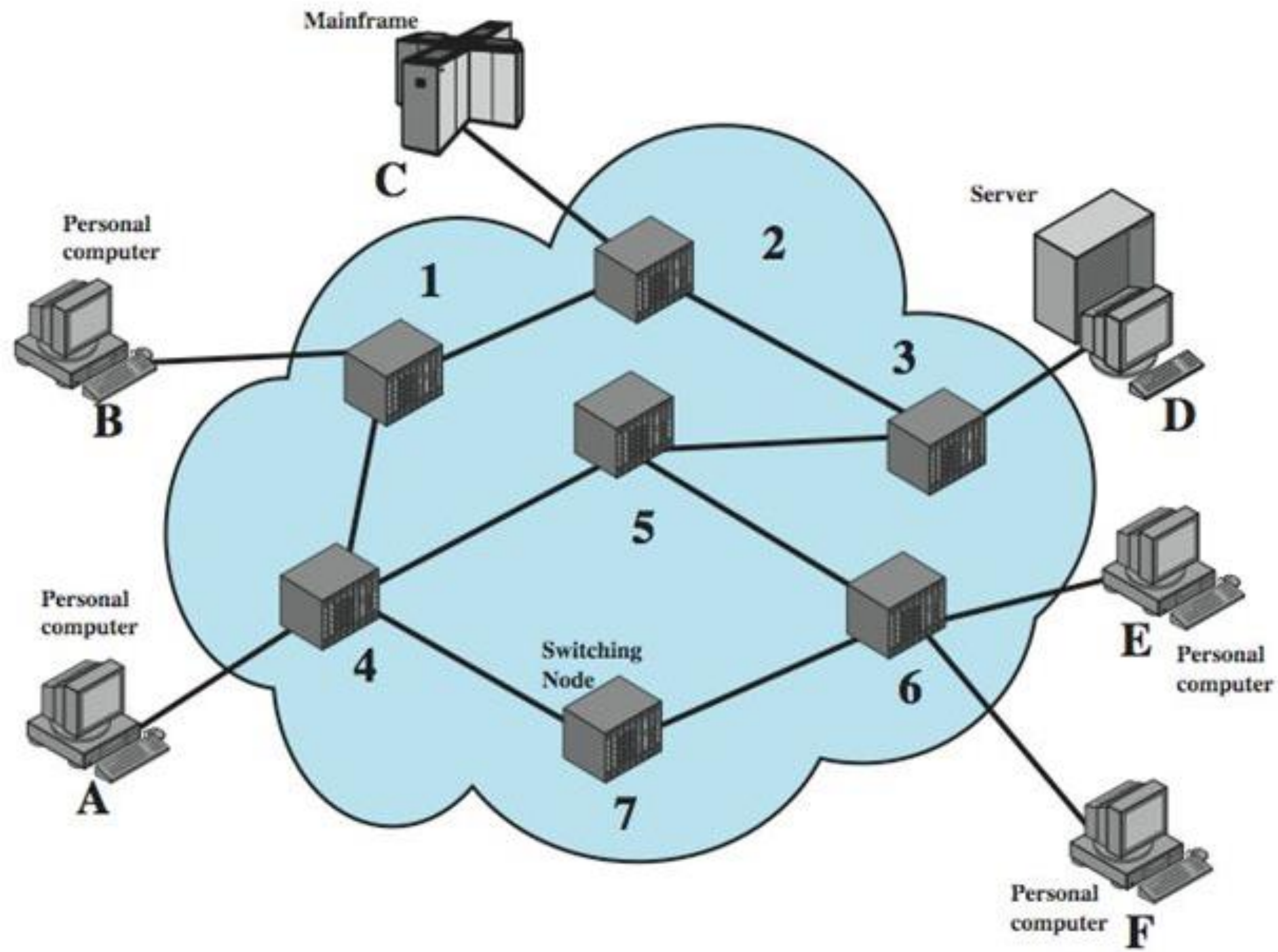
- Source 1: Analog, 2 kHz
- Source 2: Analog, 4 kHz
- Source 3: Analog, 2 kHz
- Source 4-11: Digital, 8kbps
- Sources 1, 2 and 3 are digitized such that the resulting digital signal has composite data rate of 64 kbps, carrying samples from each of the three sources.
- Find the Data Rate of the outgoing signal after multiplexing?
- Find the slot duration if one slot is of 1 bit in length?
- Find frame length, if 2 slots are allotted to a source with data rate of 8 kbps?

TDM of Analog and Digital Sources

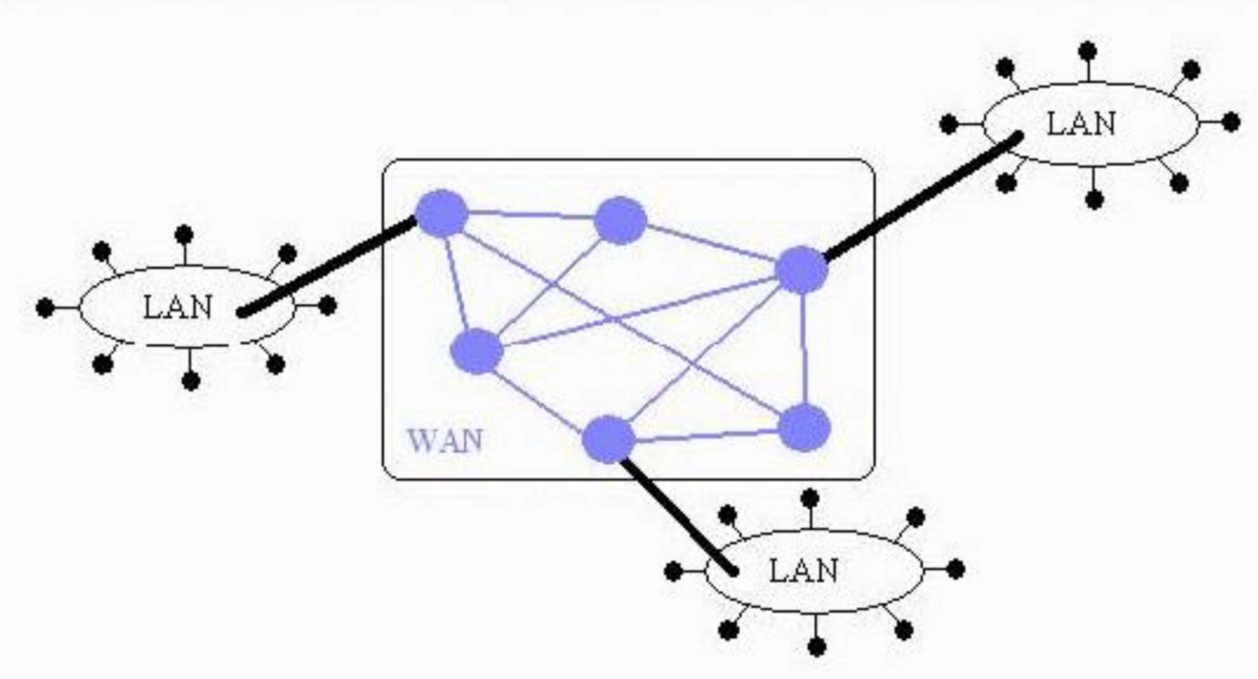


Circuit Switching and Packet Switching

Switched Communication Networks



Switched Communication Networks



Switching Techniques

- Circuit-switched (Analog Transmission)
- Packet-switched (Digital Transmission)
  -Datagram Approach
  -Virtual Circuit Approach

Circuit Switching

- Public telephone networks
- Private networks built on leased lines
- Developed to handle voice traffic
- Inefficient for digital data transmission

Circuit Switching Operation

- A dedicated circuit is established between two stations for communication
- Communication path is defined by the circuit formed by connecting a sequence of links between two nodes through the intermediate switches
- Generally, a logical channel of the physical links is used for communication
- Switching and transmission resources within the network are reserved for exclusive use of the circuit for the duration of the connection

Phases in Circuit Switching

Circuit Establishment

- Before transmitting signals an end-to-end circuit is established
- Each node selects the next node in the path based on some parameters
- Connection is generally full duplex

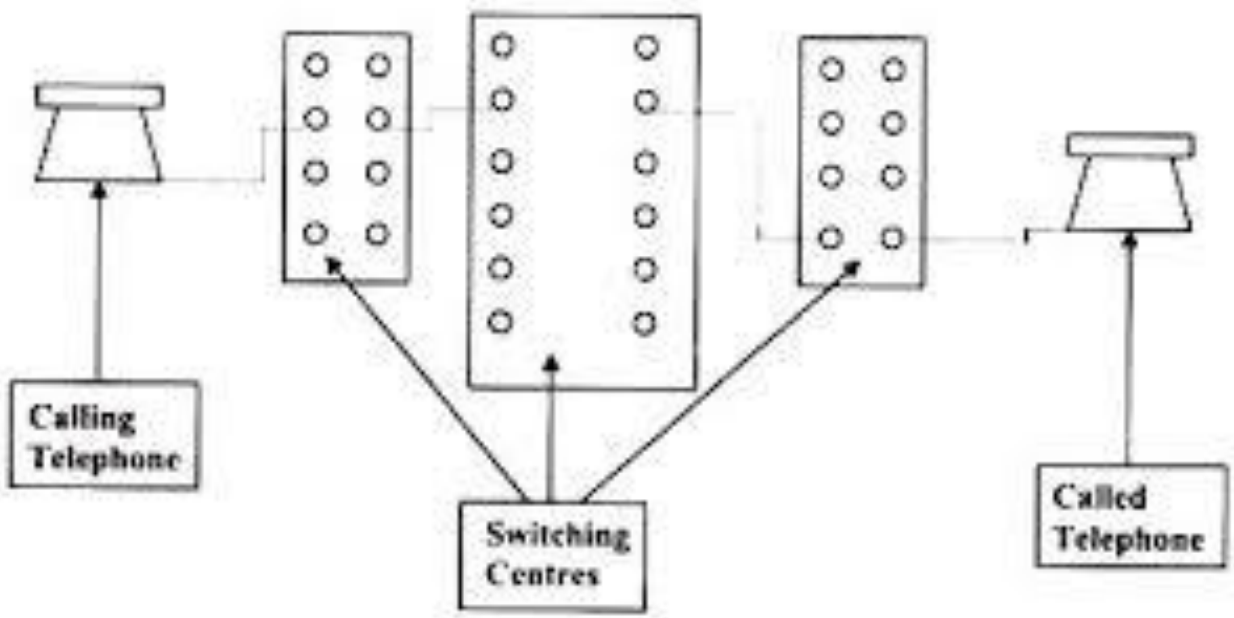
Data Transfer

- Transmission may be analog or digital
- Digital transmission of both voice and data is becoming dominant technology

Circuit Disconnect

- Circuit is disconnected when any one of the two stations terminates the connection

Public Circuit Switched Network



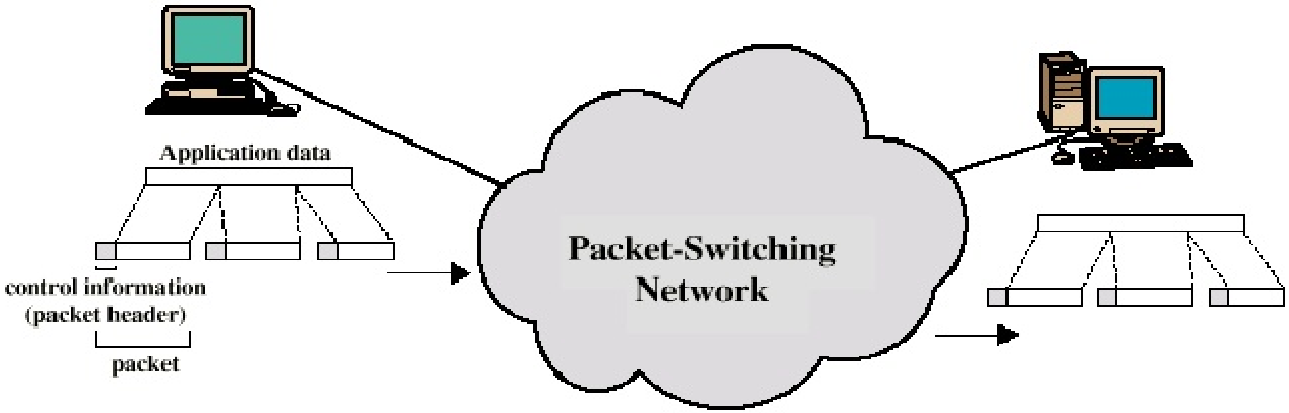
Circuit-Switched Telephone Network

Performance

- Link utilization is higher for voice communication than for data communication
- Delay in circuit establishment
- Negligible transmission delay and no variation in delay makes it suitable for transmission of voice signals

Packet Switching

- Data is transmitted in short packets
- If source has longer message to send, the message is broken into a series of packets
- Each packet has user data and some control information
- Control field includes information that help in routing packet through the network and deliver it to the intended recipient
- At each node packet is stored briefly before it is passed to the next node



Advantages over Circuit Switching

- Link utilization is better as node-to-node link is dynamically shared among multiple packets
- Switching nodes can perform data rate conversion allowing stations with different data rate to exchange information
- During heavy traffic, communication gets blocked in circuit switching, but in packet switching only delay increases
- Priorities can be used. Nodes can transmit higher priority packet first in packet switching networks

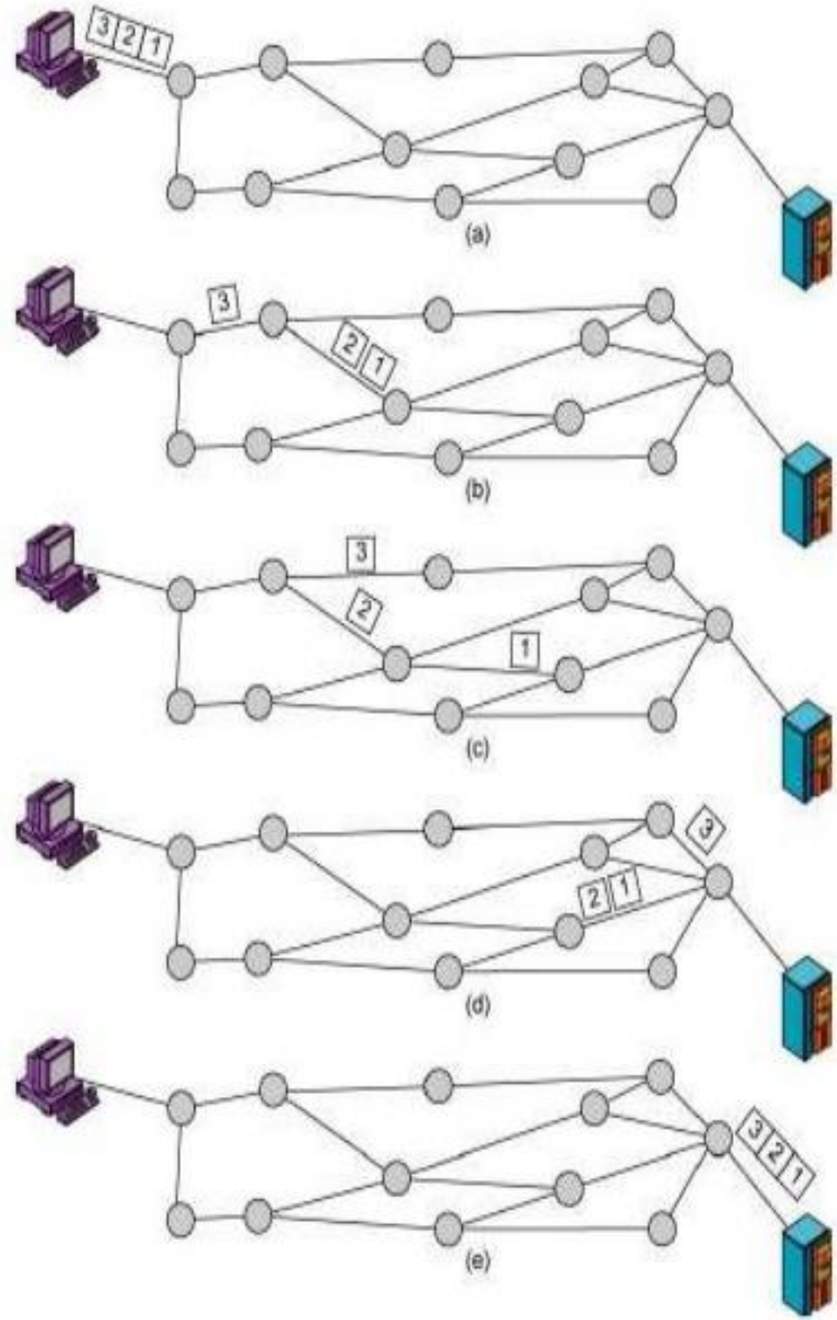
Packet Switching Techniques

- Datagram Approach
- Virtual Circuit Approach

Datagram Approach

- Packets are treated independently, are referred as datagrams
- Each node chooses the next node in the path, based on their routing information
- Packets to same destination may take different paths and arrive in different order

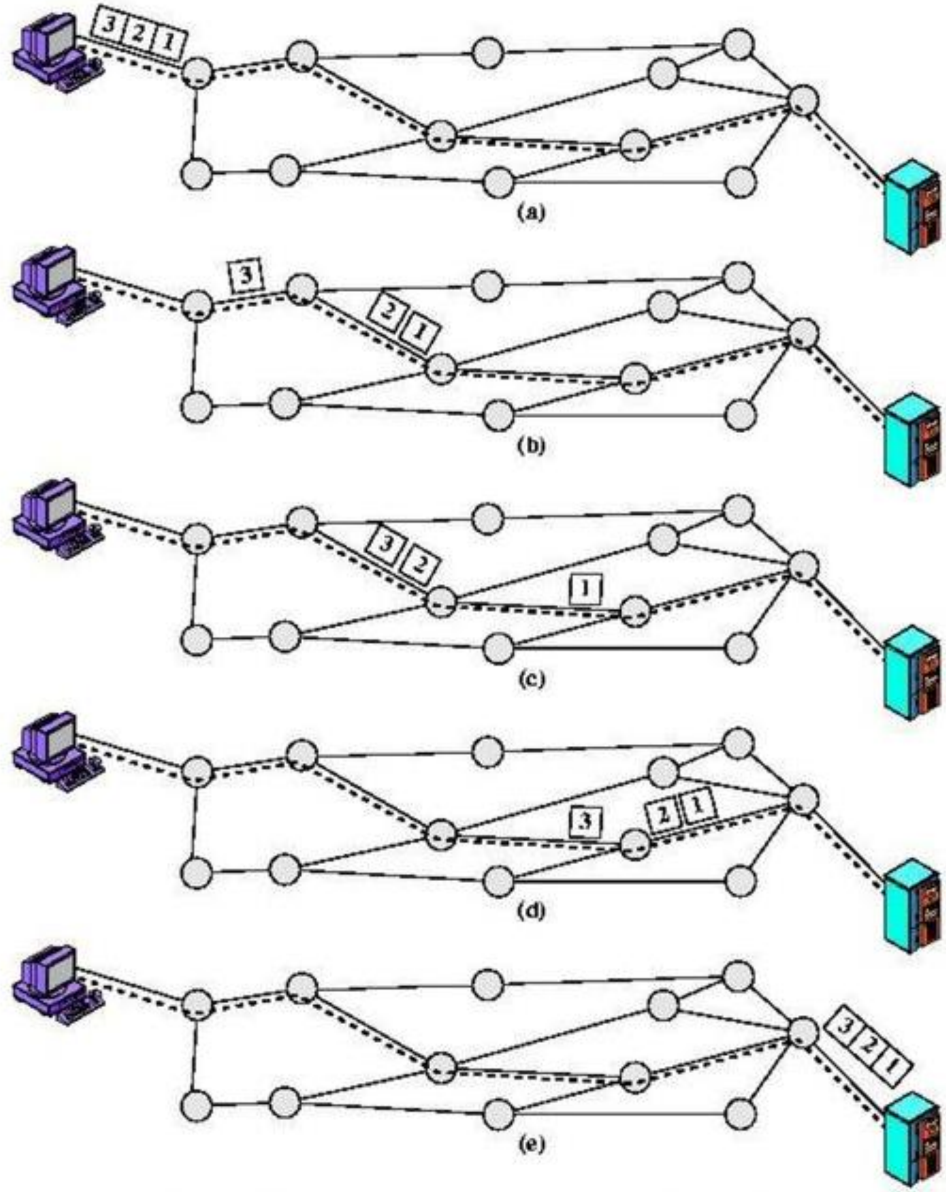
Datagram Approach



Virtual Circuit Approach

- A preplanned route is established before sending the packets
- All the packets follow the same route
- Unlike, circuit switching the path is not dedicated
- Virtual circuit information is stored at each node
- Using this information packet is quickly forwarded

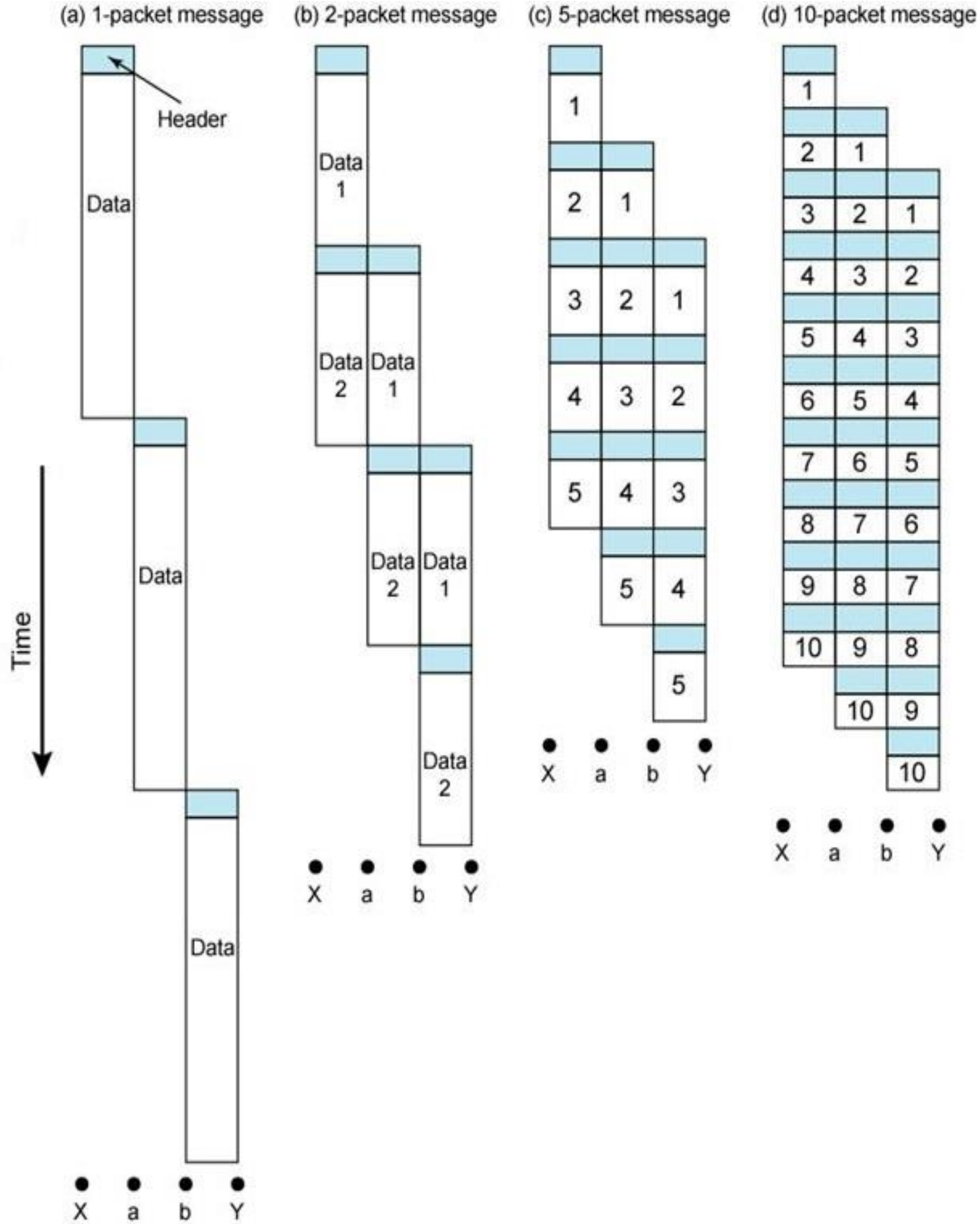
Virtual Circuit Approach



Packet Switching

- Advantages of Datagram approach over Virtual Circuit Switching
  - Call set up is not required
  - It is more flexible as routes can be changed during the transmission to avoid congestion or any other problem
  - It is more reliable as if a node fails, then the node can be bypassed to send the subsequent packets, no need to reestablish connection
- Datagram approach is commonly used in internetworks

Effect of Packet Size on Transmission Time



Comparison of Switching Techniques

Circuit Switching	Datagram Packet Switching	Virtual Circuit Packet Switching
Dedicated transmission path	No dedicated path	No dedicated path
Continuous transmission of data	Transmission of packets	Transmission of packets
Fast enough for interactive	Fast enough for interactive	Fast enough for interactive
Messages are not stored	Packets may be stored until delivered	Packets stored until delivered
The path is established for entire conversation	Route established for each packet	Route established for entire conversation
Call setup delay; negligible transmission delay	Packet transmission delay	Call setup delay; packet transmission delay
Busy signal if called party busy	Sender may be notified if packet not delivered	Sender notified of connection denial
Overload may block call setup; no delay for established calls	Overload increases packet delay	Overload may block call setup; increases packet delay
Electromechanical or computerized switching nodes	Small switching nodes	Small switching nodes
User responsible for message loss protection	Network may be responsible for individual packets	Network may be responsible for packet sequences
Usually no speed or code conversion	Speed and code conversion	Speed and code conversion
Fixed bandwidth	Dynamic use of bandwidth	Dynamic use of bandwidth
No overhead bits after call setup	Overhead bits in each packet	Overhead bits in each packet