SWITCHING NETWORKS

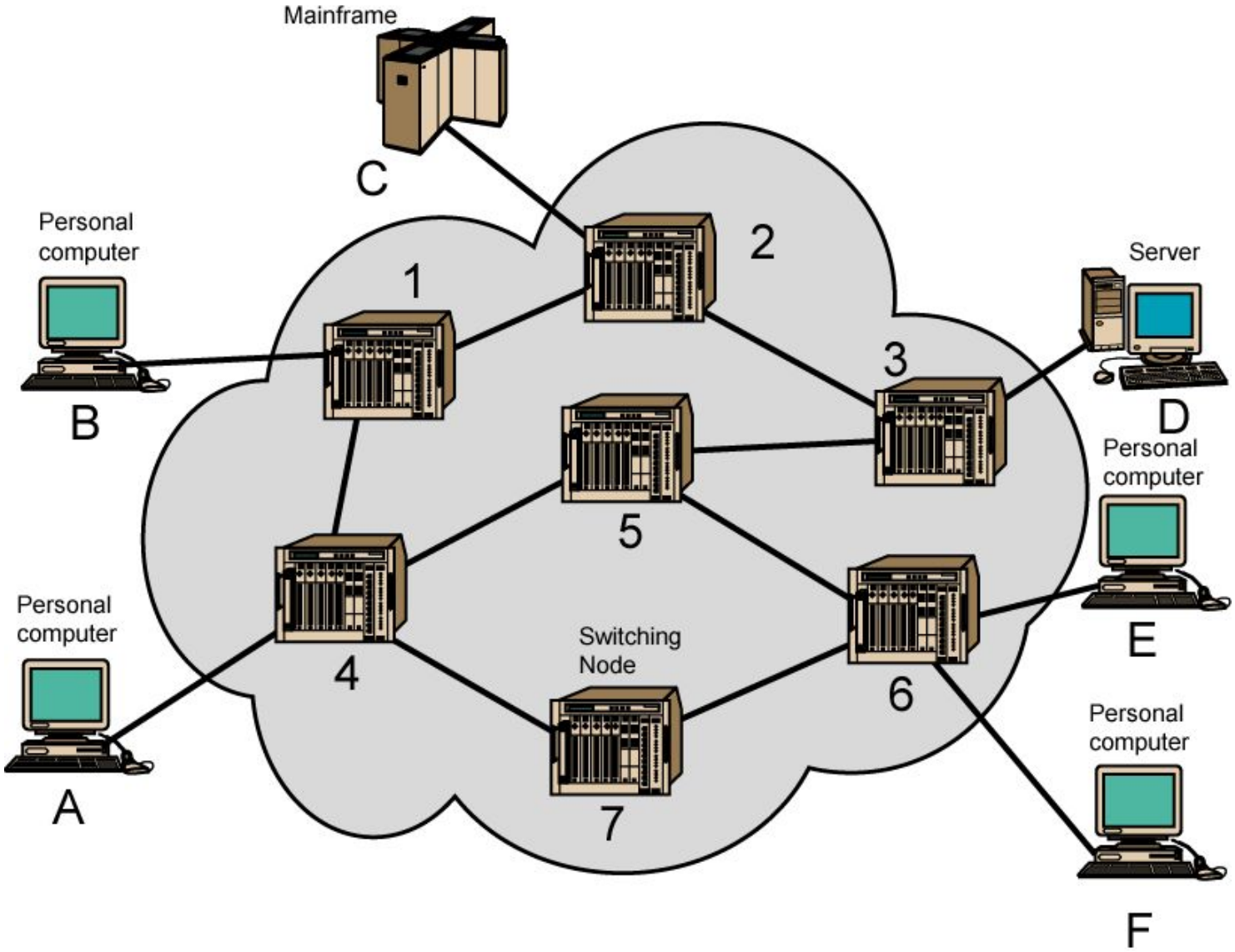
Overview

- Networks are used to interconnect many devices.
  - Since the invention of the telephone, **circuit switching** has been the dominant technology for voice communications.
  - Since 1970, **packet switching** has evolved substantially for digital data communications. It was designed to provide a more efficient facility than circuit switching for bursty data traffic.
    - Two types of packet switching:
      - Datagram (such as today's Internet)
      - Virtual circuit (such as Frame Relay, ATM)

Switched Communications Networks

- Long distance transmission between stations (called "end devices") is typically done over a network of **switching nodes**.
- Switching nodes do not concern with content of data. Their purpose is to provide a switching facility that will move the data from node to node until they reach their destination (the end device).
- A collection of nodes and connections forms a communications network.
- In a switched communications network, data entering the network from a station are **routed** to the destination by being switched from node to node.

Simple Switching Network



Switching Nodes

- Nodes may connect to other nodes, or to some stations.
- Network is usually partially connected
  - However, some redundant connections are desirable for reliability
- Two different switching technologies
  - Circuit switching
  - Packet switching

Circuit Switching

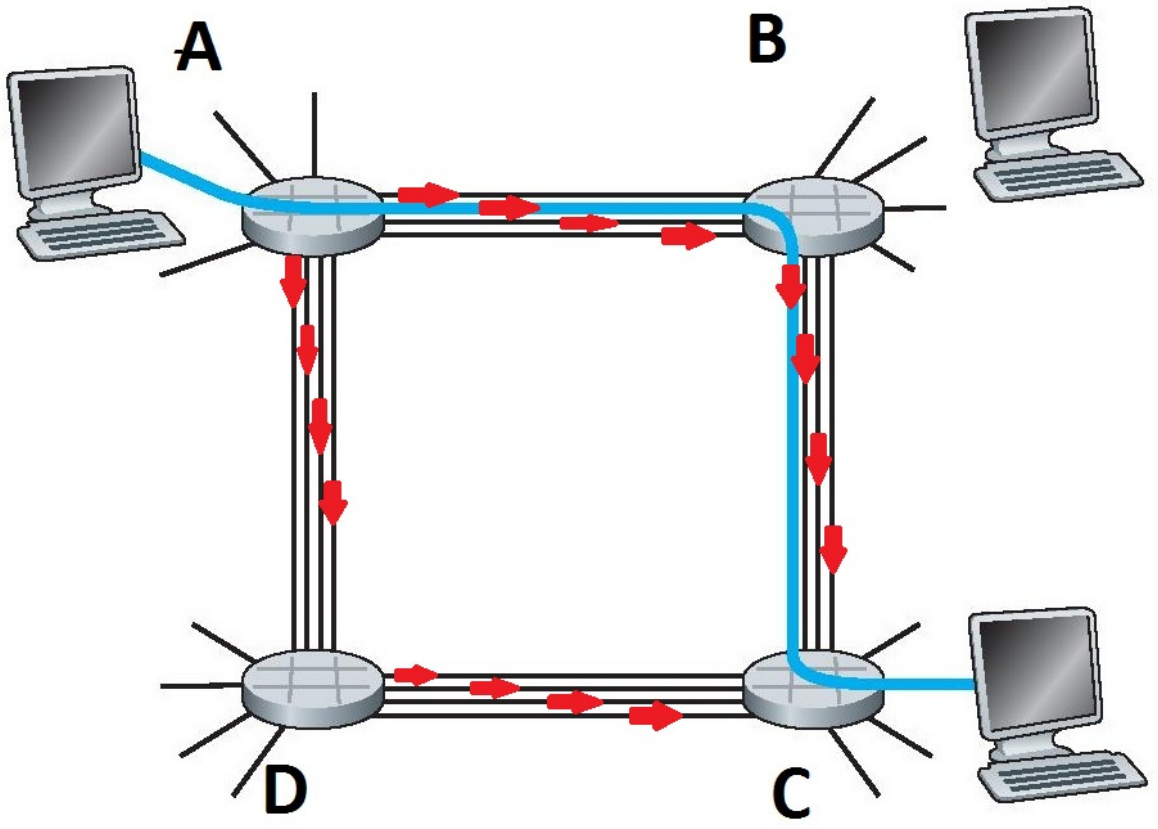


Figure 1.13 ♦ A simple circuit-switched network consisting of four switches and four links

Circuit Switching

- Circuit switching:
  - There is a dedicated communication path between two stations (end-to-end)
  - The path is a connected sequence of links between network nodes. On each physical link, a logical channel is dedicated to the connection.

- Communication via circuit switching has three phases:
  - Circuit establishment (link by link)/ **Setup phase**
    - Routing & resource allocation (FDM or TDM)
  - **Data transfer phase**
  - Circuit disconnect/ **teardown phase**
    - Deallocate the dedicated resources
- The switches must know how to find the route to the destination and how to allocate bandwidth (channel) to establish a connection.

Circuit Switching Properties

- Inefficiency
  - Channel capacity is dedicated for the whole duration of a connection.
  - If no data, capacity is wasted.

- Delay
  - Long initial delay: circuit establishment takes time.
  - Low data delay: after the circuit establishment, information is transmitted at a fixed data rate with no delay other than the propagation delay. The delay at each node is negligible.

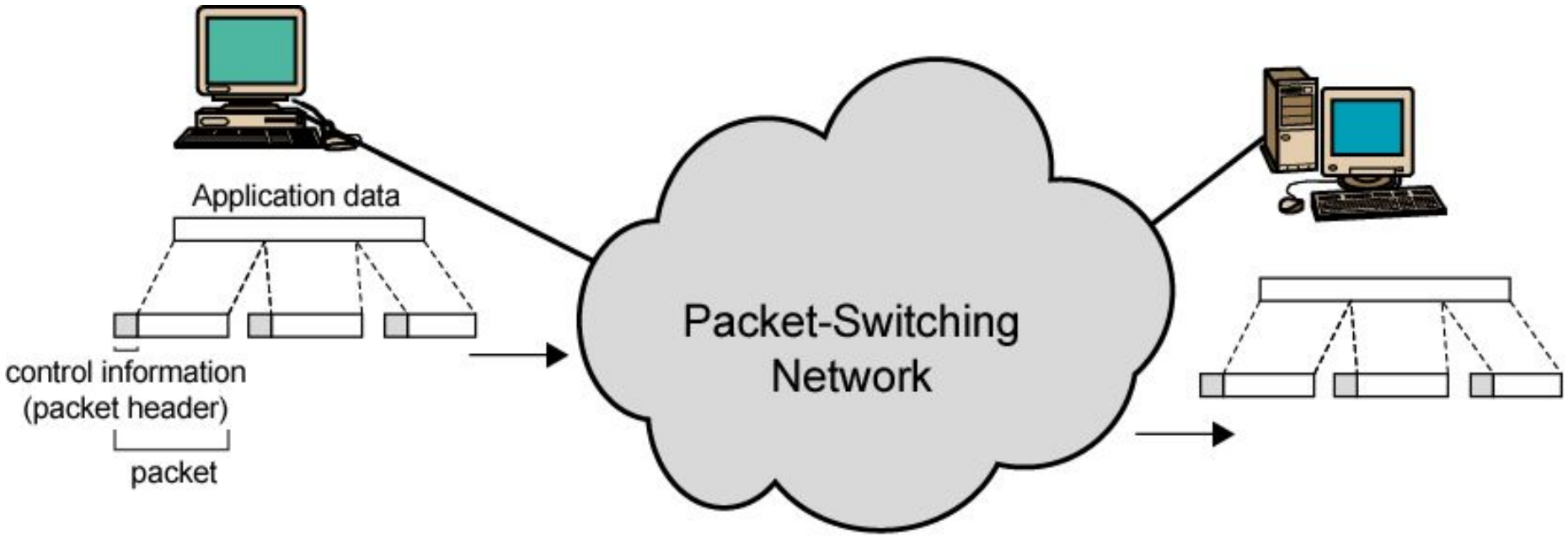
Packet Switching Principles

- Problem of circuit switching
  - designed for voice service
  - Resources dedicated to a particular call
  - For data transmission, much of the time the connection is idle (say, web browsing)
  - Data rate is fixed
    - Both ends must operate at the same rate during the entire period of connection

Basic Operation

- Data are transmitted in short packets
- Control information

Use of Packets



Advantages of Packet Switching

- Line efficiency
  - Single node-to-node link can be dynamically shared by many packets over time
  - Packets are queued up and transmitted as fast as possible
- In circuit-switching, a connection could be blocked if there lacks free resources. On a packet-switching network, even with heavy traffic, packets are still accepted, by delivery delay increases.
- Priorities can be used

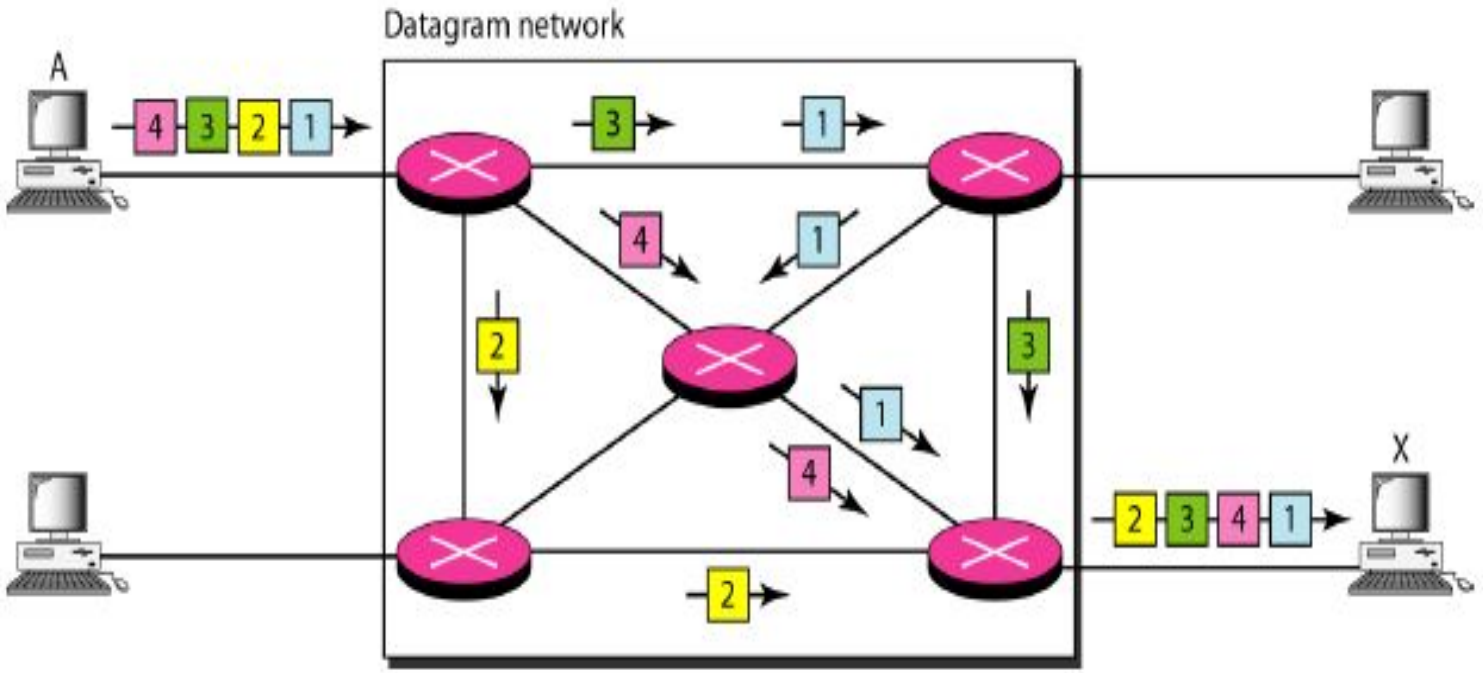
Packet Switching Technique

- A station breaks long message into packets
- Packets are sent out to the network sequentially, one at a time
- How will the network handle this stream of packets as it attempts to route them through the network and deliver them to the intended destination?
  - Two approaches
    - **Datagram** approach
    - **Virtual circuit** approach

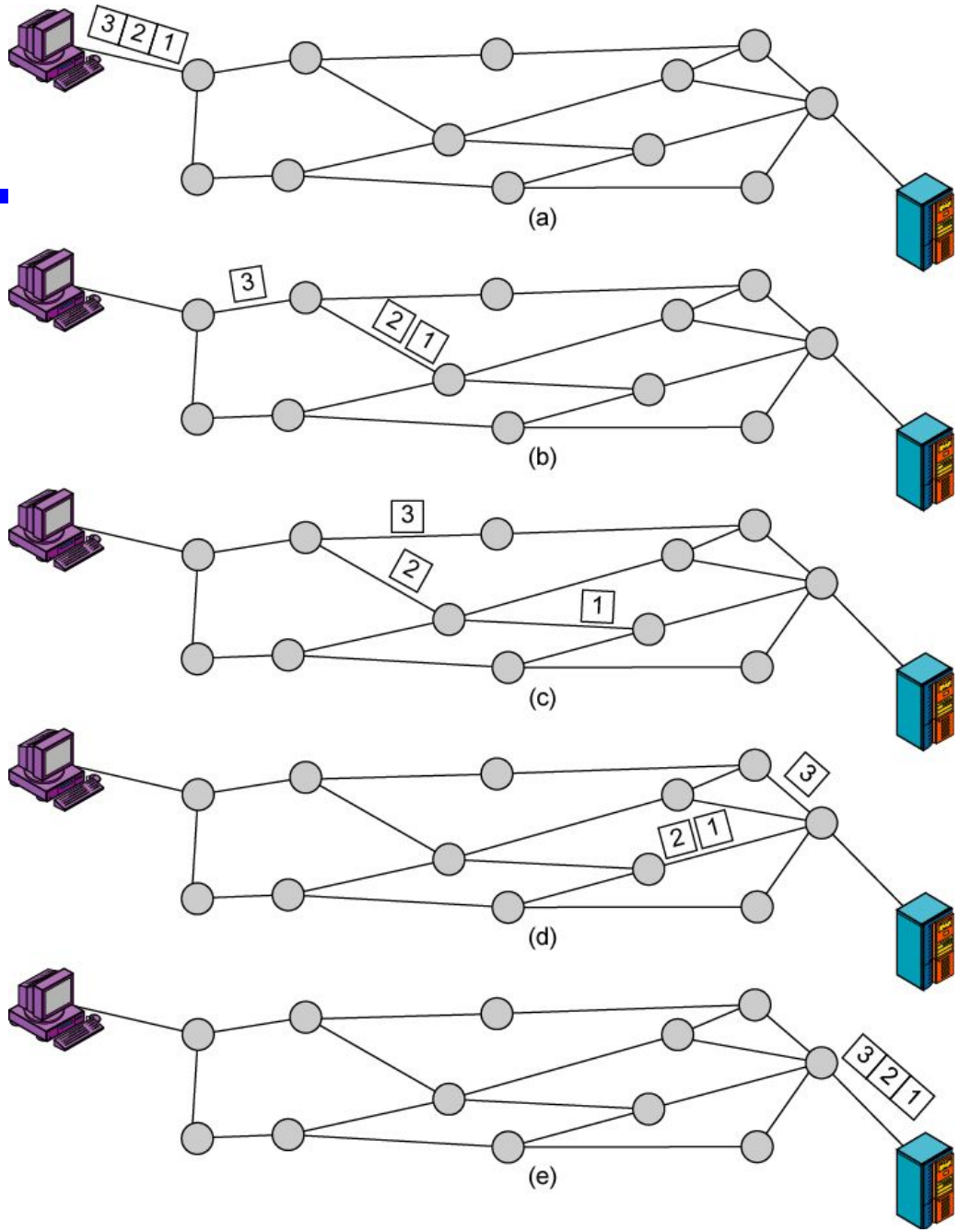
Datagram

- Each packet is treated independently, with no reference to packets that have gone before.
  - Each node chooses the next node on a packet's path.
- Packets can take any possible route.
- Packets may arrive at the receiver out of order.
- Packets may go missing.
- It is up to the receiver to re-order packets and recover from missing packets.
- Example: Internet

Datagram



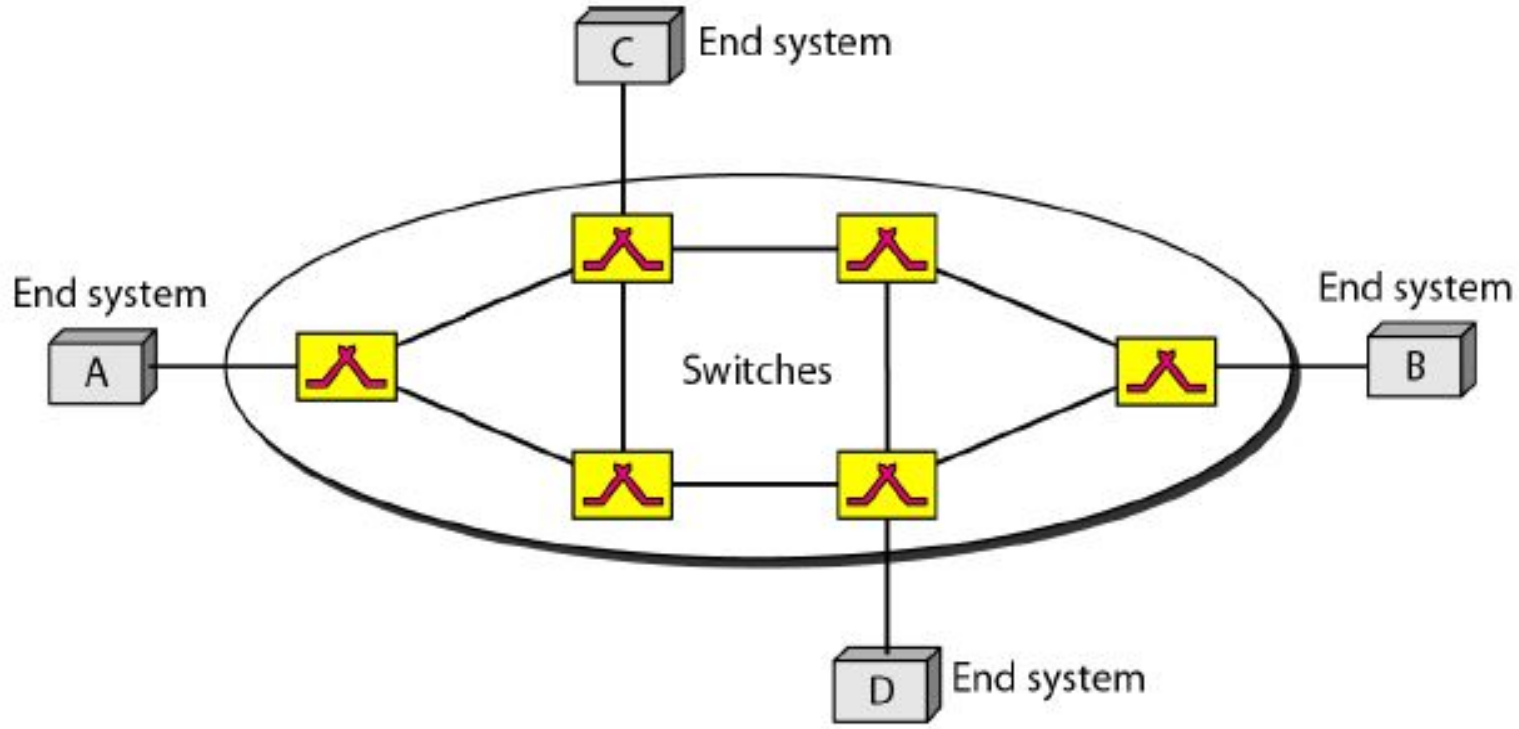
Datagram



Virtual Circuit

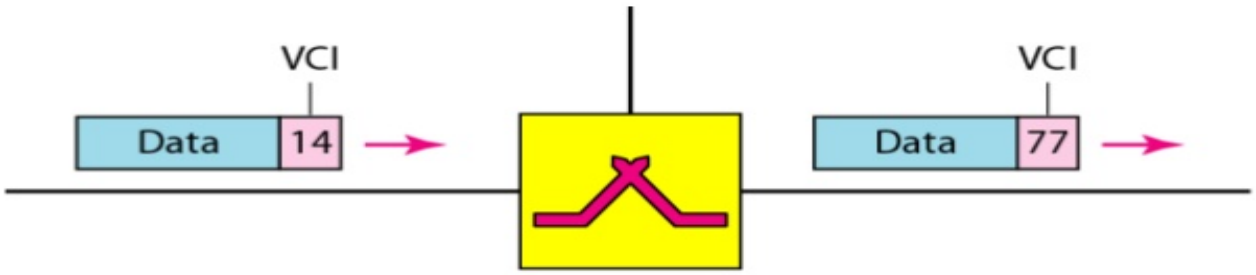
- In virtual circuit, a preplanned route is established before any packets are sent, then all packets follow the same route.
- Each packet contains a **virtual circuit identifier** instead of destination address, and each node on the pre-established route knows where to forward such packets.
  - The node need not make a routing decision for each packet.
- Example: X.25, Frame Relay, ATM

Virtual Circuit



Virtual Circuit

Figure 8.11 *Virtual-circuit identifier*



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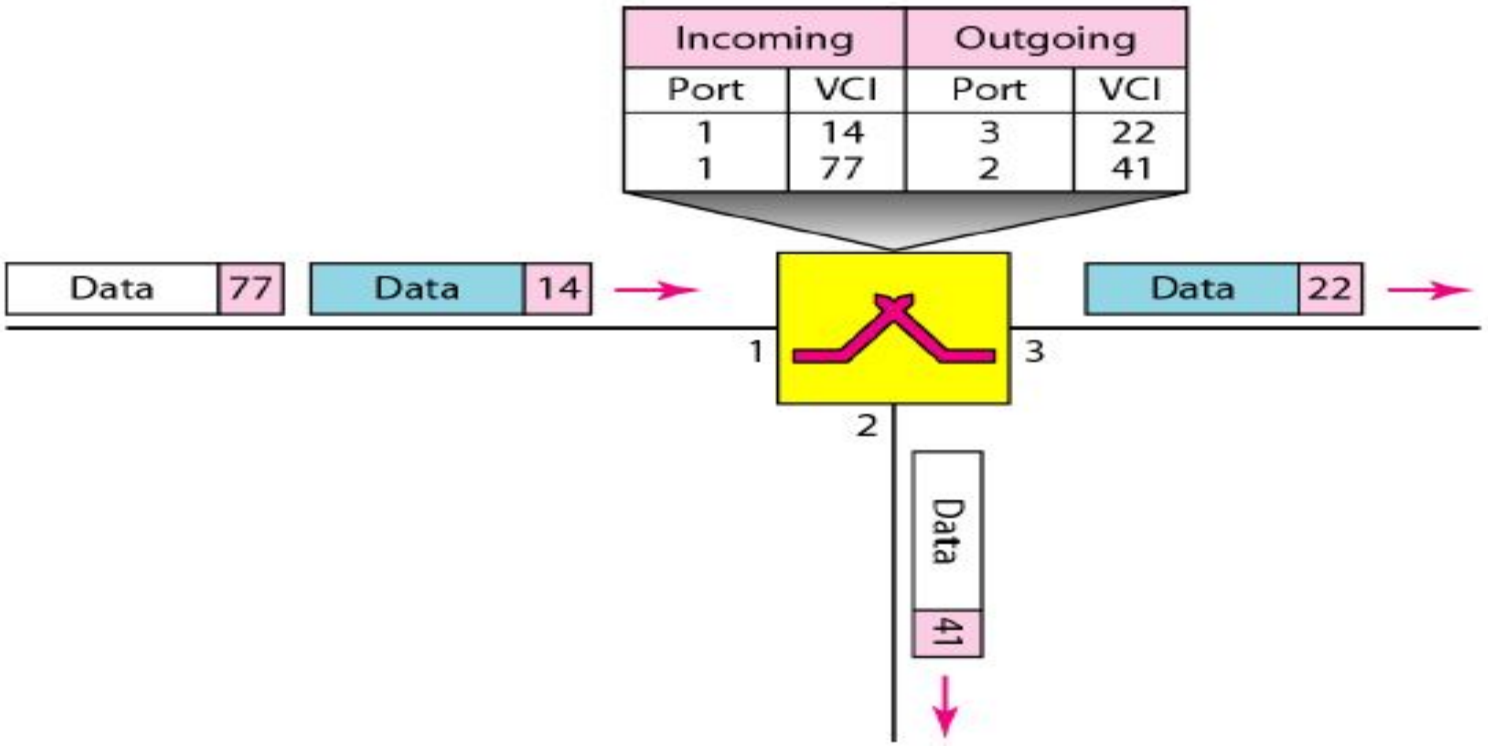
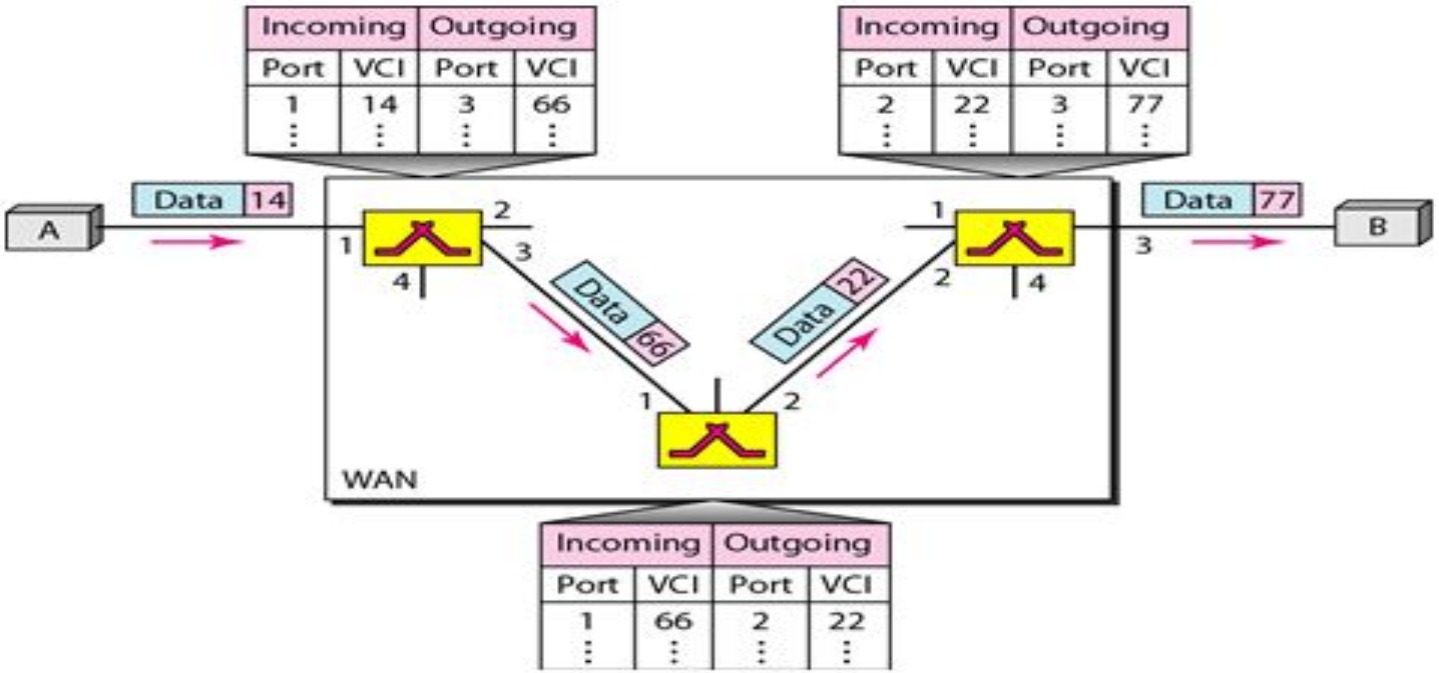
Virtual Circuit

Switch and tables in a virtual circuit network



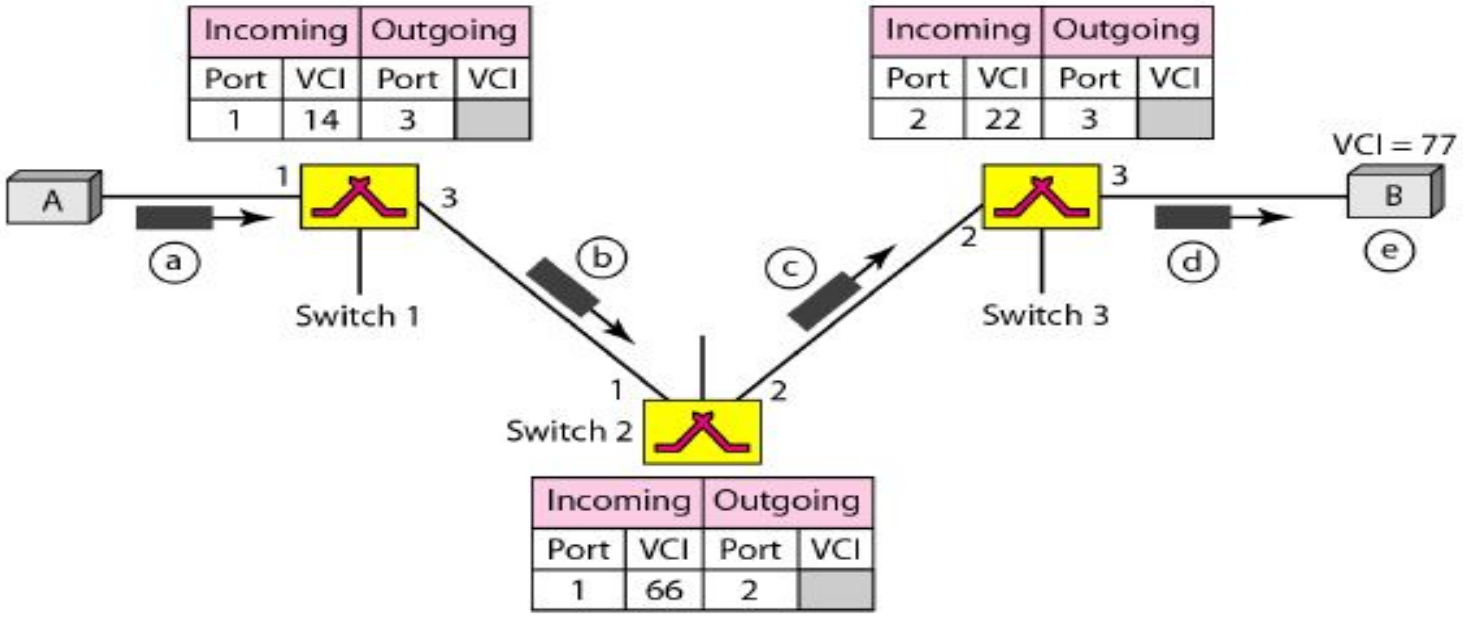
Virtual Circuit

Source to destination data transfer in a virtual circuit network



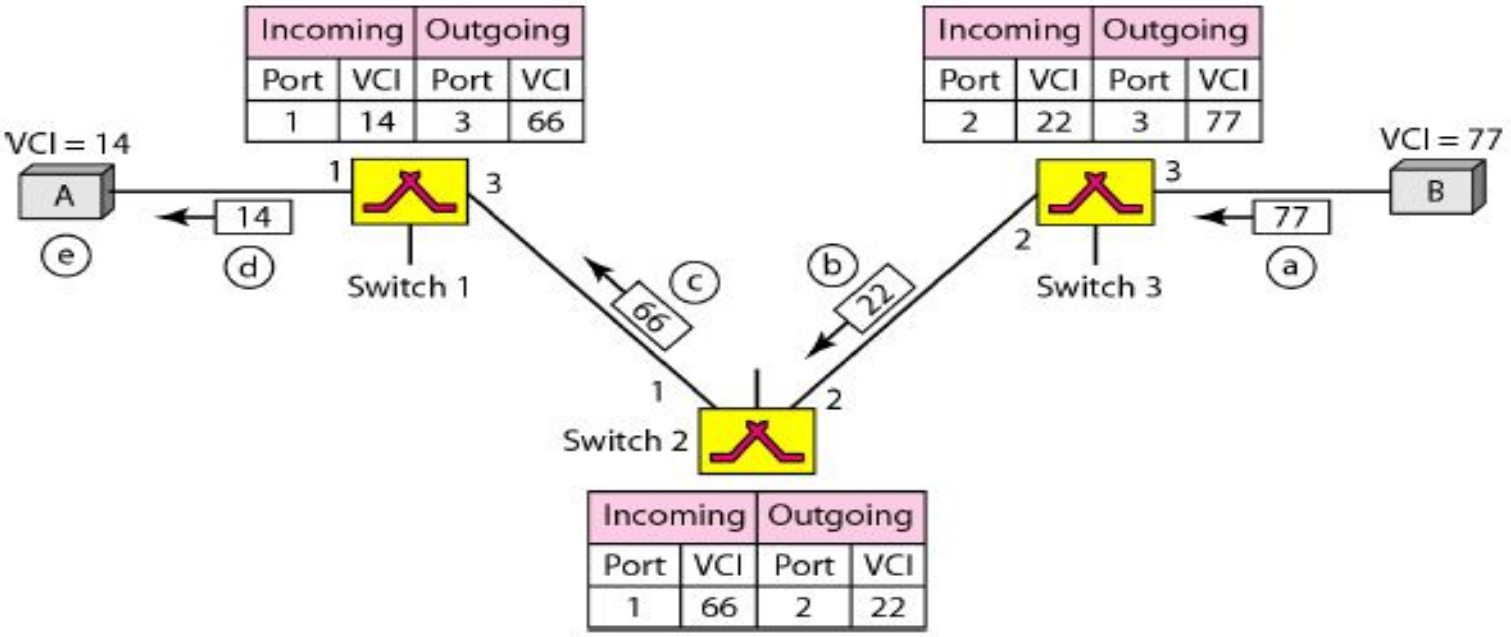
Virtual Circuit

Setup Request in a virtual circuit network



Virtual Circuit

Setup Acknowledgement in a virtual circuit network

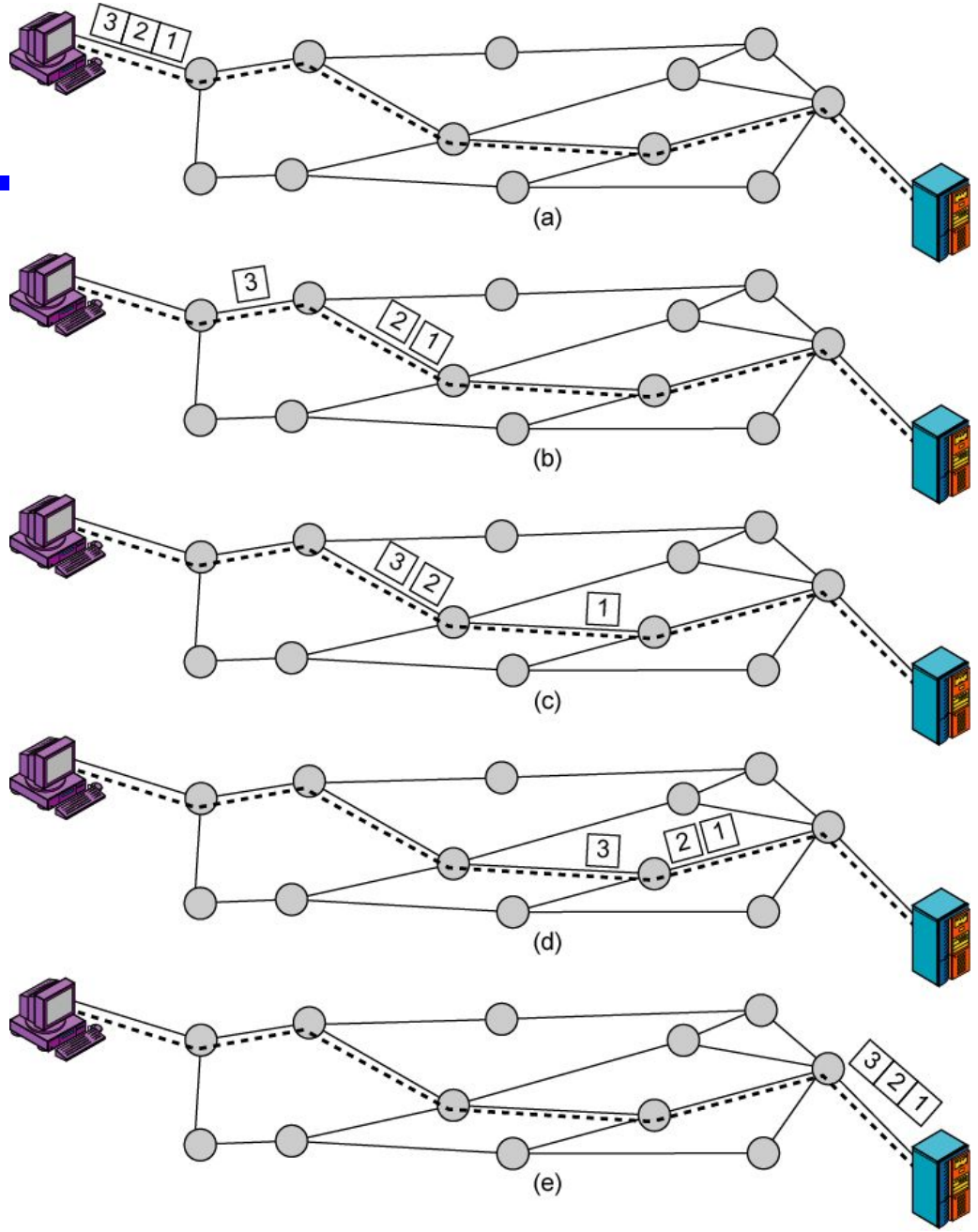


Virtual Circuit

A route between stations is set up prior to data transfer.

All the data packets then follow the same route.

But there is no dedicated resources reserved for the virtual circuit! Packets need to be stored-and-forwarded.



Virtual Circuits v Datagram

- Virtual circuits
  - Network can provide sequencing (packets arrive at the same order) and error control (retransmission between two nodes).
  - Packets are forwarded more quickly
    - Based on the virtual circuit identifier
    - No routing decisions to make
  - Less reliable
    - If a node fails, all virtual circuits that pass through that node fail.
- Datagram
  - No call setup phase
    - Good for bursty data, such as Web applications
  - More flexible
    - If a node fails, packets may find an alternate route
    - Routing can be used to avoid congested parts of the network

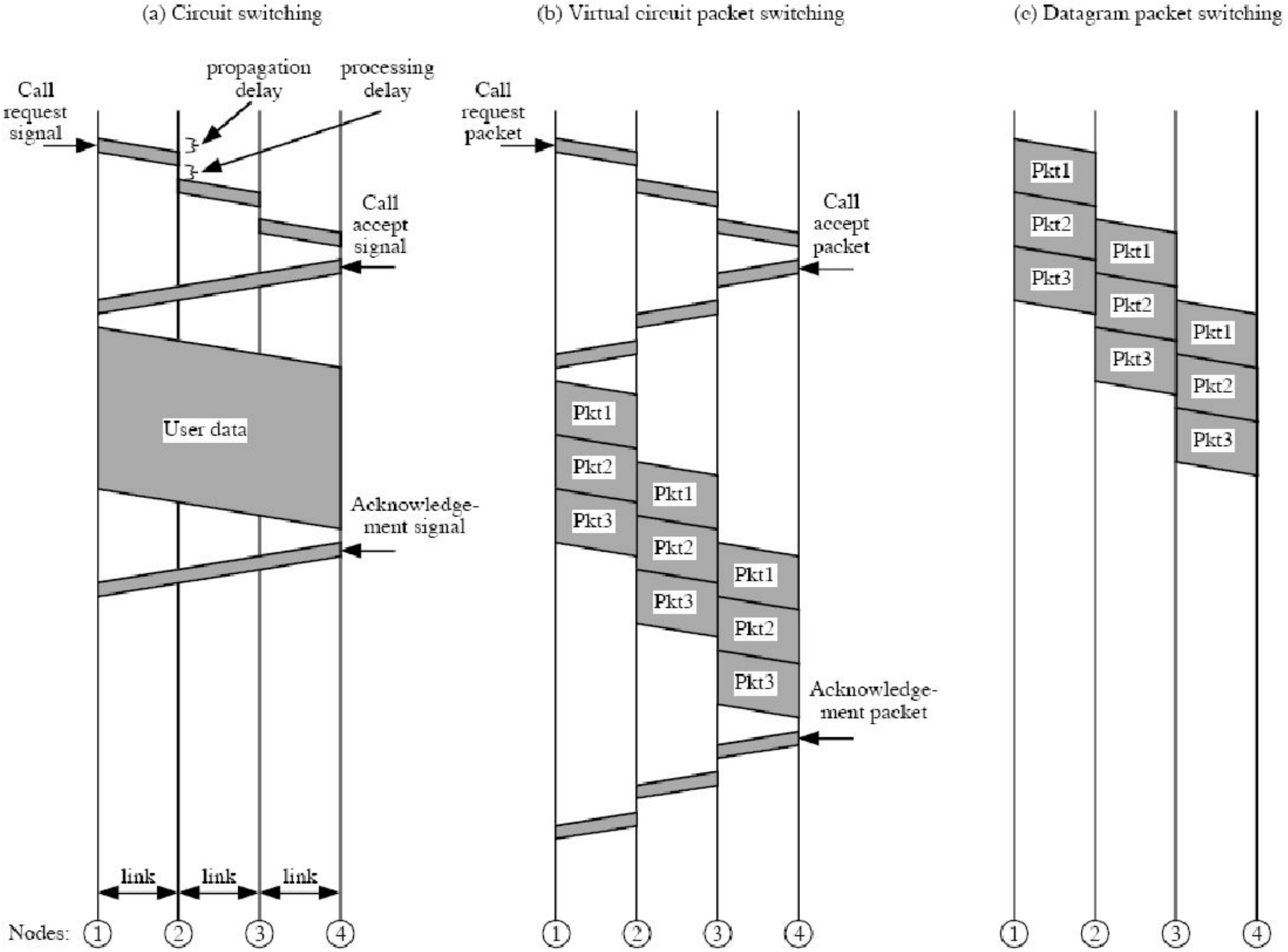


Figure 10.15 Event Timing for Circuit Switching and Packet Switching

Comparison of communication 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