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# Switching

# Overview

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- In large networks there might be multiple paths linking sender and receiver.
- Information may be switched as it travels through various communication channels.

# Switching Networks

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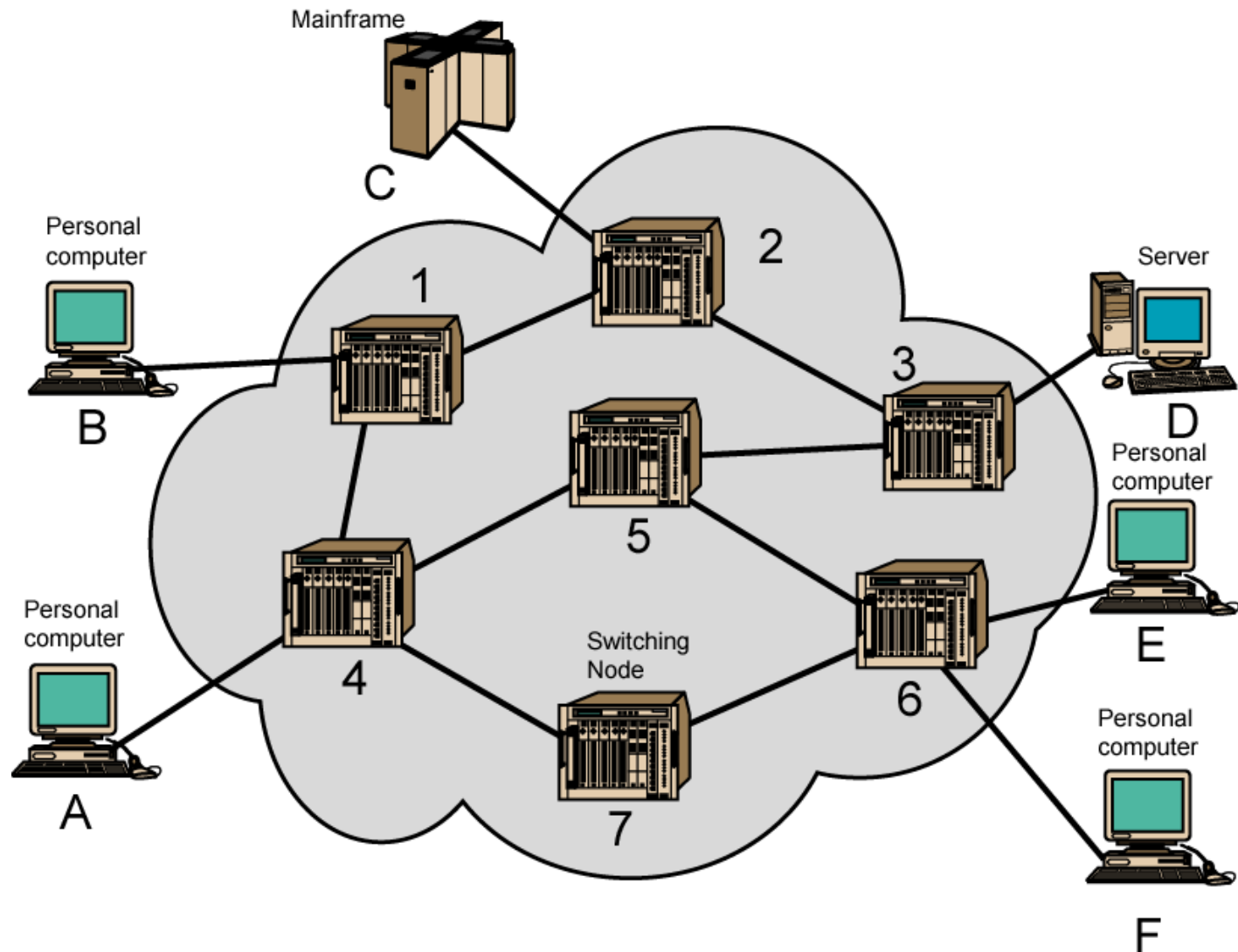
- Long distance transmission is typically done over a network of switched nodes
- Nodes not concerned with content of data
- End devices are stations
  - Computer, terminal, phone, etc.
- A collection of nodes and connections is a communications network
- Data routed by being switched from node to node

# Nodes

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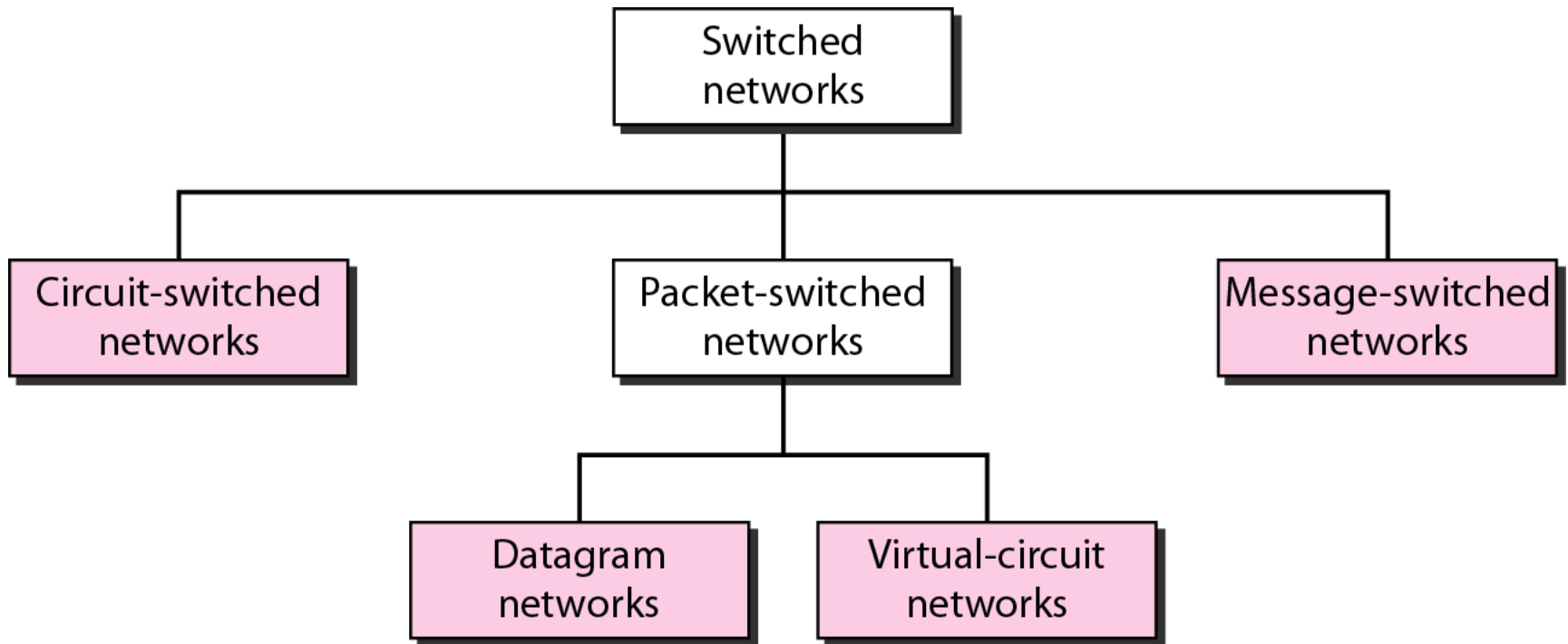
- Nodes may connect to other nodes only, or to stations and other nodes
- Node to node links usually multiplexed
- Network is usually partially connected
- Some redundant connections are desirable for reliability

# Switched network



# Switched Network

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# CIRCUIT-SWITCHED NETWORKS

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- A circuit-switched network consists of a set of switches connected by physical links.
- A connection between two stations is a dedicated path made of one or more links.
- However, each connection uses only one dedicated channel on each link.
- Each link is normally divided into  $n$  channels by using FDM or TDM.

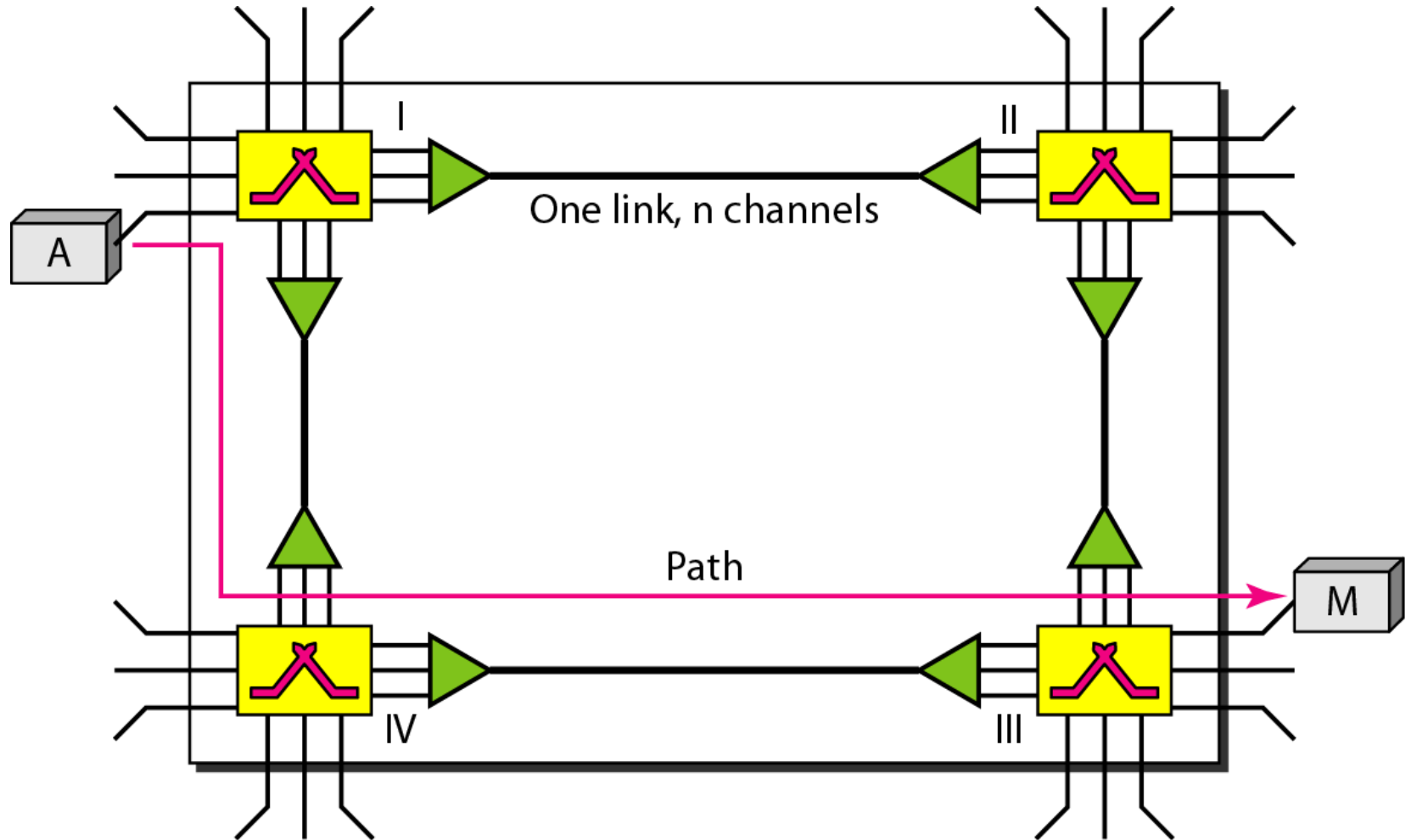
# CIRCUIT-SWITCHED NETWORKS

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- Dedicated communication path between two stations
- Three phases
  - Establish
  - Transfer
  - Disconnect
- Must have switching capacity and channel capacity to establish connection
- Must have intelligence to work out routing



# A trivial circuit-switched network



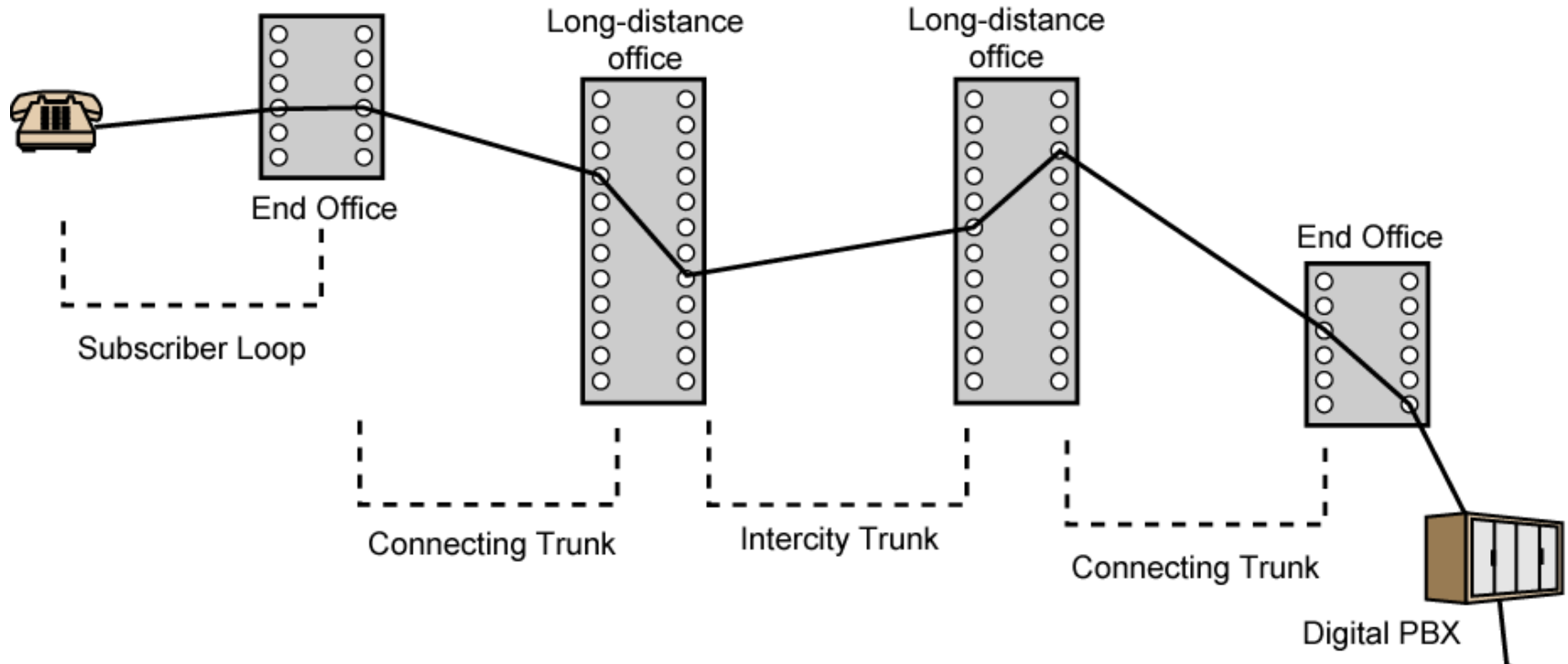
# **Circuit Switching - Applications**

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- Inefficient
  - Channel capacity dedicated for duration of connection
  - If no data, capacity wasted
- Set up (connection) takes time
- Once connected, transfer is transparent
- Developed for voice traffic (phone)

# Public Circuit Switched Network

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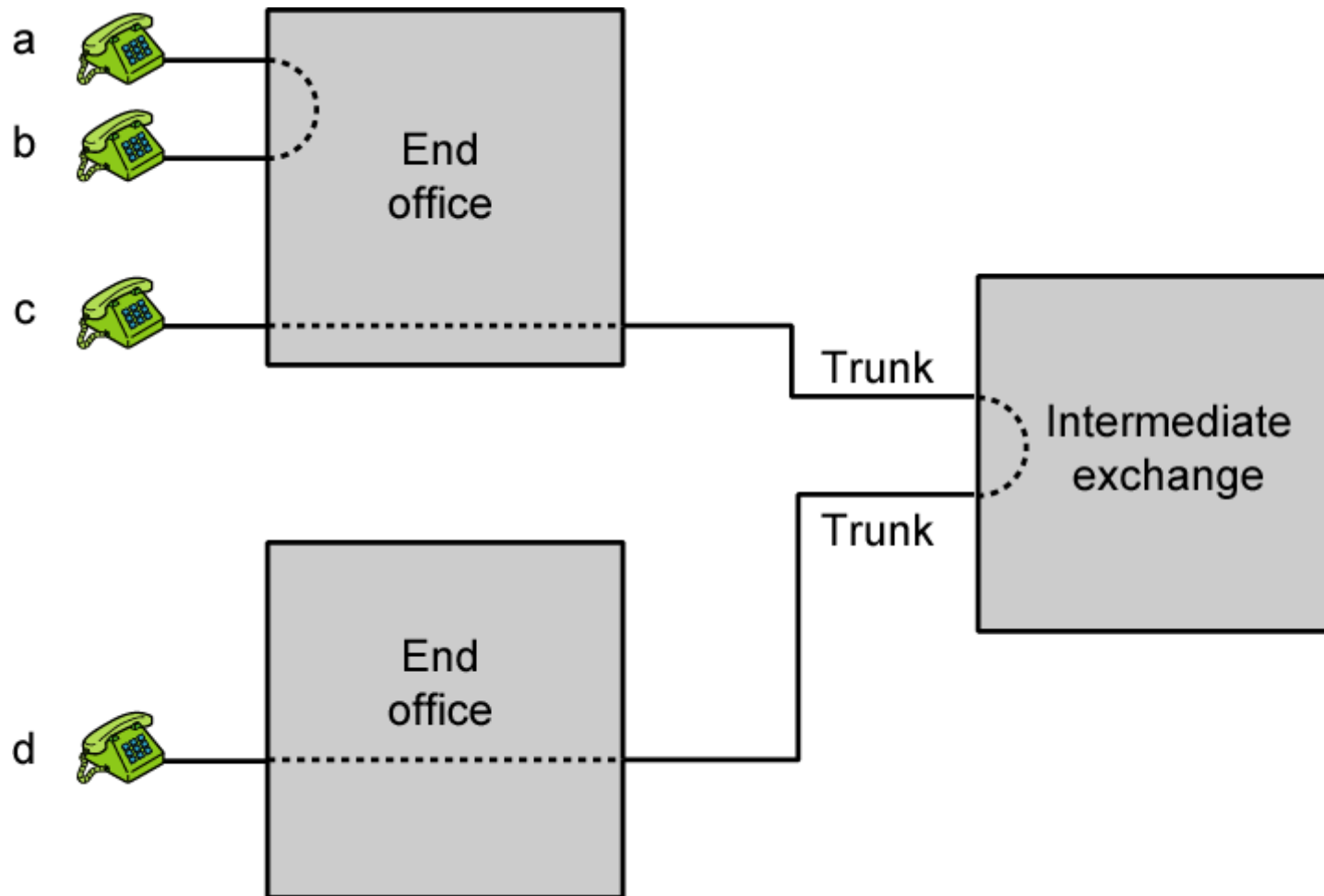
# Telecomms Components

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- Subscriber
  - Devices attached to network
- Subscriber line
  - Local Loop
  - Subscriber loop
  - Connection to network
  - Few km up to few tens of km
- Exchange
  - Switching centers
  - End office - supports subscribers
- Trunks
  - Branches between exchanges
  - Multiplexed

# Circuit Establishment

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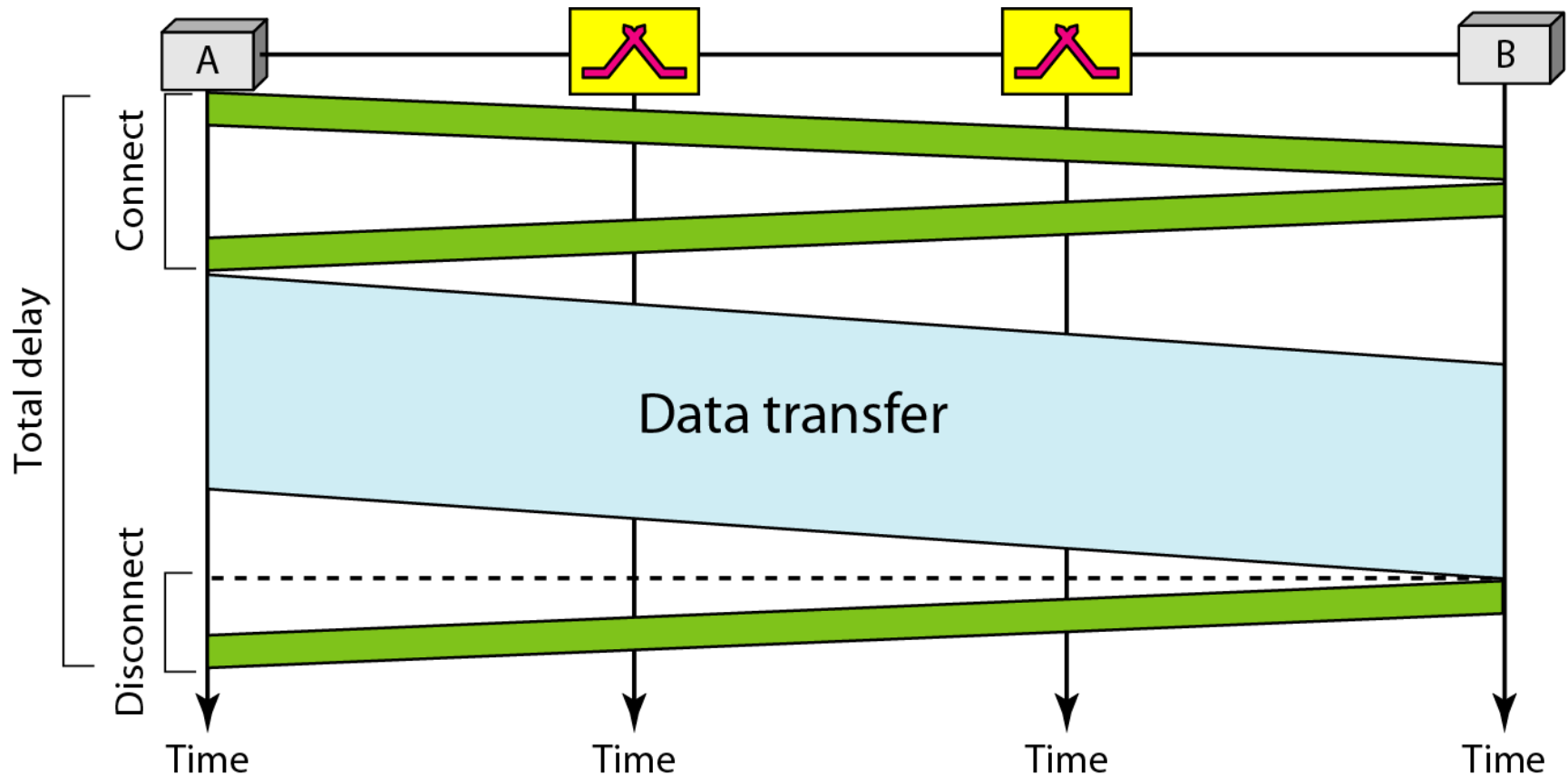


# Circuit Switching Concepts

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- Digital Switch
  - Provide transparent signal path between devices
- Network Interface
- Control Unit
  - Establish connections
    - Generally on demand
    - Handle and acknowledge requests
    - Determine if destination is free
    - construct path
  - Maintain connection
  - Disconnect

# Delay in a circuit-switched network



# Blocking or Non-blocking

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- Blocking
  - A network is unable to connect stations because all paths are in use
  - A blocking network allows this
  - Used on voice systems
    - Short duration calls
- Non-blocking
  - Permits all stations to connect (in pairs) at once
  - Used for some data connections



# Circuit switching

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- Advantages:

- The communication channel (once established) is dedicated.

- Disadvantages:

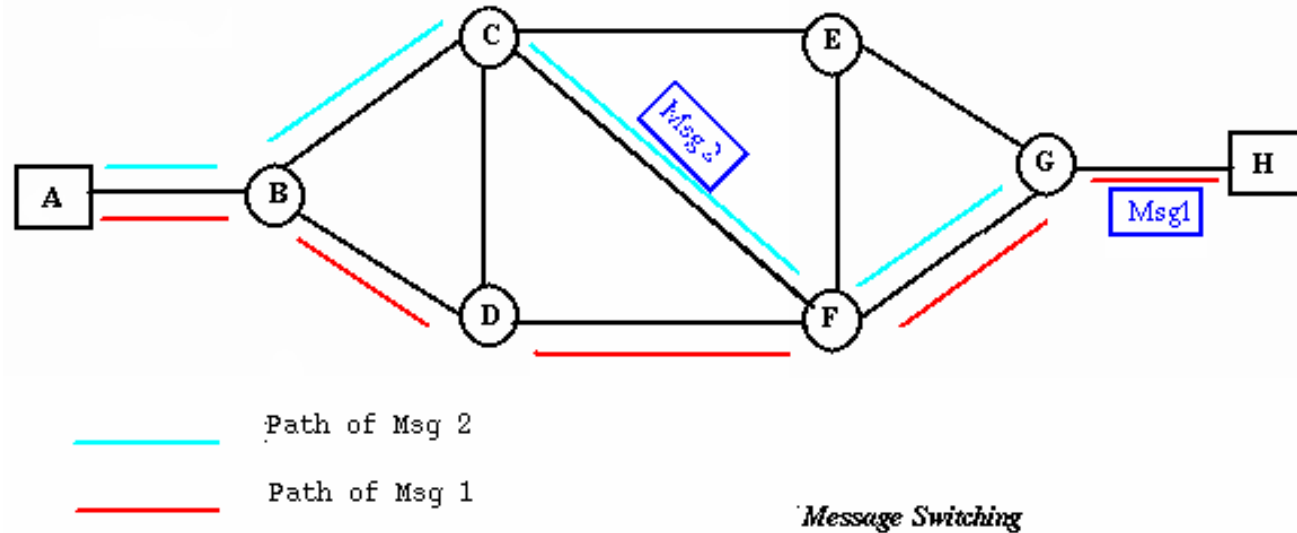
- Possible long wait to establish a connection, (10 seconds, more on long- distance or international calls.) during which no data can be transmitted.
- More expensive than any other switching techniques, because a dedicated path is required for each connection.
- Inefficient use of the communication channel, because the channel is not used when the connected systems are not using it.

# Message Switching

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- In message switching there is no need to establish a dedicated path between two stations.
- When a station sends a message, the destination address is appended to the message.
- The message is then transmitted through the network, in its entirety, from node to node.
- Each node receives the entire message, stores it in its entirety on disk, and then transmits the message to the next node.
- This type of network is called a **store-and-forward** network.

# Message Switching



A message-switching node is typically a general-purpose computer. The device needs sufficient secondary-storage capacity to store the incoming messages, which could be long. A time delay is introduced using this type of scheme due to store- and-forward time, plus the time required to find the next node in the transmission path.

# Advantages

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- Channel efficiency can be greater compared to circuit-switched systems, because more devices are sharing the channel.
- Traffic congestion can be reduced, because messages may be temporarily stored in route.
- Message priorities can be established due to store-and-forward technique.
- Message broadcasting can be achieved with the use of broadcast address appended in the message.

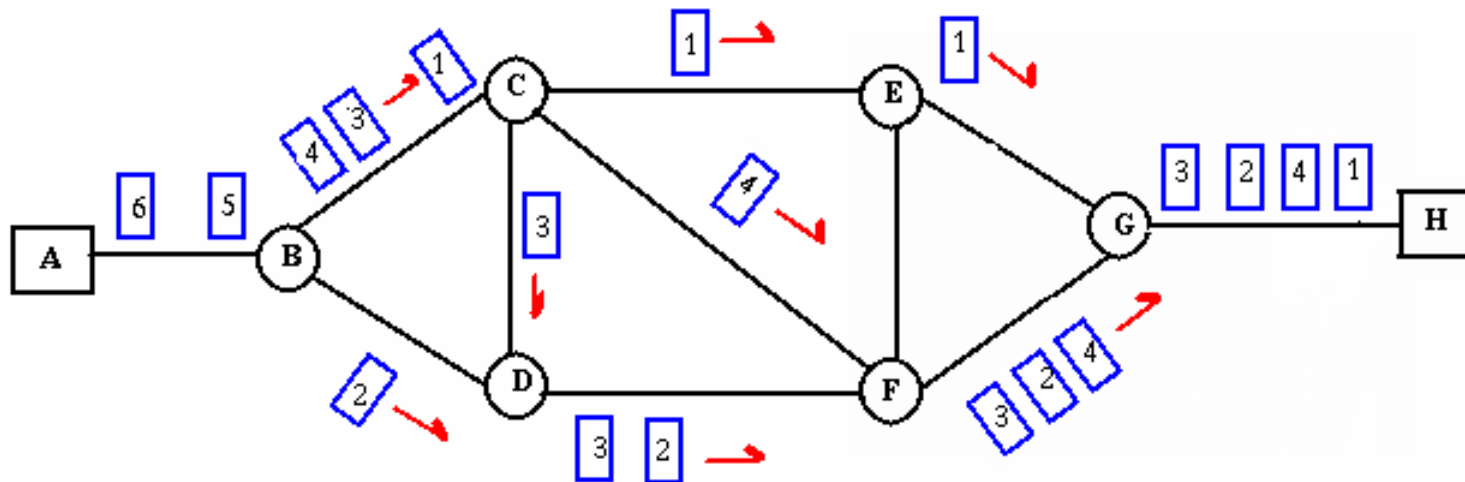
# Disadvantages

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- Message switching is not compatible with interactive applications.
- Store-and-forward devices are expensive, because they must have large disks to hold potentially long messages.

# Packet Switching

- Packet switching can be seen as a solution that tries to combine the advantages of message and circuit switching and to minimize the disadvantages of both.



*Packet Switching*

# Basic Operation

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- Data transmitted in small packets
  - Longer messages split into series of packets
  - Each packet contains a portion of user data plus some control info
- Control info
  - Routing (addressing) info
- Packets are received, stored briefly (buffered) and pass on to the next node
  - Store and forward

# Advantages

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- Line efficiency
  - Single node to node link can be shared by many packets over time
  - Packets queued and transmitted as fast as possible
- Data rate conversion
  - Each station connects to the local node at its own speed
  - Nodes buffer data if required to equalize rates
- Packets are accepted even when network is busy
  - Delivery may slow down
- Priorities can be used



# Switching Technique

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- Station breaks long message into packets
- Packets sent one at a time to the network
- Packets handled in two ways
  - Datagram
  - Virtual circuit

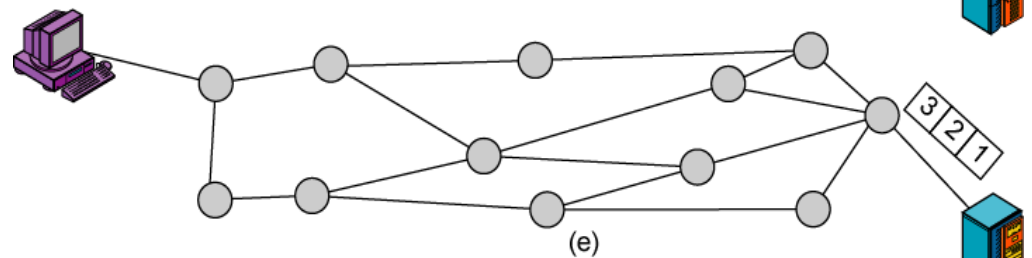
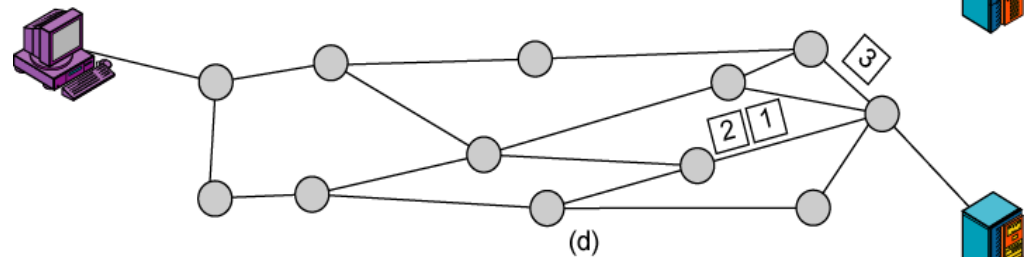
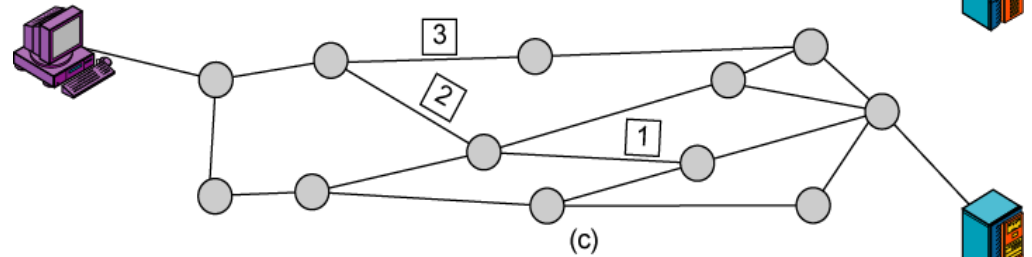
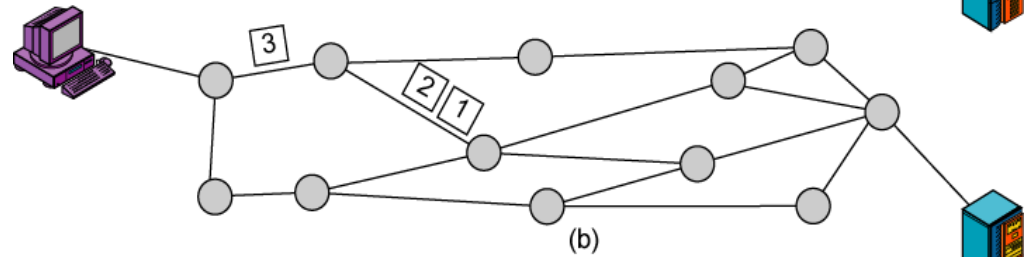
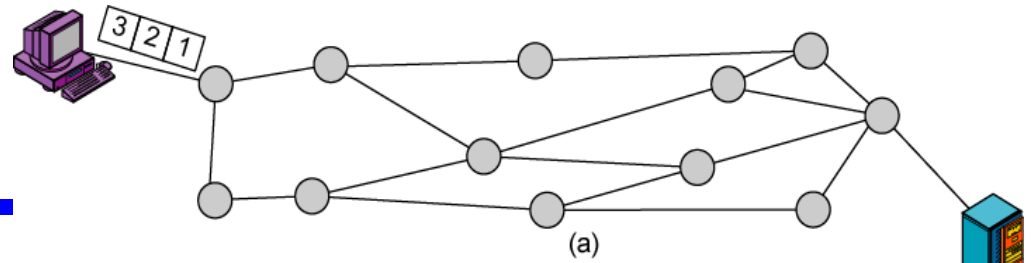
# **Datagram**

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- Each packet treated independently
- Packets can take any practical route
- Packets may arrive out of order
- Packets may go missing
- Up to receiver to re-order packets and recover from missing packets

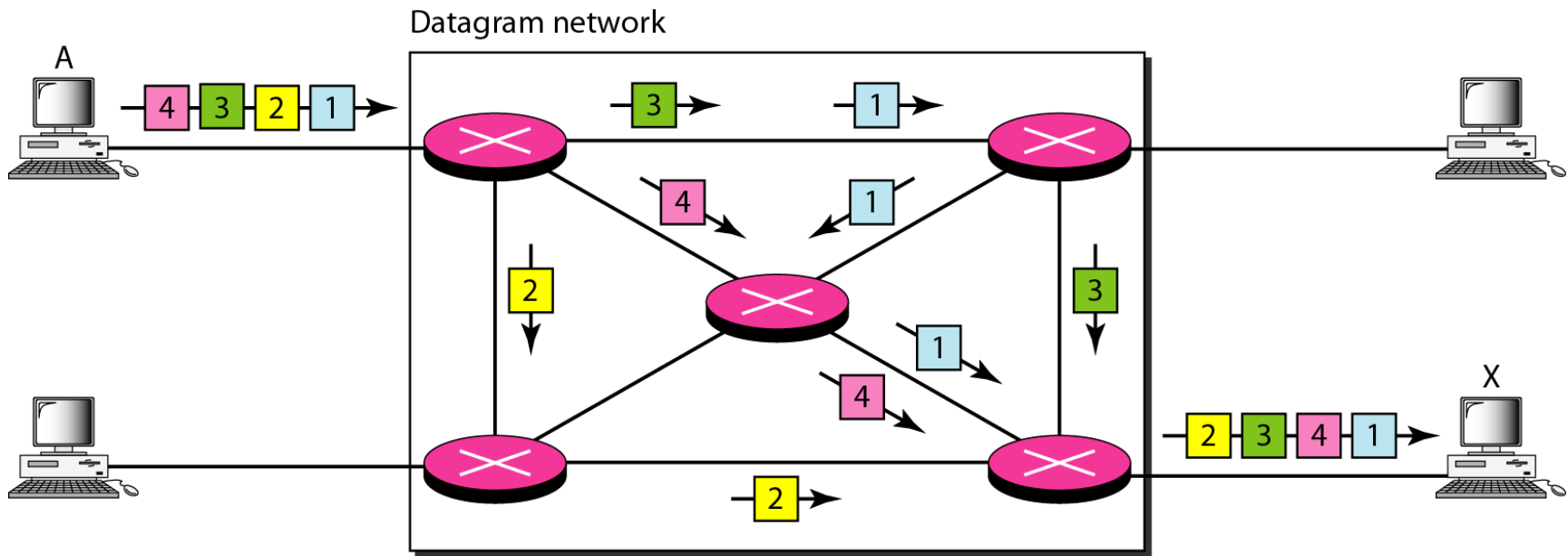
# Datagram Diagram

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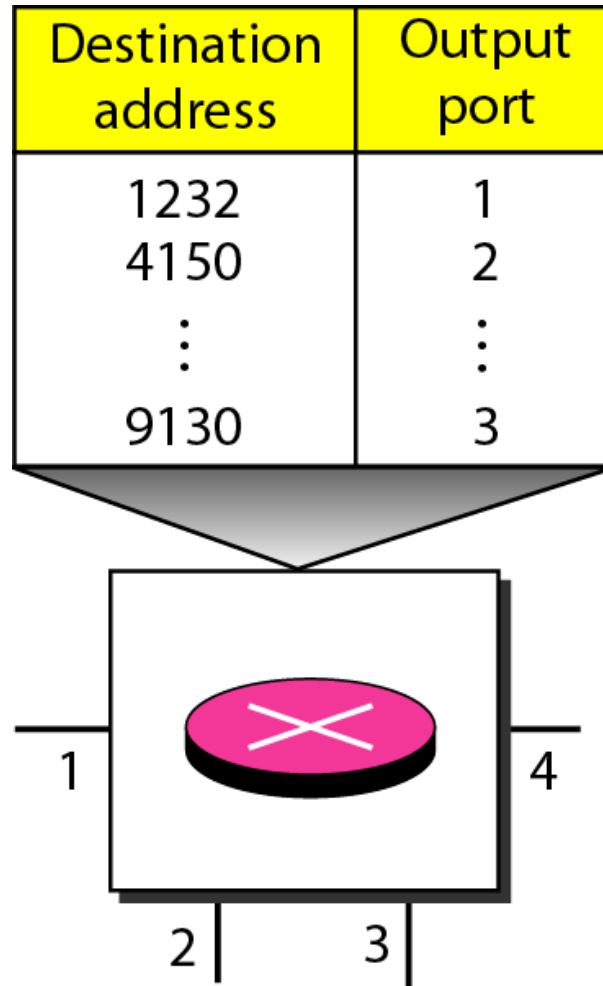
# A datagram network with four switches (routers)

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# Routing table in a datagram network

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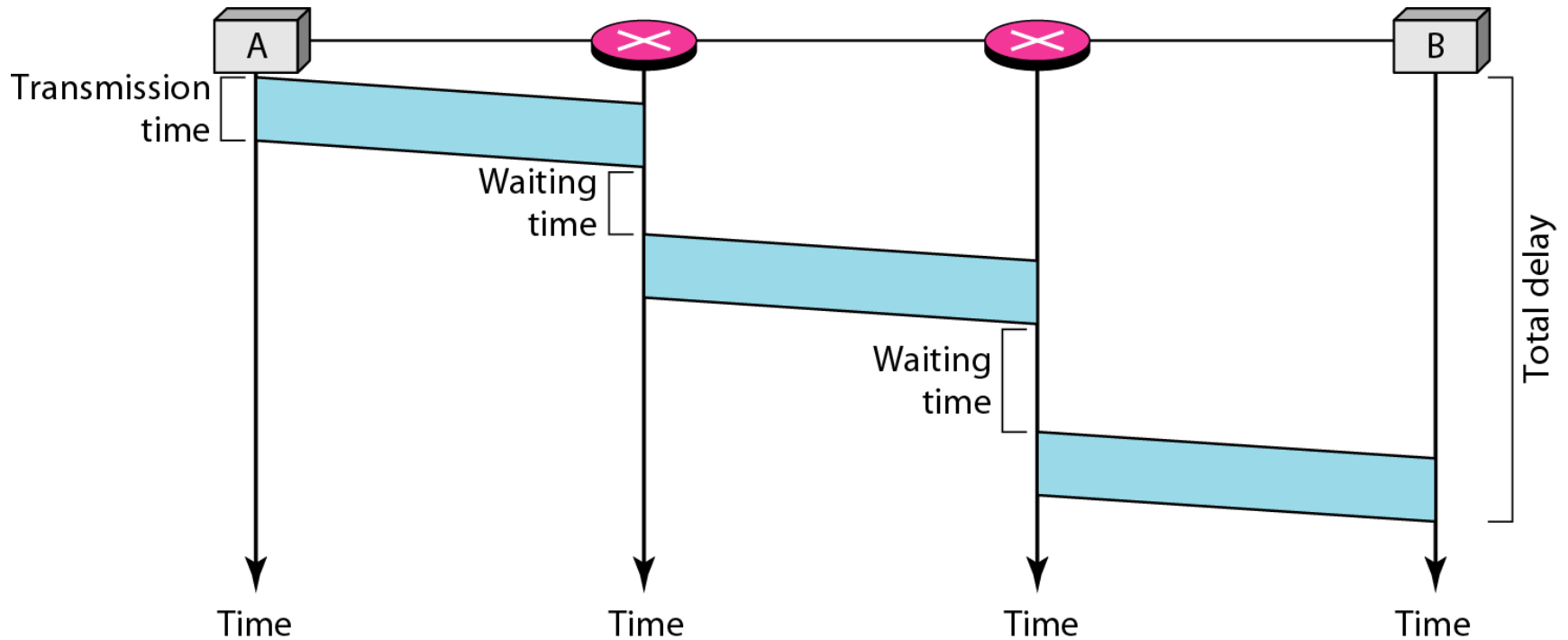
# **Datagram**

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**A switch in a datagram network uses a routing table that is based on the destination address.**

**The destination address in the header of a packet in a datagram network remains the same during the entire journey of the packet.**

# Delay in a datagram network



# **Datagram**

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**Switching in the Internet is done by using the datagram approach to packet switching at the network layer.**

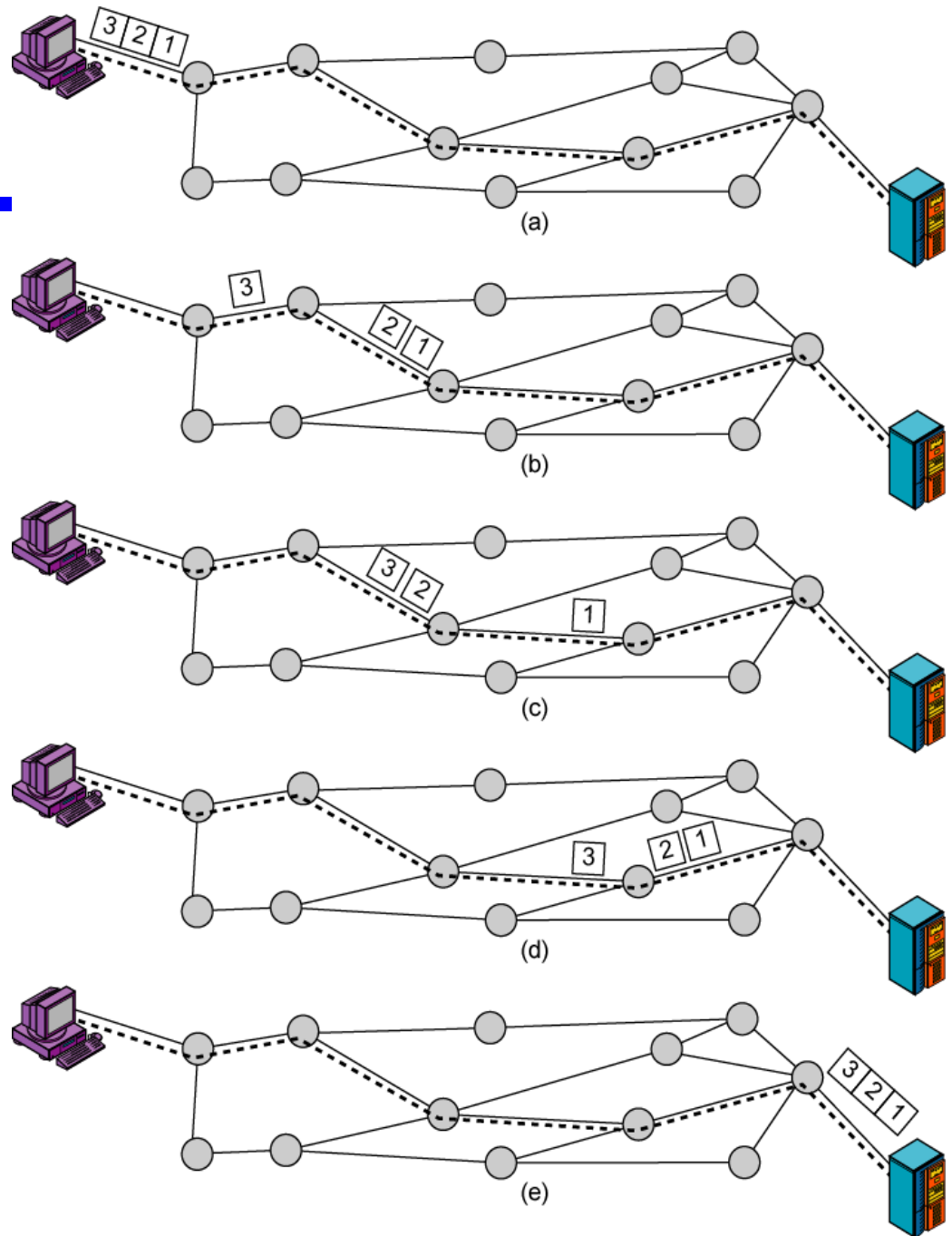


# Virtual Circuit

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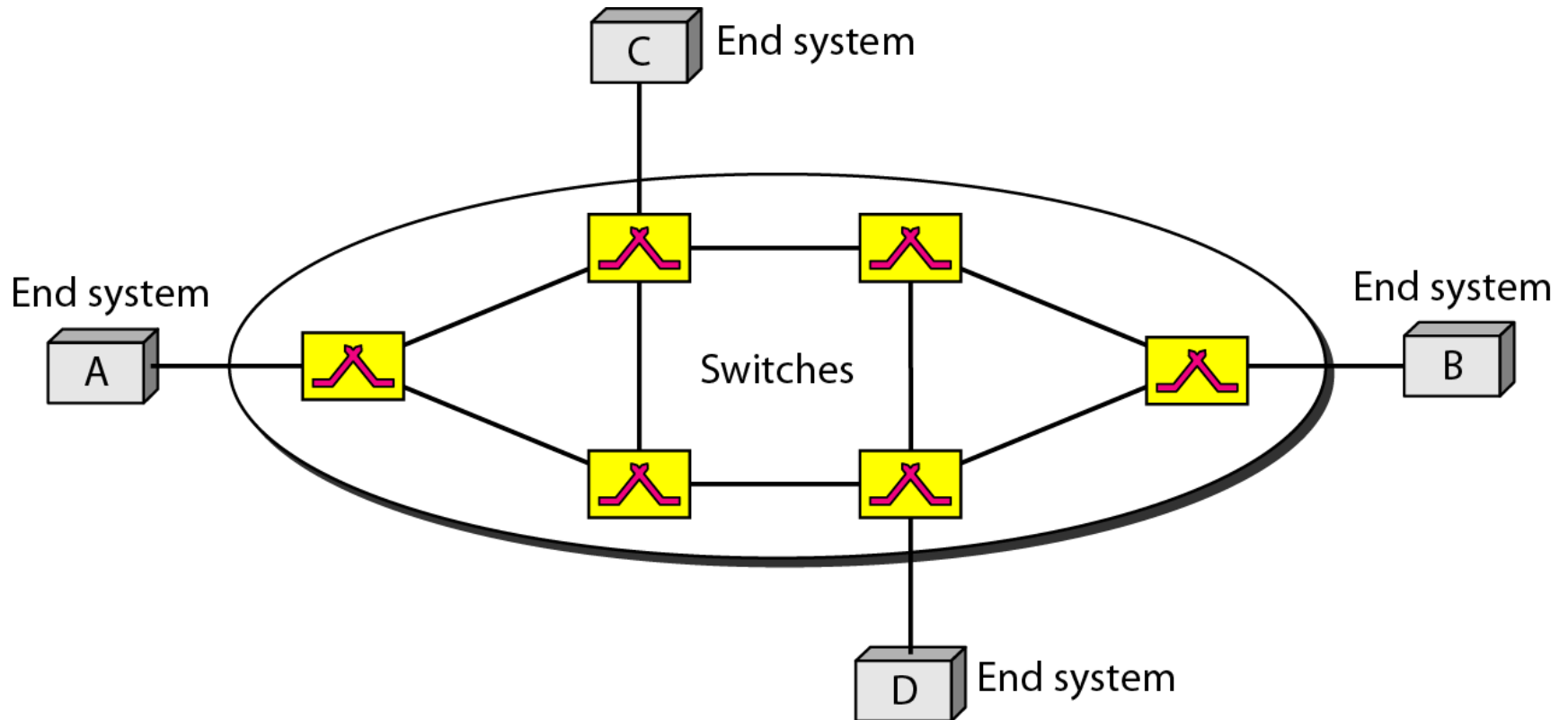
- Preplanned route established before any packets sent
- Call request and call accept packets establish connection (handshake)
- Each packet contains a virtual circuit identifier instead of destination address
- No routing decisions required for each packet
- Clear request to drop circuit
- Not a dedicated path

# Virtual Circuit Diagram



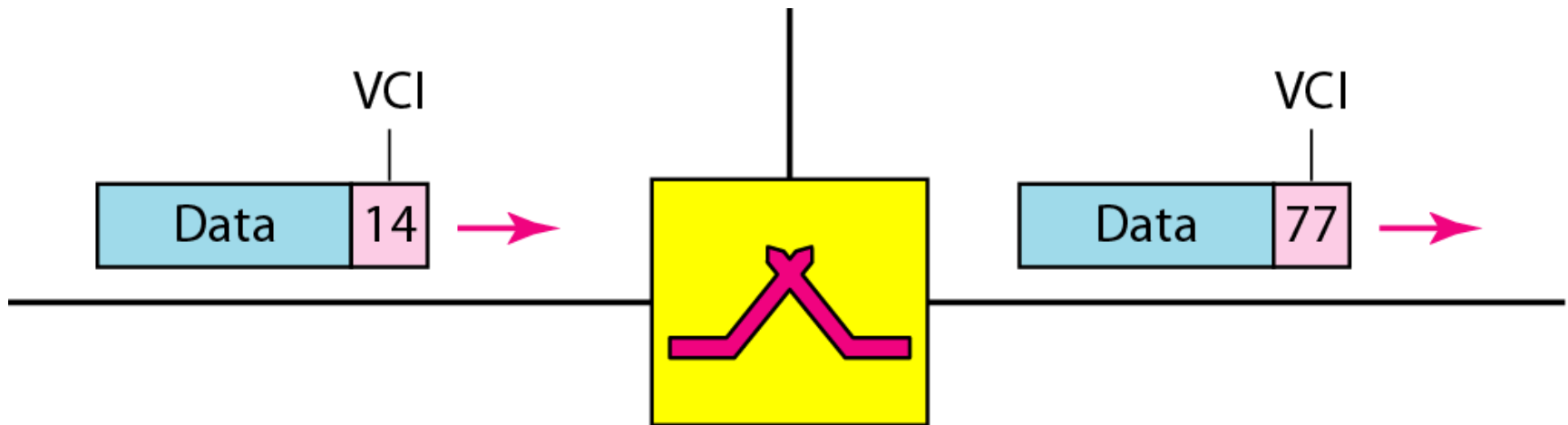
# Virtual-circuit network

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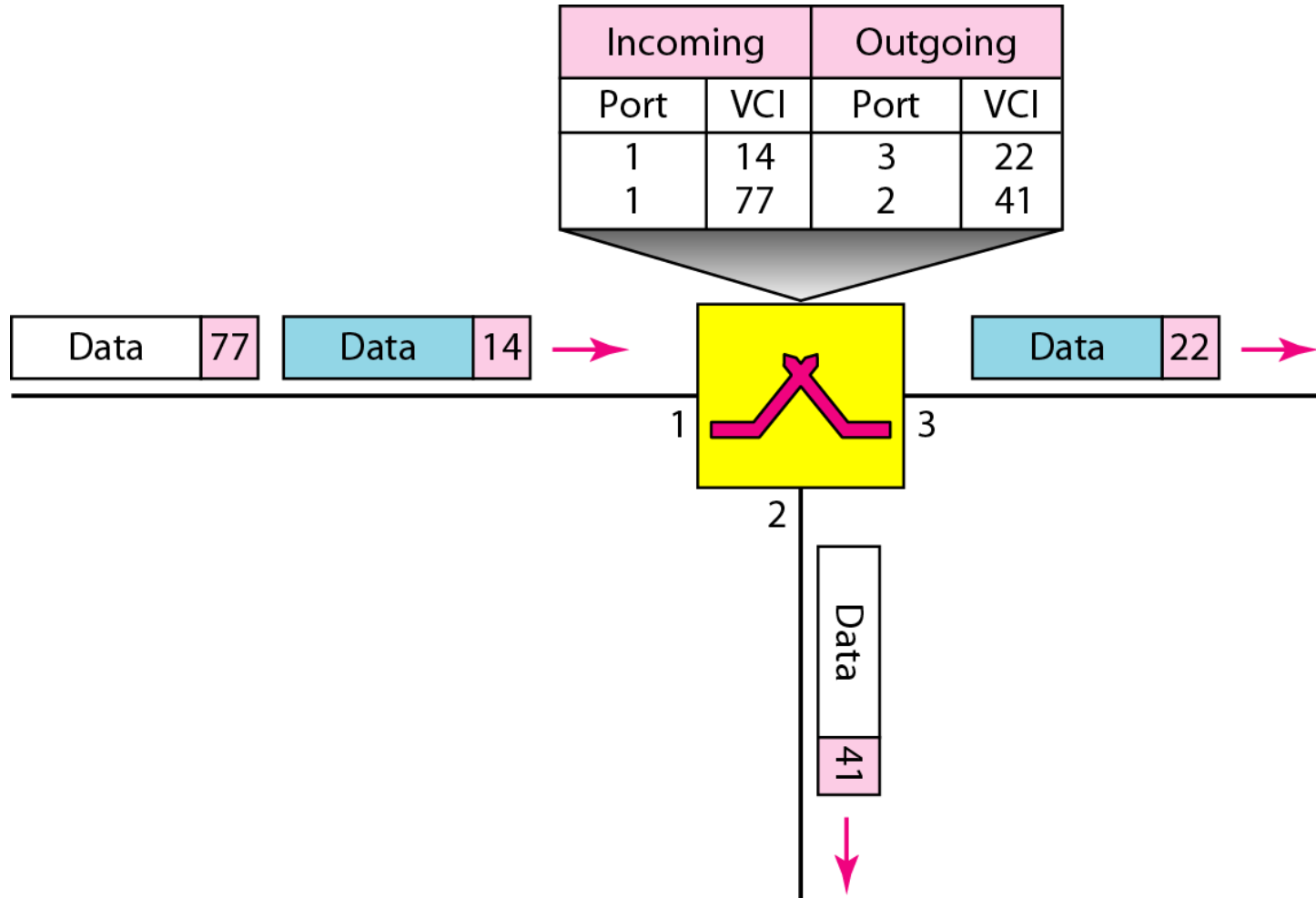


# Virtual-circuit identifier

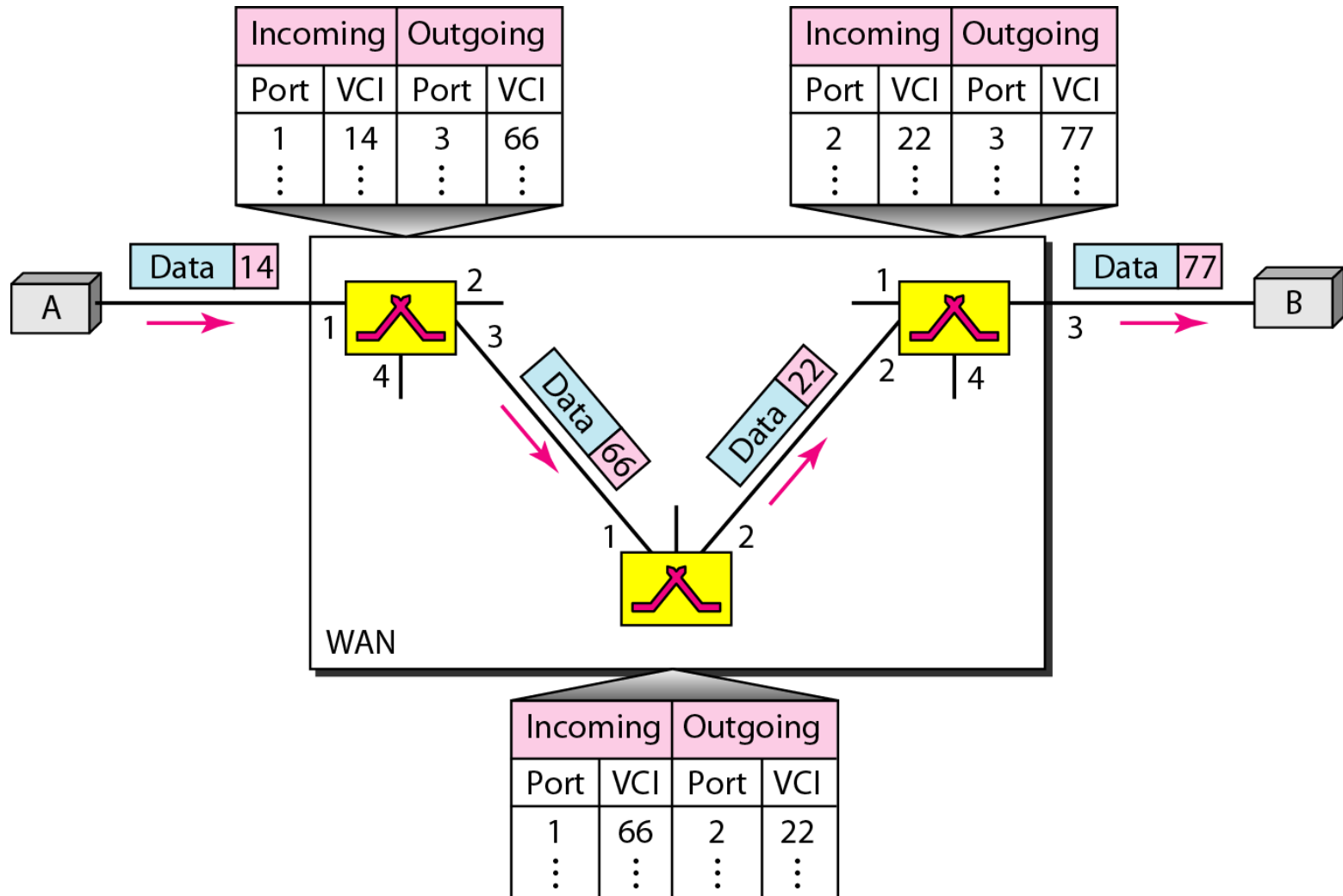
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# Switch and tables in a virtual-circuit network



# Source-to-destination data transfer in a virtual-circuit network



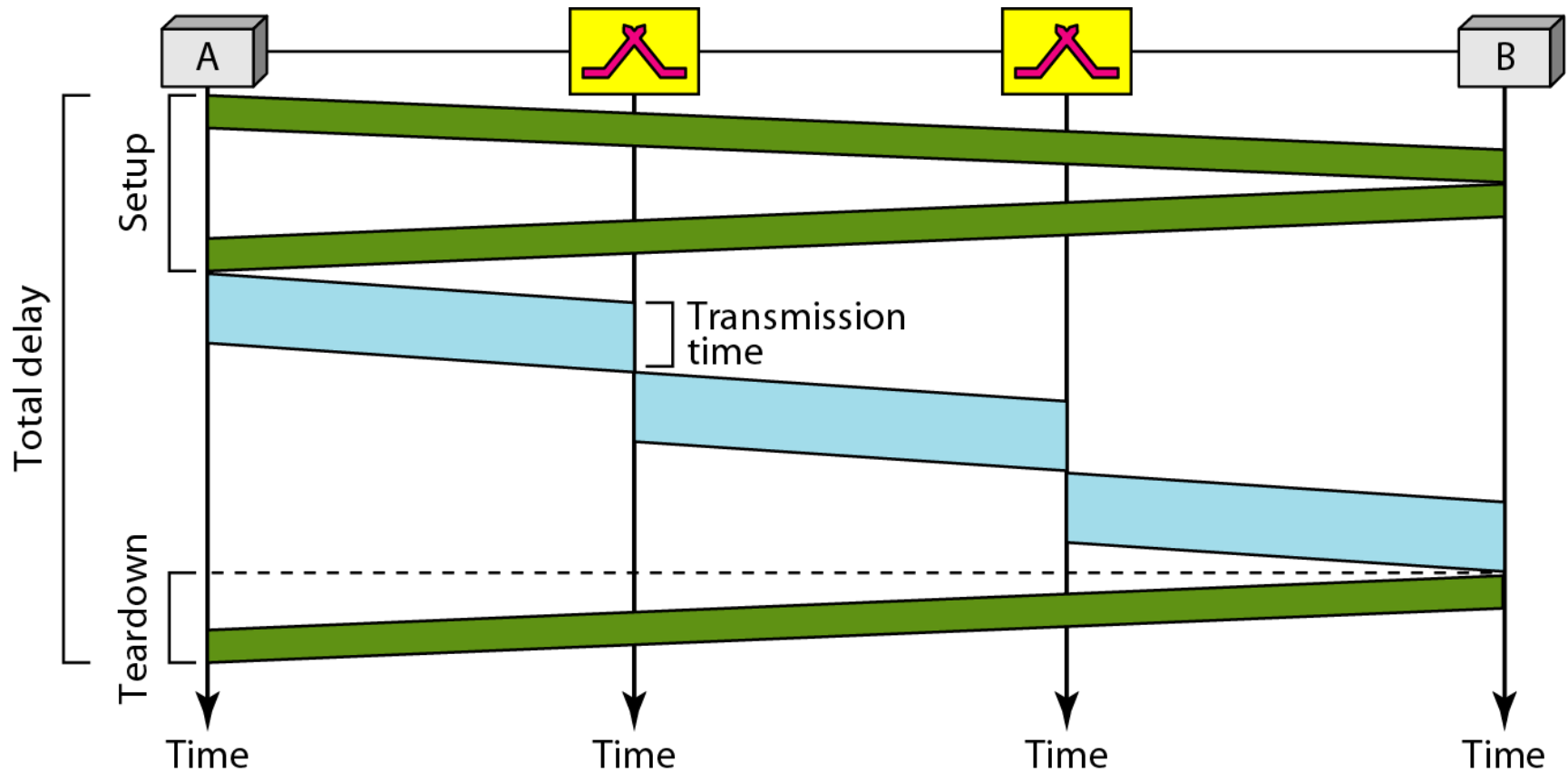
# **Virtual Circuits**

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**In virtual-circuit switching, all packets belonging to the same source and destination travel the same path; but the packets may arrive at the destination with different delays if resource allocation is on demand.**

**Switching at the data link layer in a switched WAN is normally implemented by using virtual-circuit techniques.**

# Delay in a virtual-circuit network





# Virtual Circuits v Datagram

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- Virtual circuits
  - Network can provide sequencing and error control
  - Packets are forwarded more quickly
    - No routing decisions to make
  - Less reliable
    - Loss of a node loses all circuits through that node
- Datagram
  - No call setup phase
    - Better if few packets
  - More flexible
    - Routing can be used to avoid congested parts of the network

# Advantages of packet switching

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- Packet switching is cost effective, because switching devices do not need massive amount of secondary storage.
- Packet switching offers improved delay characteristics, because there are no long messages in the queue (maximum packet size is fixed).
- Packet can be rerouted if there is any problem, such as, busy or disabled links.
- The advantage of packet switching is that many network users can share the same channel at the same time. Packet switching can maximize link efficiency by making optimal use of link bandwidth.

# Disadvantages of packet switching

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- Protocols for packet switching are typically more complex.
- It can add some initial costs in implementation.
- If packet is lost, sender needs to retransmit the data.
- Another disadvantage is that packet-switched systems still can't deliver the same quality as dedicated circuits in applications requiring very little delay - like voice conversations or moving images.