CS311: Data Communication

Switching

by

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Switched Communication Network

- There is not a direct link between every possible pair of nodes
- Some nodes connect only to other nodes
- Other nodes have one or more stations attached as well
- Node-station links are generally dedicated point-to-point links
- Node-node links are usually multiplexed (using TDM, FDM)

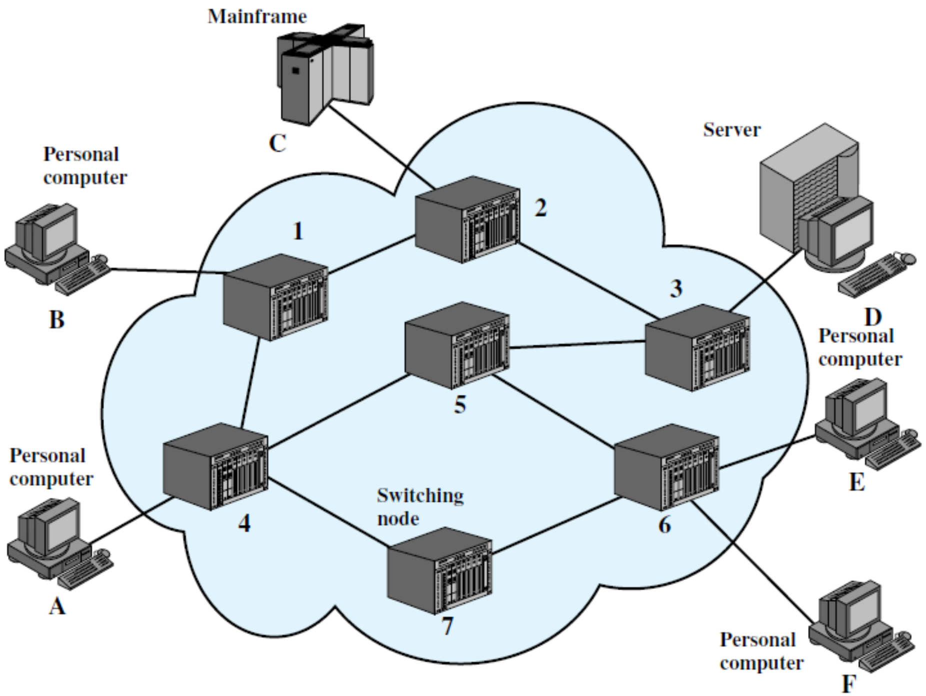
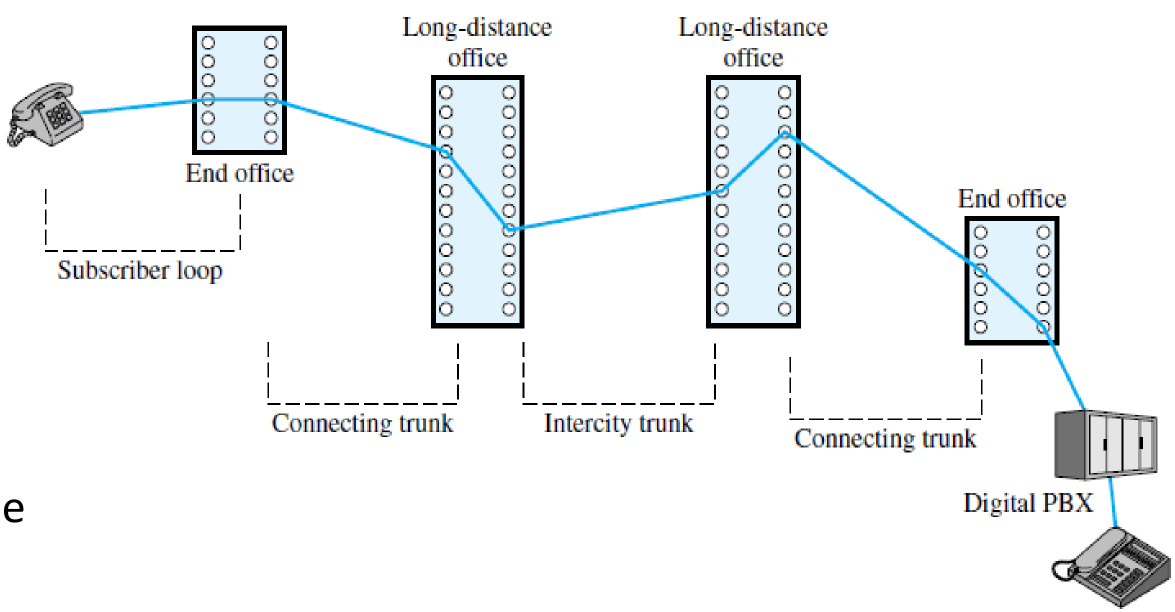


Figure 10.1 Simple Switching Network

- Two different technologies are used :
  - circuit switching
  - packet switching

Circuit Switching

- This has been the dominant technology for voice communications as it is well suited to the analog transmission of voice signals
- It implies that there is a dedicated communication path between two stations
- path is a connected sequence of links between network nodes
- It involves three phases
  - Circuit establishment
  - Data transfer
  - Circuit disconnect



The best-known example of a circuit-switching network is the public telephone network.

Digital Circuit Switch

- The function of the digital switch is to provide a transparent signal path between any pair of attached devices
- The **control unit** performs three general tasks
  - establishes connections
  - maintain the connection
  - tear down the connection
- Blocking or non-blocking
  - Blocking occurs when the network is unable to connect two stations because all possible paths between them are already in use
- Switching techniques
  - Space Division Switching
  - Time Division Switching

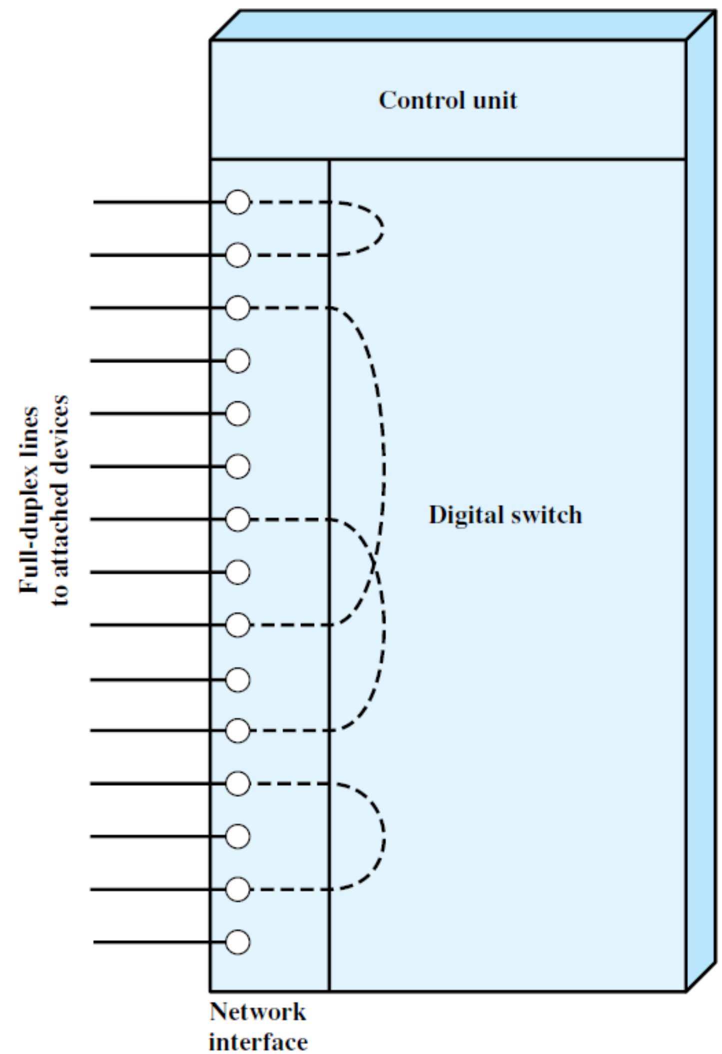


Figure 10.4 Elements of a Circuit-Switch Node

Space Division Switching

- the signal paths are physically separate from one another (divided in space).
- The basic building block of the switch is a metallic crosspoint or semiconductor gate that can be enabled and disabled by a control unit.
- Interconnection is possible between any two lines by enabling the appropriate crosspoint.
- Limitations:
  - crosspoints grows with the square of the number of stations
  - crosspoints are inefficiently utilized
  - single point failure (loss of crosspoint)

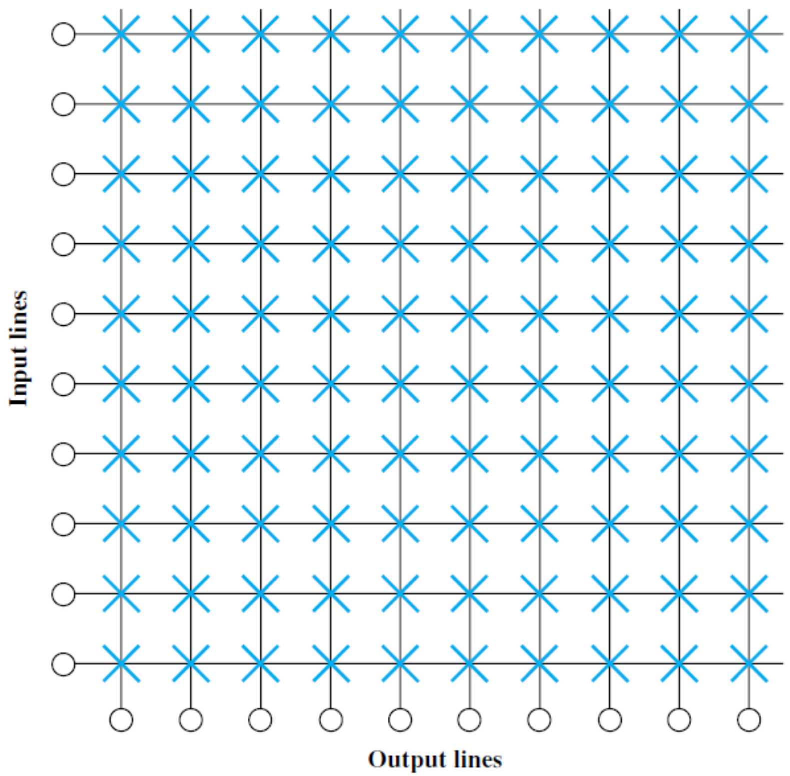


Figure 10.5 Space Division Switch

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- To overcome these limitations, multiple-stage switches are employed
- the total number of crosspoints for 10 stations is reduced from 100 to 48.

Advantage:
- increasing crossbar utilization
- increasing reliability as multiple paths between two endpoints

Disadvantage:
- more complex control
- it may be blocking

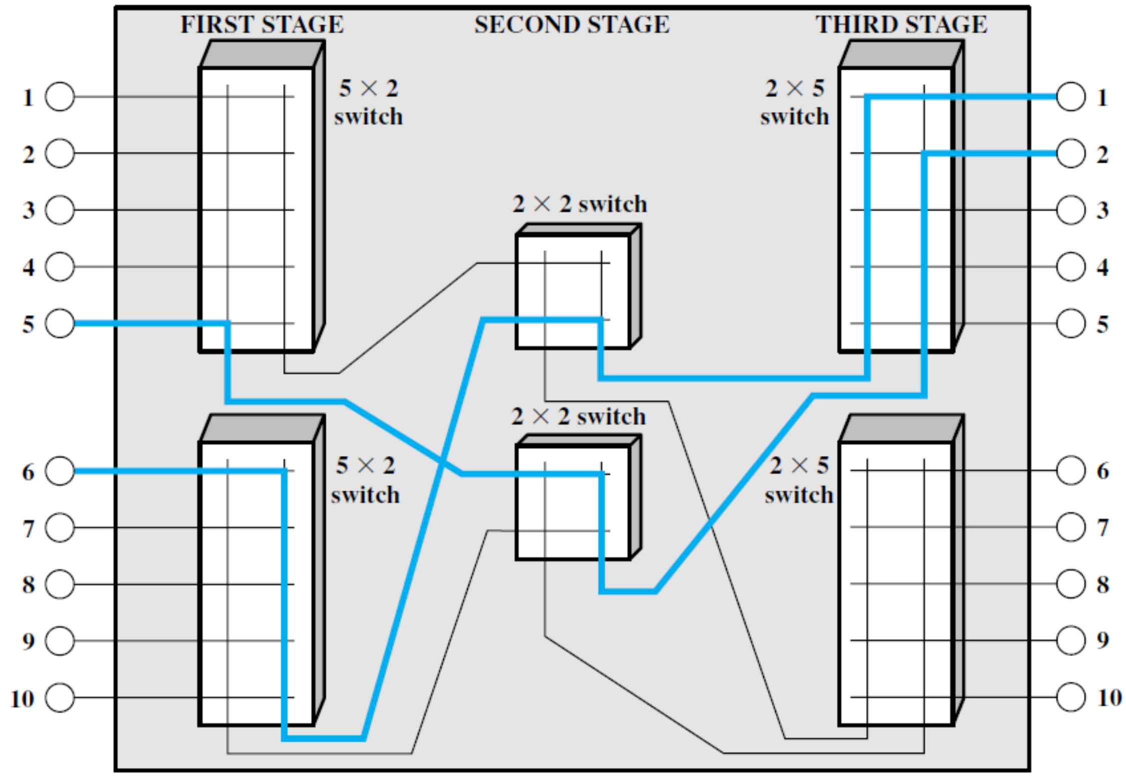
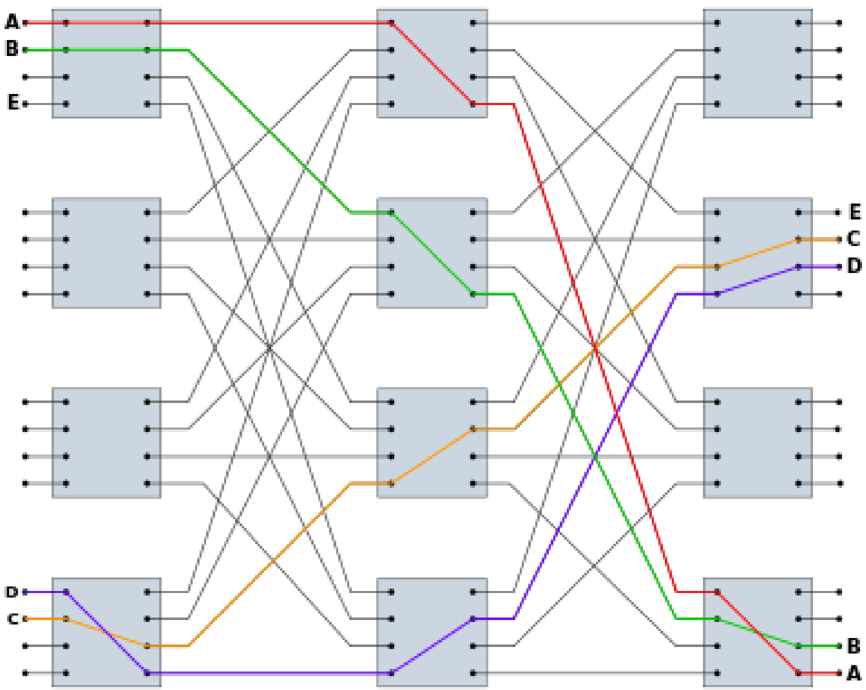


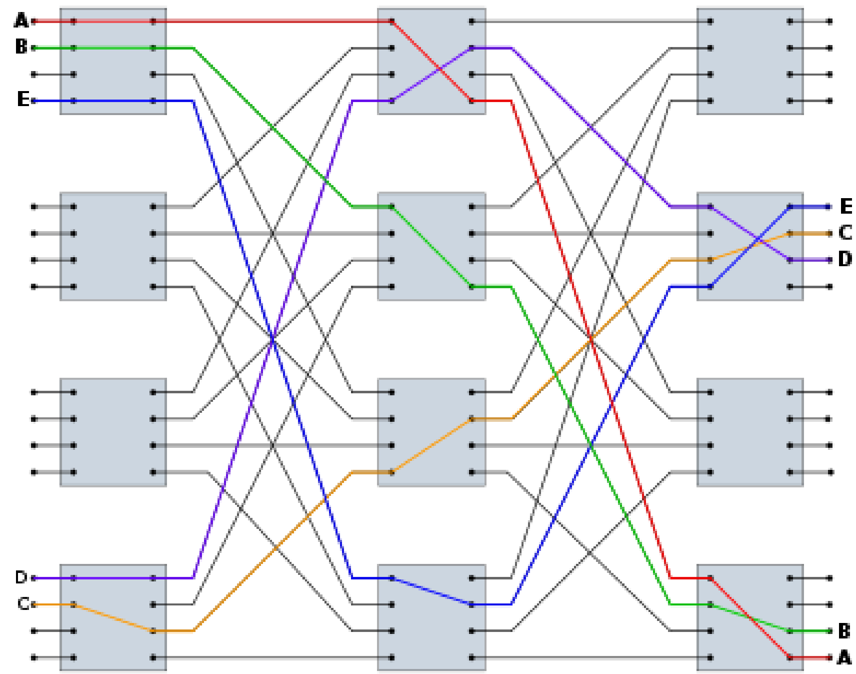
Figure 10.6 Three-Stage Space Division Switch

Blocking vs Nonblocking

strict-sense nonblocking meaning that an unused input on an ingress switch can always be connected to an unused output on an egress switch, *without having to re-arrange existing calls*



Signals A, B, C, D are routed but signal E is blocked, unless a signal, such as D shown in purple is rerouted



After D, in purple, is rerouted, Signal E can be routed and all the additional signals plus E are connected

Clos networks

Clos networks are defined by three integers *n*, *m*, and *r*.

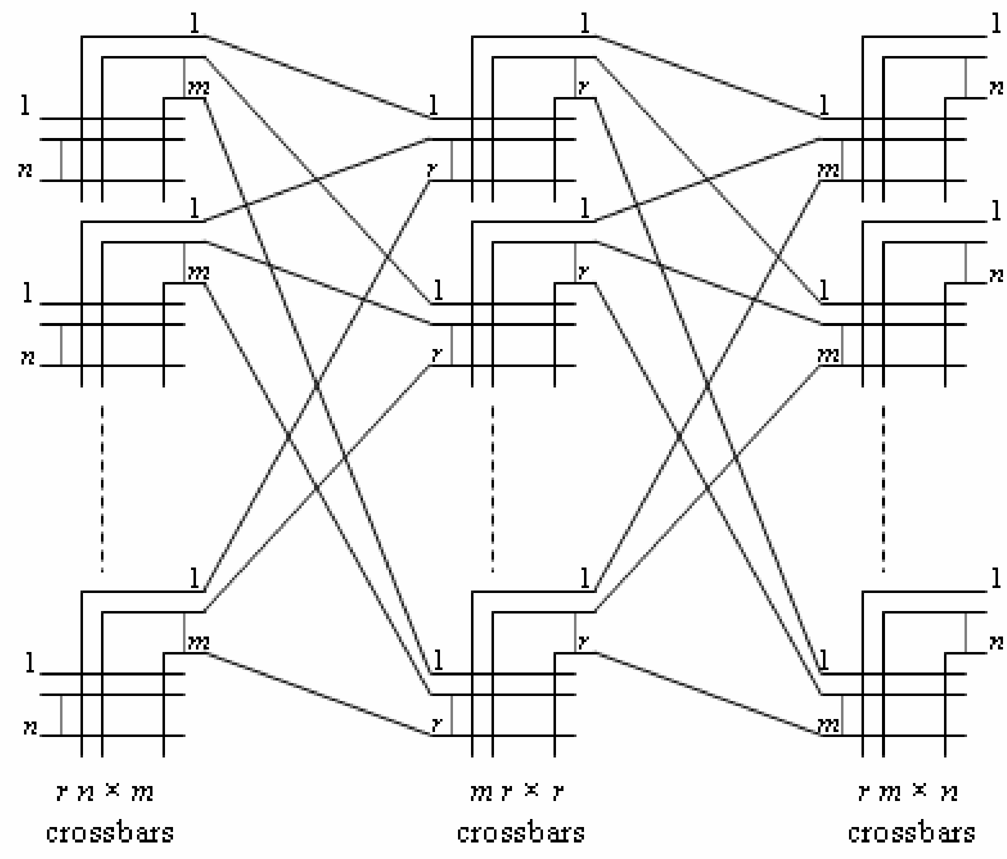
n represents the number of sources which feed into each of *r* ingress stage crossbar switches.

Each ingress stage crossbar switch has *m* outlets, and there are *m* middle stage crossbar switches.

There is exactly one connection between each ingress stage switch and each middle stage switch.

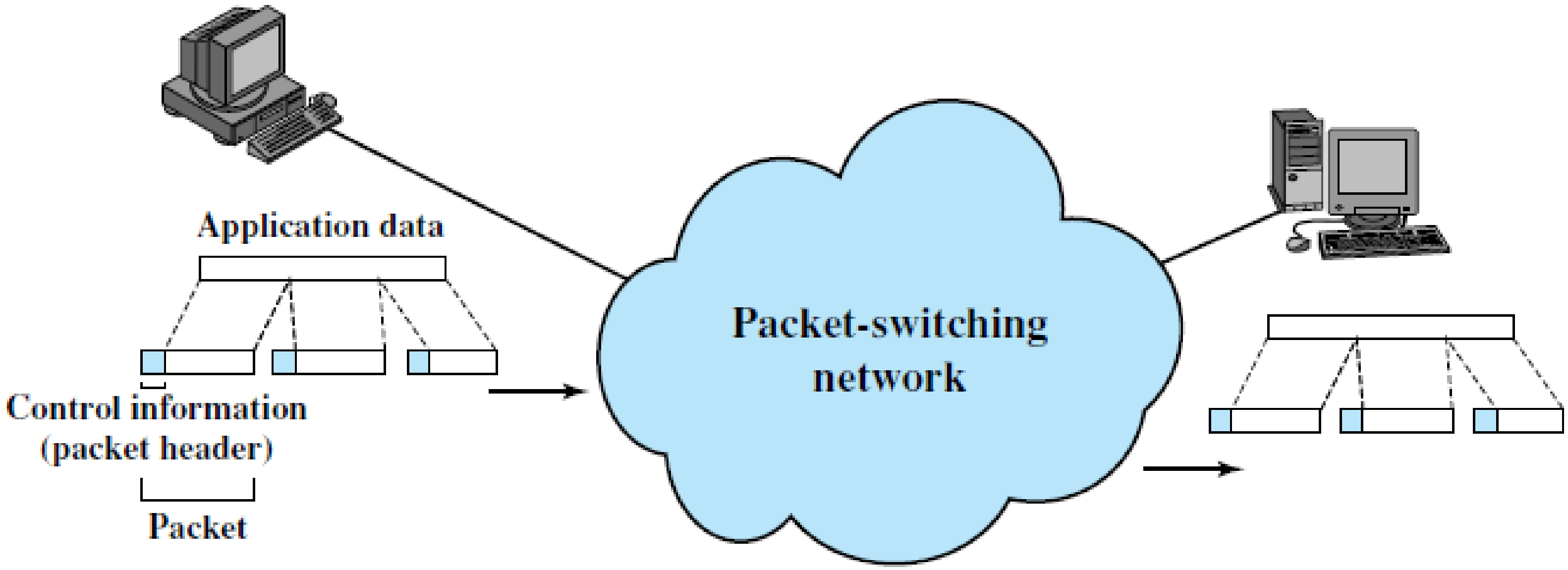
There are *r*egress stage switches, each with *m* inputs and *n* outputs.

Each middle stage switch is connected exactly once to each egress stage switch.



Property: If $m \geq 2n-1$, the Clos network is *strict-sense nonblocking*, meaning that an unused input on an ingress switch can always be connected to an unused output on an egress switch, *without having to re-arrange existing calls*.

Packet Switching



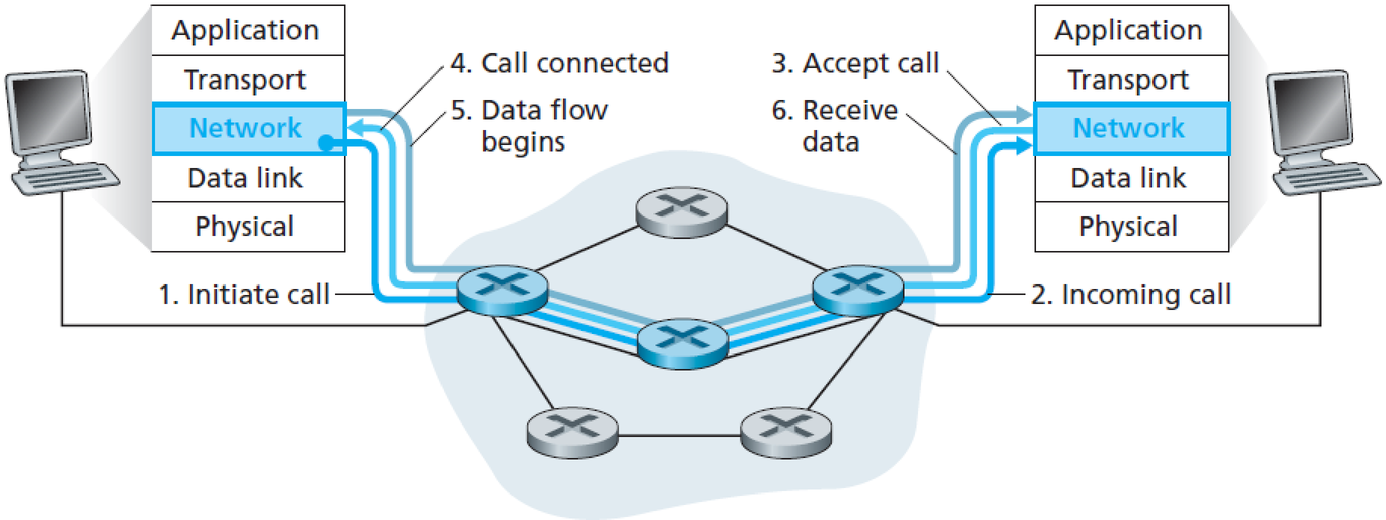
- Advantages of Packet Switching over Circuit Switching
  - Higher line efficiency, because a single node-to-node link can be dynamically shared by many packets over time
  - Two end stations of different data rates can exchange packets
  - Under heavy traffic condition, circuit switching refuses connection, but packet allows with higher delay
  - Priorities can be applied

Packet Switching Techniques

- Datagram Approach
  - each packet is treated independently, with no reference to packets that have gone before
  - Connectionless

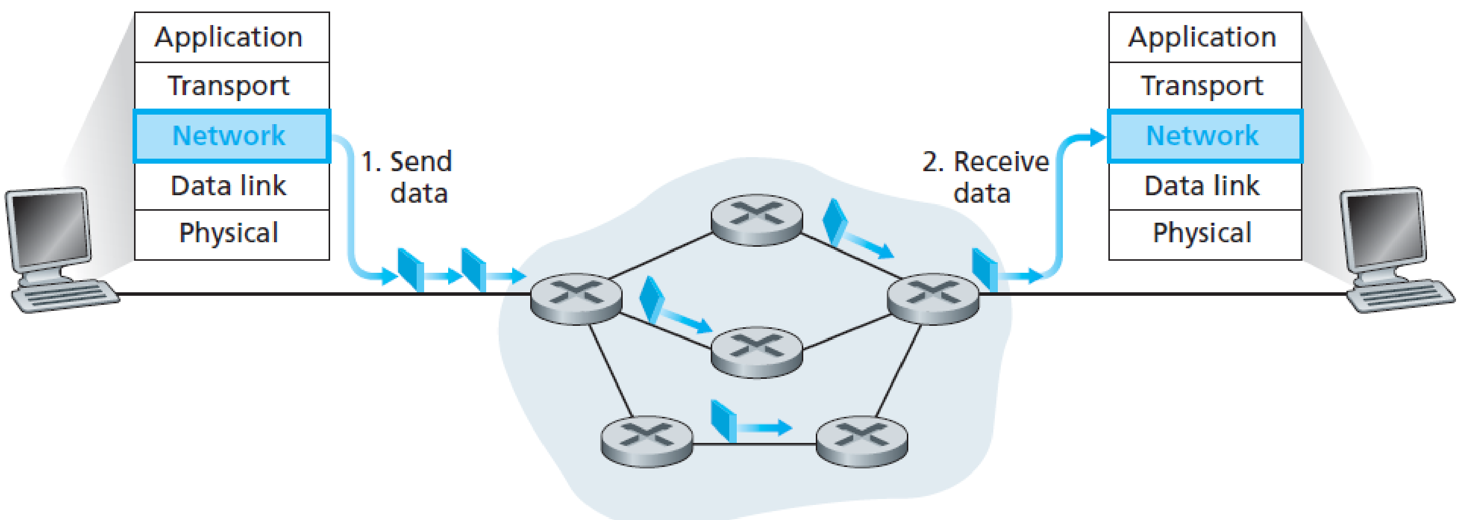
- Virtual Circuit Approach
  - a pre-planned route is established before any packets are sent. Once the route is established, all the packets between a pair of communicating parties follow this same route through the network
  - Connection-oriented

Virtual Circuit & Datagram Approaches



Virtual Circuit

Datagram Approach



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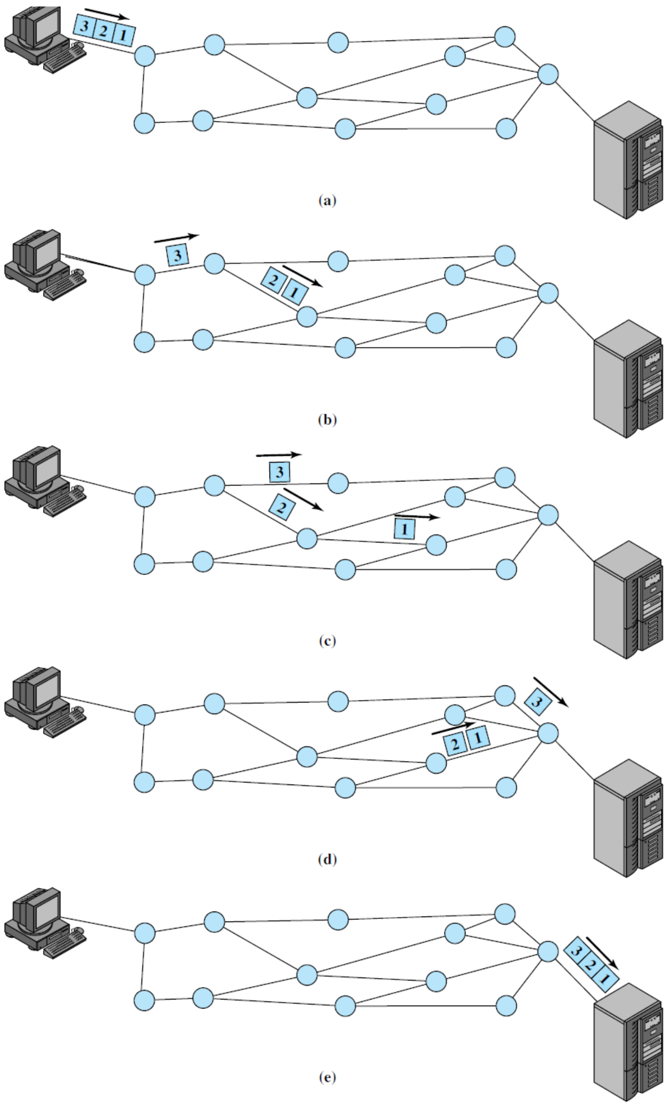


Figure 10.9 Packet Switching: Datagram Approach

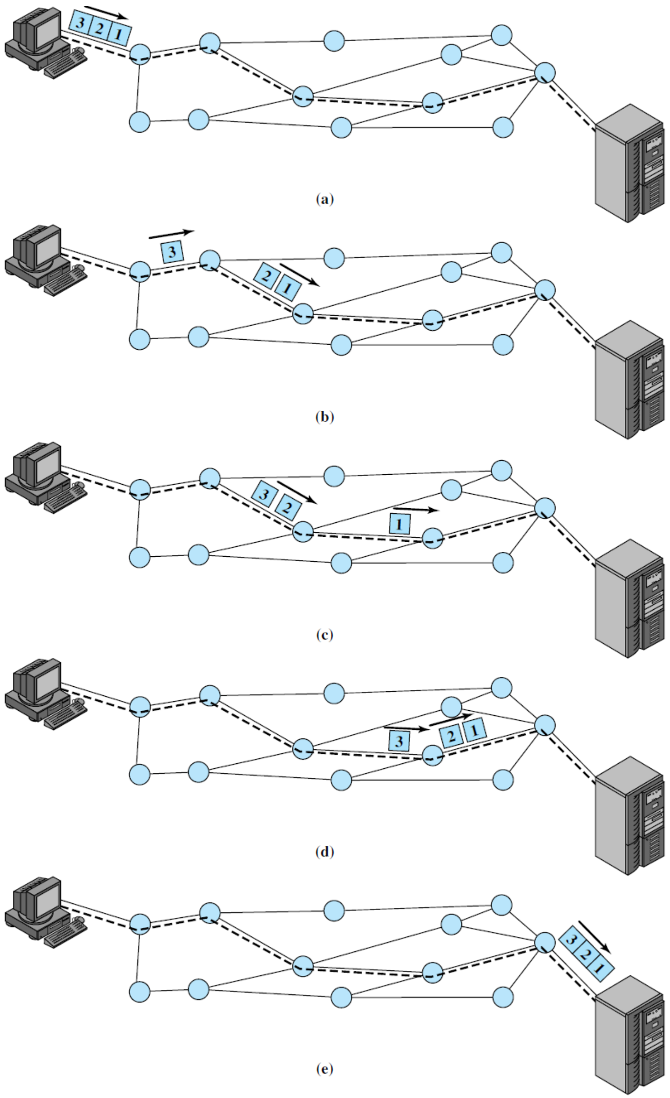
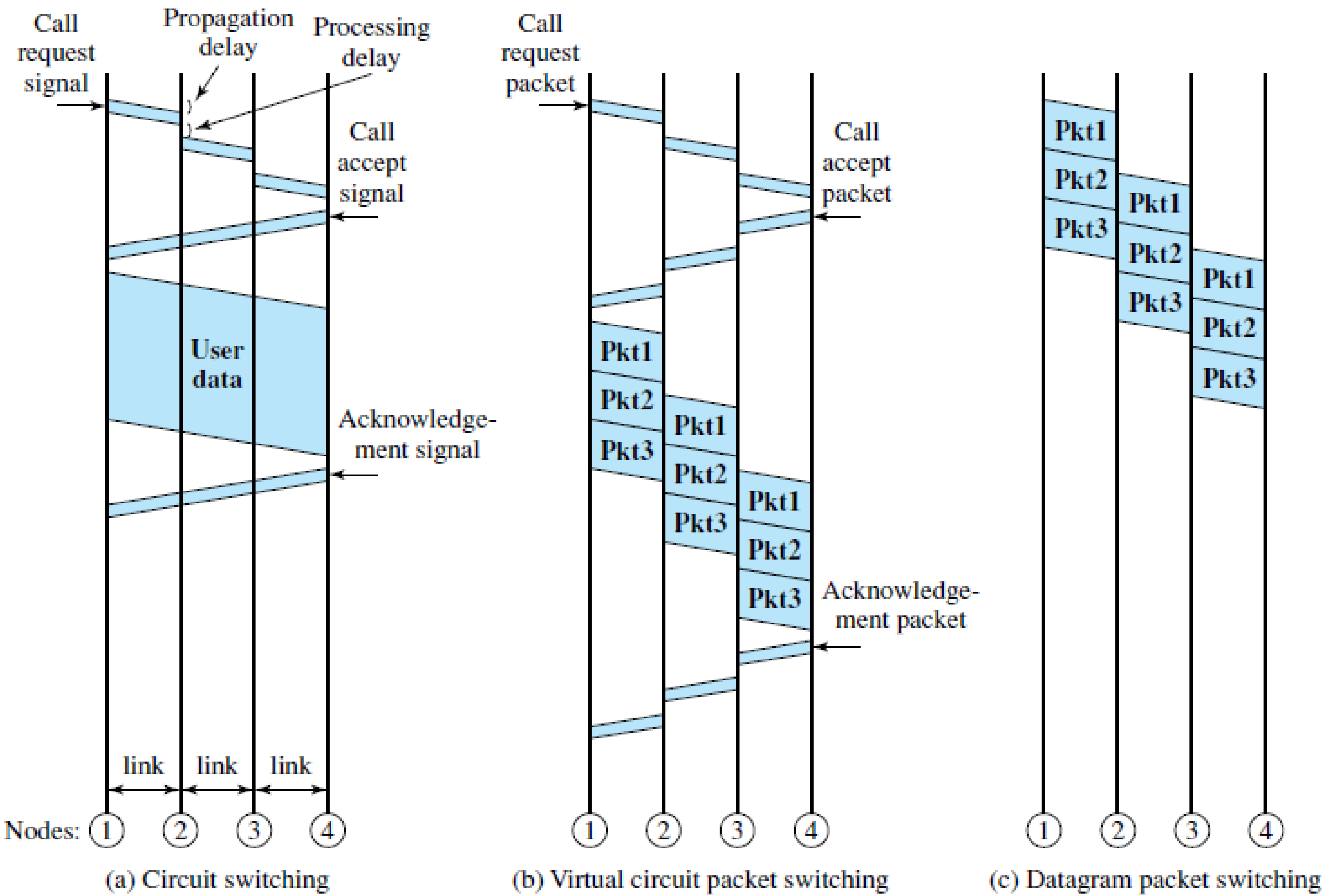


Figure 10.10 Packet Switching: Virtual-Circuit Approach

Comparison



Call request signal
Propagation delay
Processing delay
Call accept signal
User data
Acknowledge-ment signal
link
link
link
Nodes: 1 2 3 4
(a) Circuit switching
Call request packet
Call accept packet
Pkt1
Pkt2
Pkt3
Acknowledge-ment packet
1 2 3 4
(b) Virtual circuit packet switching
Pkt1
Pkt2
Pkt3
1 2 3 4
(c) Datagram packet switching

Cont…

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

Which one is better?

- Ans.: None for all condition.

- For short message
  - Circuit switching might be faster

- For long message
  - Virtual Circuit switching might be faster

- w.r.t. average delay, flexibility, reliability
  - Datagram approach is better

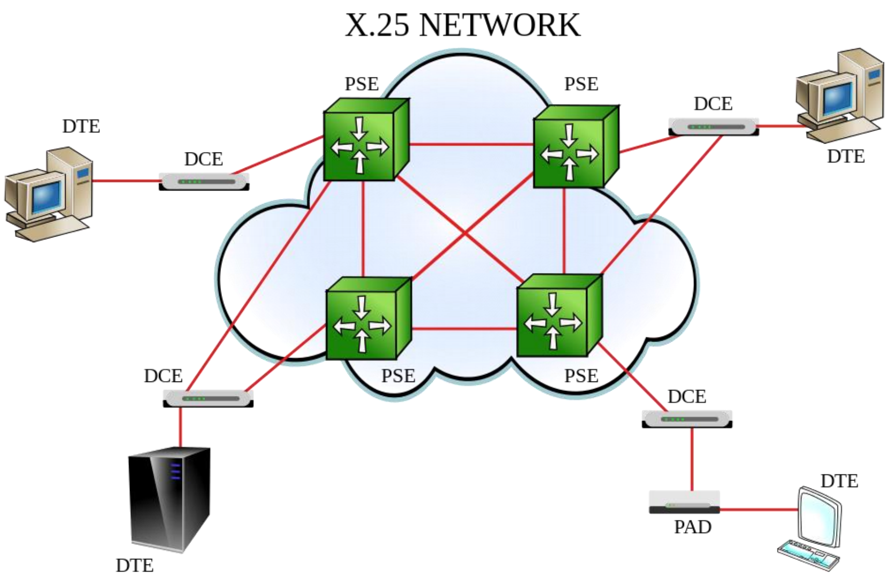
X.25

- packet-switching requires a certain level of cooperation between the network and the attached stations
- This cooperation is embodied in an interface standard. The standard for traditional packet-switching networks is X.25.
- The X.25 specification defines the interface between a subscriber (DTE) and an X.25 network (DCE)

functionalities of X.25 :

- Packet level : virtual circuit service
- Link level : LAPB (Link Access Protocol – Balanced).
- Physical level : X.21 standard.

DTE: data terminating equipment (e.g. PC)
DCE: data circuit-terminating equipment (e.g. modem)
PSE: packet-switching exchange



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- packet level provides a virtual circuit service which enables any subscriber to set up logical connections to other subscribers
- Exchanging control and user data packets

- link level provides for the reliable transfer of data across the physical link, by transmitting the data as a sequence of frames.
- Consists of the link access procedure for data interchange on the link between a DTE and a DCE

- physical level deals with the physical interface between an attached station (computer, terminal) and the link that attaches that station to the packet-switching node.
- Control the physical link between a DTE and a DCE.

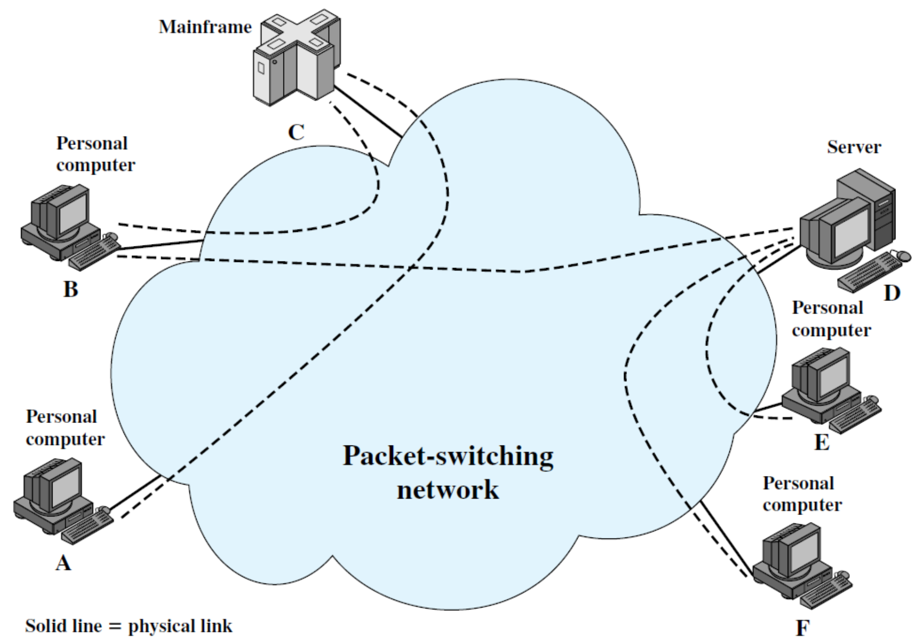

Figure 10.13 The Use of Virtual Circuits

control information in X.25 packet

- Virtual circuit number with which a packet is associated
- Send and Receive Sequence number

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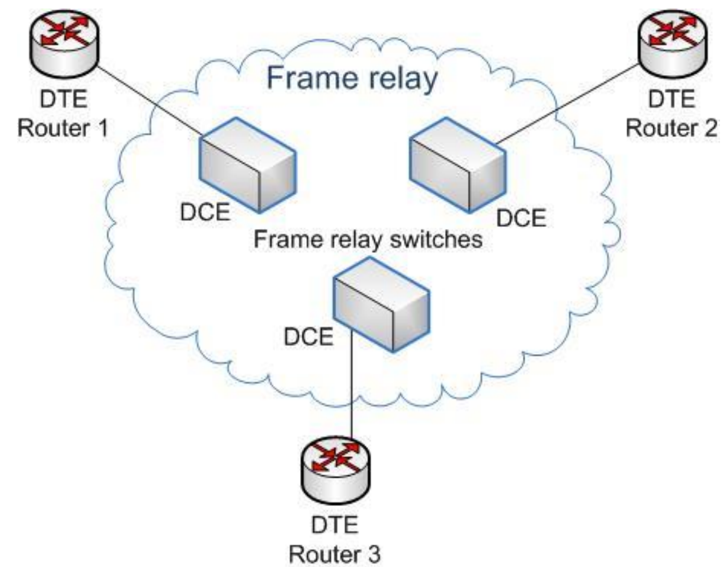
- OSI Layers & X.25 Layers
  - the OSI physical Layer corresponds to the X.25 *physical layer*
  - the OSI data link layer to the X.25 *link layer*
  - the OSI network layer to the X.25 *packet layer*

- Disadvantages of X.25
  - at each intermediate node, state tables must be maintained for each virtual circuit in X.25 (for call control)
  - At each hop the DLC protocol involves the exchange of data and ack frames (for error control/flow control)

Frame Relay

- Frame Relay offers higher performance and greater transmission efficiency than X.25

- Frame Relay vs X.25
  - Call control signaling is carried on a separate logical connection from user data. Thus, intermediate nodes need not maintain state tables
  - There is no hop-by-hop flow control and error control.
  - Multiplexing and switching of logical connections takes place at layer 2 instead of layer 3, eliminating one entire layer of processing.
  - Frame Relay is a Layer 2 protocol suite, X.25 provides services at Layer 3



- It is less expensive than leased lines and that is one reason for its popularity.
- It handles the transmission over a frequently changing path.

Thanks!

Figure and slide materials are taken from the following sources:

1. W. Stallings, (2010), Data and Computer Communications
2. NPTL lecture on Data Communication, by Prof. A. K. Pal, IIT Kharagpur
3. B. A. Forouzan, (2013), Data Communication and Networking