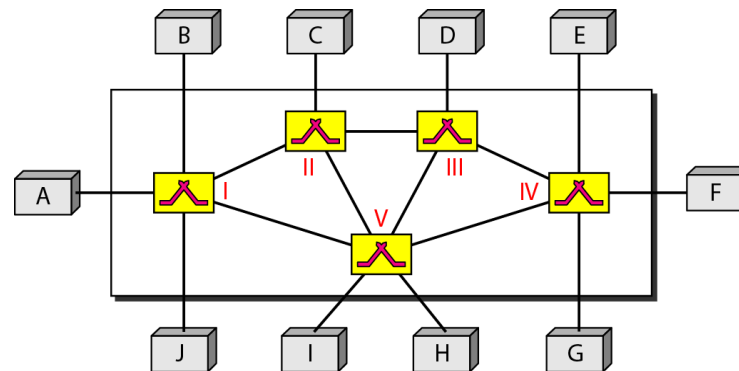


# Computer Network and Distributed Systems

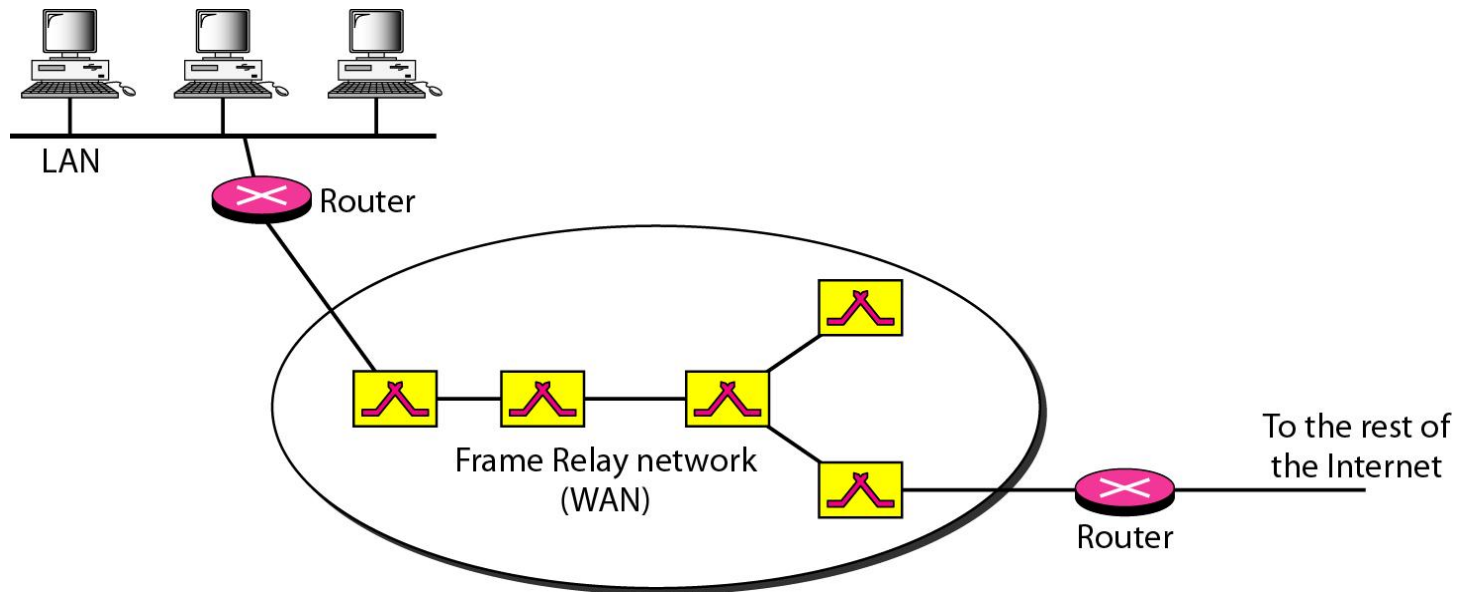
Wide Area Network and Switching

# WAN

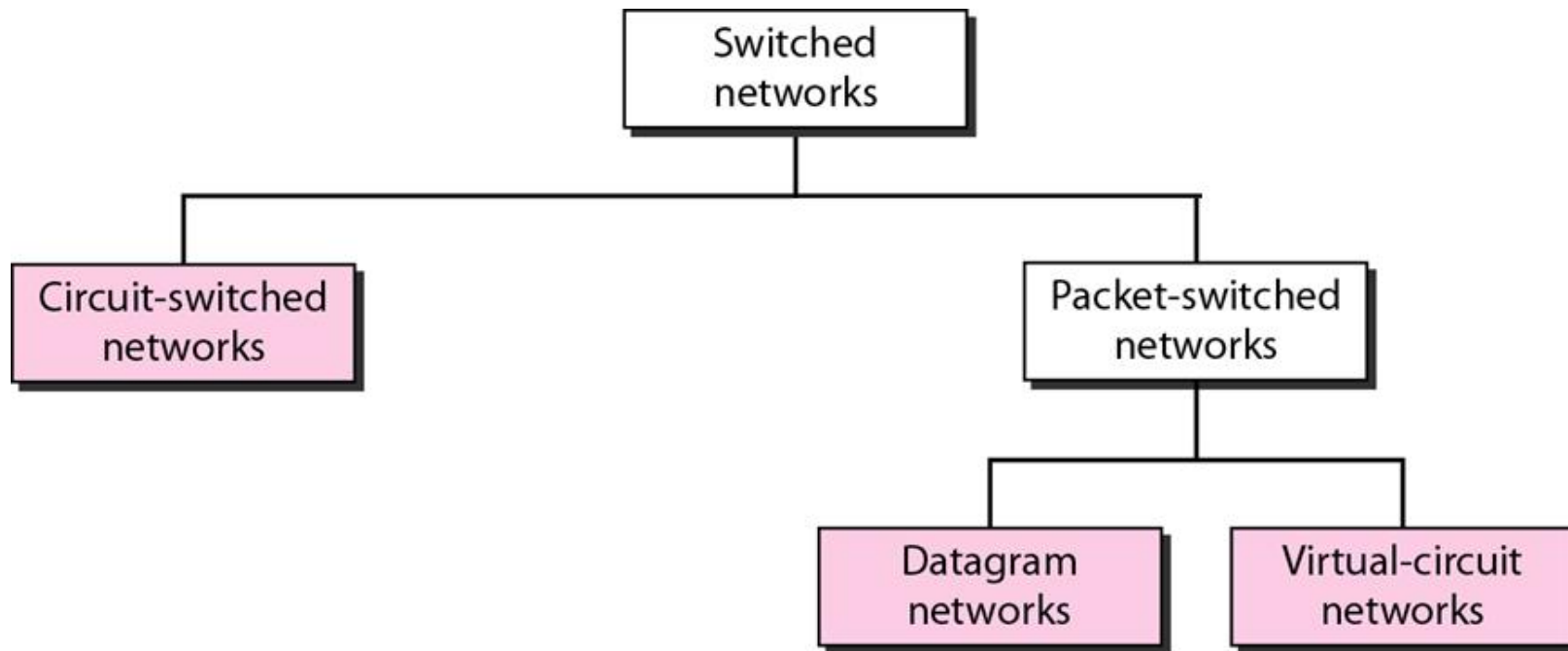
- ❑ Network spread over large geographic area
  - All nodes in WAN may not be directly connected to each other
  - Some redundant connections desirable for reliability
- ❑ Communication network: collections of nodes and connections
- ❑ Nodes of two types
  - End devices
  - Switching nodes
- ❑ Data sent by source node is switched from node to node until it reaches destination node



# A typical WAN



# Switching Methods



# Circuit Switching

- ❑ Before sending data, a dedicated communication path (circuit) set up between source node & destination node, using intermediate nodes
- ❑ Three phases
  - Establish: signaling to set up the path
  - Transfer: transfer data through the path
  - Disconnect: signaling to tear down connection
- ❑ Links in the path dedicated to a single connection
- ❑ All data sent from source follows the same path to the destination

## Circuit Switching (contd.)

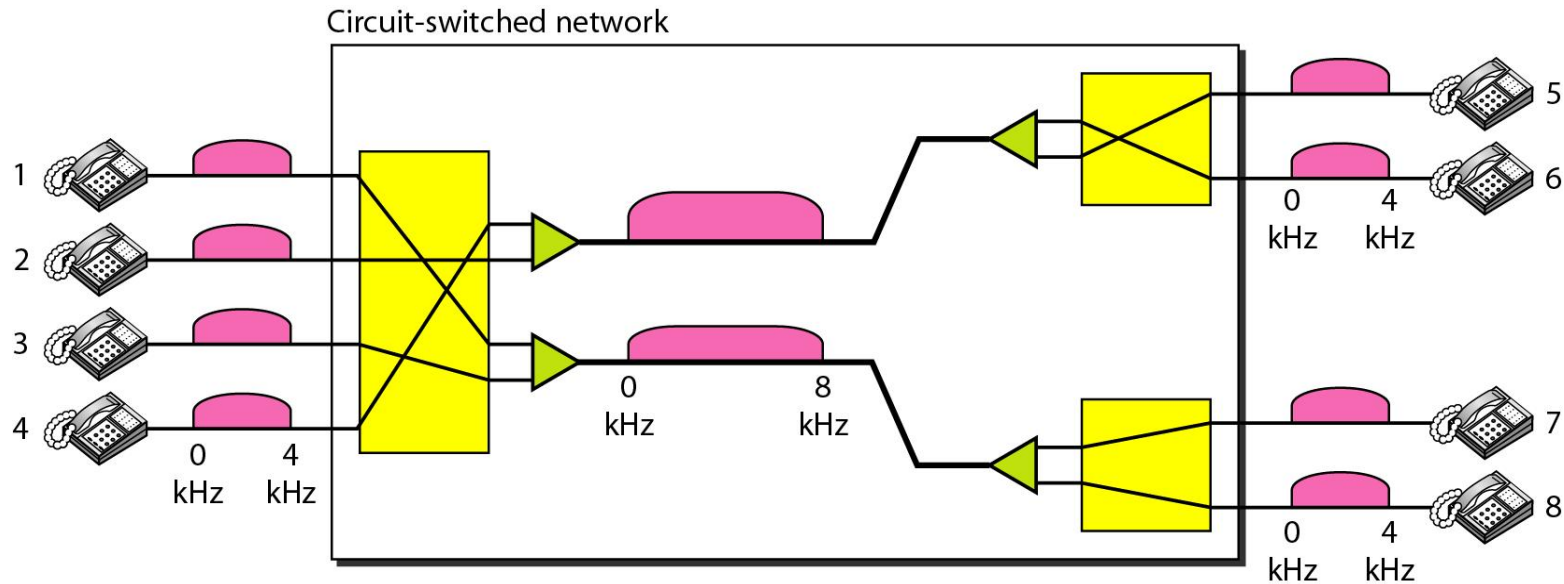
### □ Advantages

- Once connected, data transfer is fast
- Usually in-order reception of data at receiver

### □ Disadvantages

- Inefficient: Channel capacity dedicated for duration of connection, if no data transmitted, capacity wasted
- **Setting up connection takes time** (high overhead if only small amount of data to send)
- Failure of any intermediate node breaks connection
- Less flexibility: if one node slows down, entire circuit slows down

## An example of Circuit-switched network



Here assumed that each link uses FDM to connect maximum two voice channels. Bandwidth of each link is then 8KHz.

# Packet Switching

- ❑ Data transmitted in short units called packets
  - Maximum packet size is pre-defined
  - Longer messages split into sequence of packets
  - Each packet contains a portion of user data plus some control information (address, error check info, sequence info, ...)
- ❑ Intermediate nodes receive packets, store briefly (buffer) and pass on to next node – Store and Forward
- ❑ Packet switching handled in two ways
  - Datagram approach
  - Virtual circuit approach



# Advantages of packet switching

## ❑ 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

- Nodes buffer data if required to equalize rates

## ❑ Packets are accepted even when network is busy

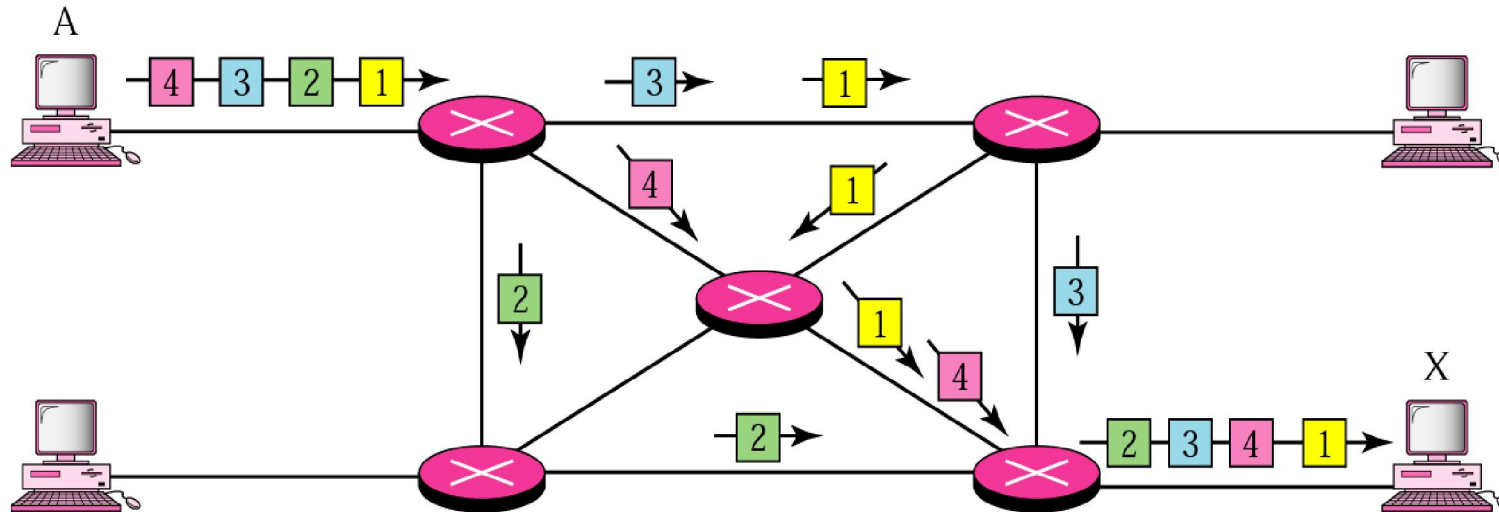
- Delivery may slow down

## ❑ Priorities can be used

## Datagram approach

- ❑ Each packet treated independently of any other packet (each packet has destination address)
- ❑ Packets sent by a source node can take different routes to the same destination
- ❑ Packets may arrive out of order at destination node, may be lost
  - Up to destination node to re-order packets and recover from missing packets

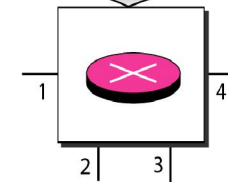
# Datagram Approach



- ❑ 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

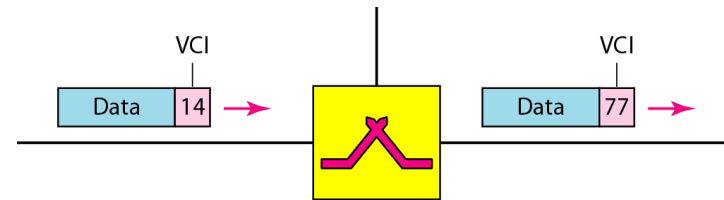
Destination address	Output port
1232	1
4150	2
⋮	⋮
9130	3

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



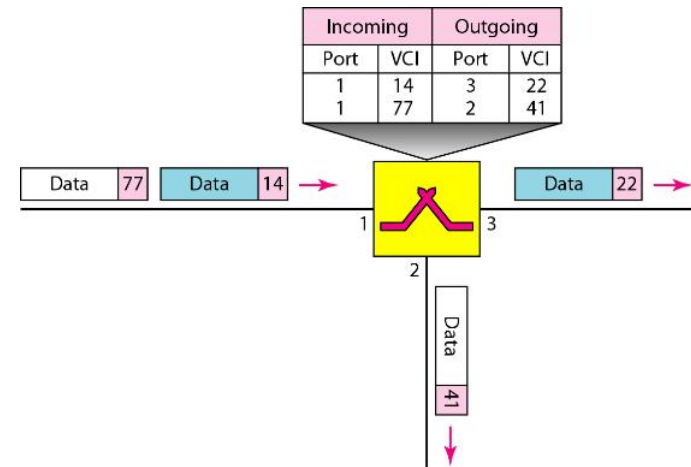
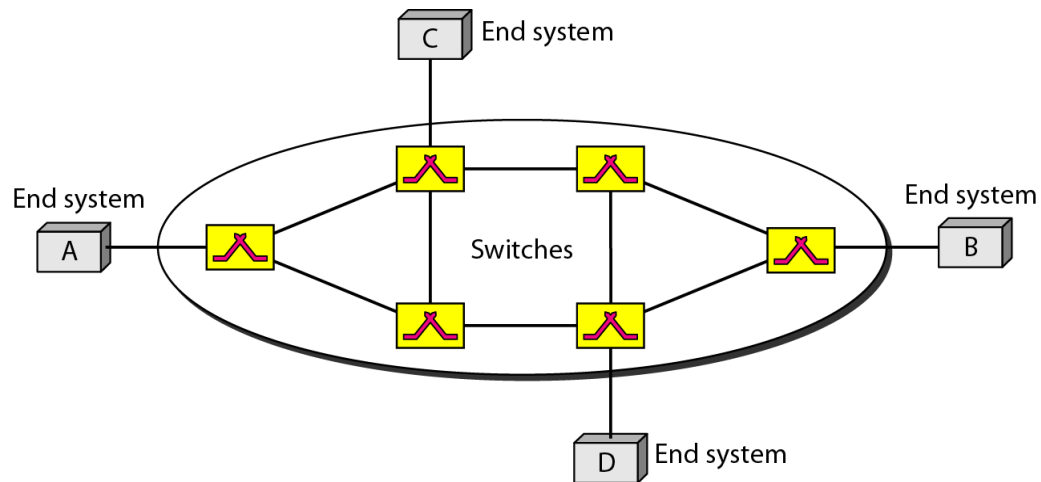
## Virtual Circuit Approach

- ❑ Pre-planned route or '**circuit**' established between source & destination before any data packets sent
  - Establish circuit: call request and call accept packets
  - Disconnect: clear request packets exchanged at the end
  - Each node maintains information about each virtual circuit passing through itself, in a table
  - Each packet contains a **Virtual Circuit Identifier (VCI)** instead of destination address



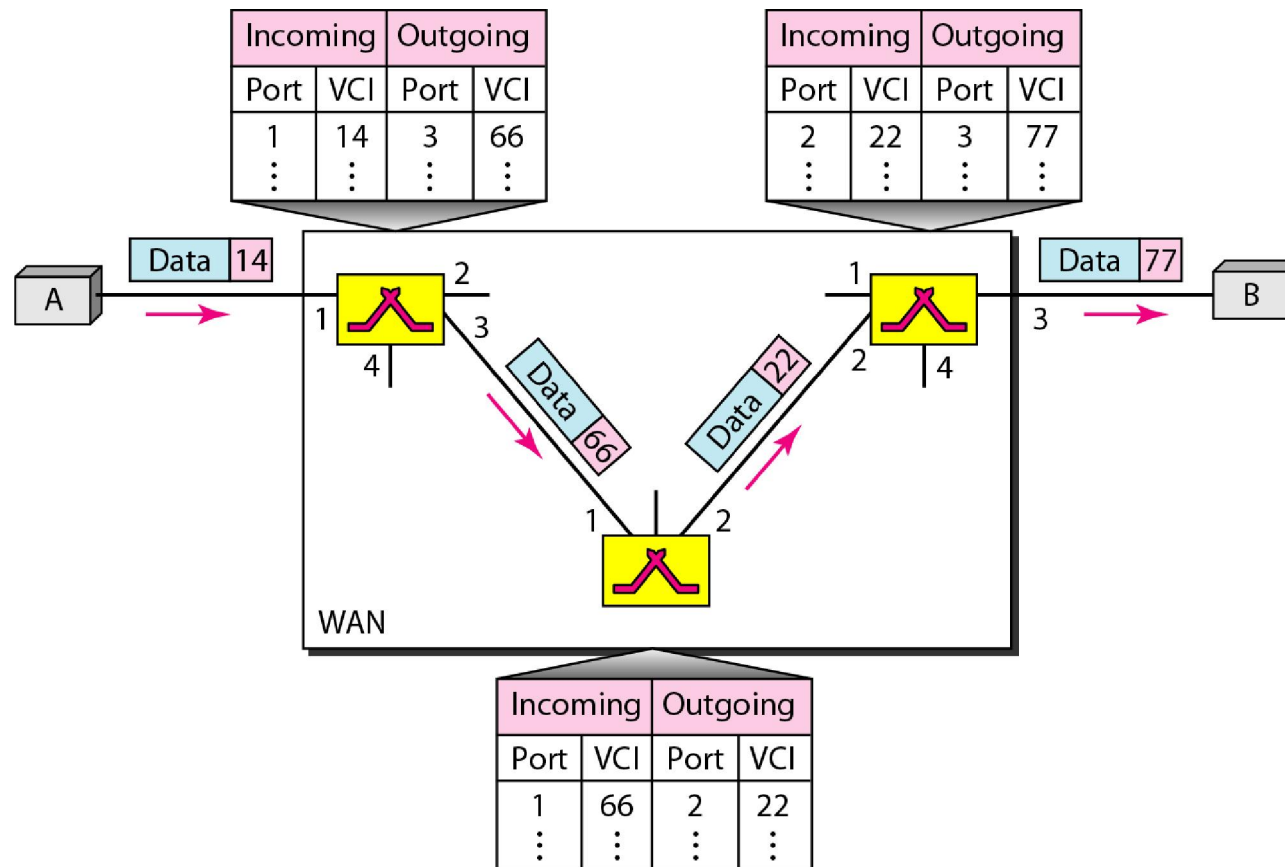
- ❑ The links in a path are NOT dedicated – may be shared among different virtual circuits

# Virtual-circuit network

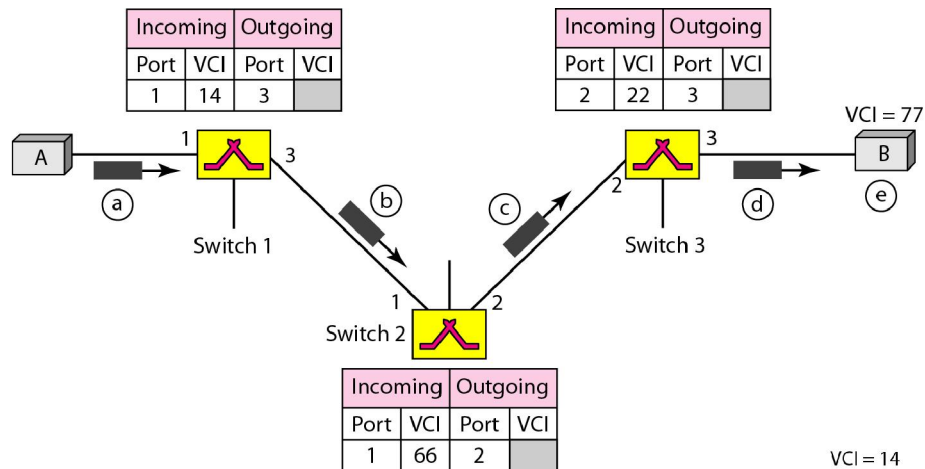


- ❑ Unlike global address, VCI is a small number that has only switch scope, it is used by a frame between two switches. When a frame arrives at a switch, it has a VCI, when it leaves, it has a different VCI.
- ❑ Switching at the data link layer in a switched WAN is normally implemented by using virtual-circuit techniques

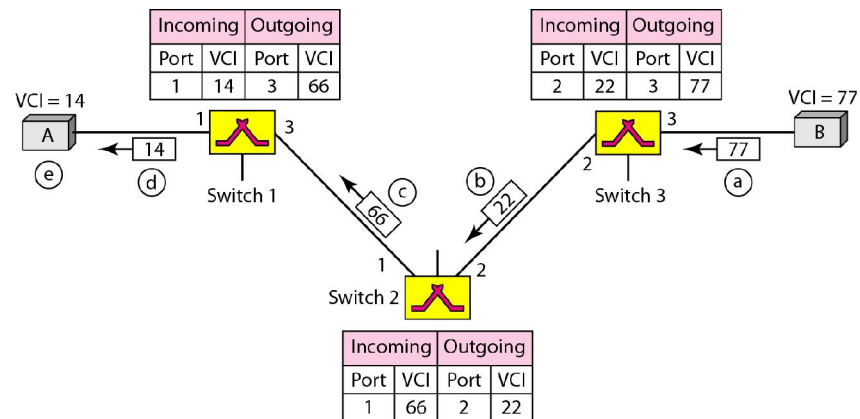
## Source-to-destination data transfer in a virtual-circuit network



# Setup request and Setup acknowledgment in a virtual-circuit network



*SetupRequest*



*SetupAck*

# Virtual Circuit vs Datagram

## ❑ Virtual circuit

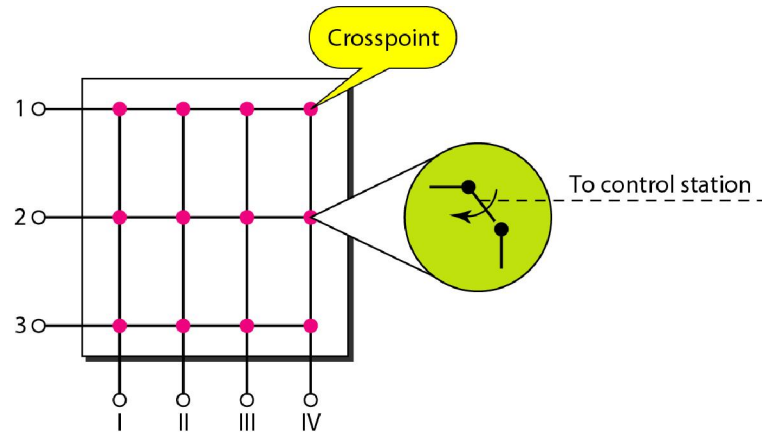
- Network can provide sequencing and error control
- Packets are forwarded more quickly
- Less reliable: loss of a node disconnects all circuits through that node

## ❑ Datagram

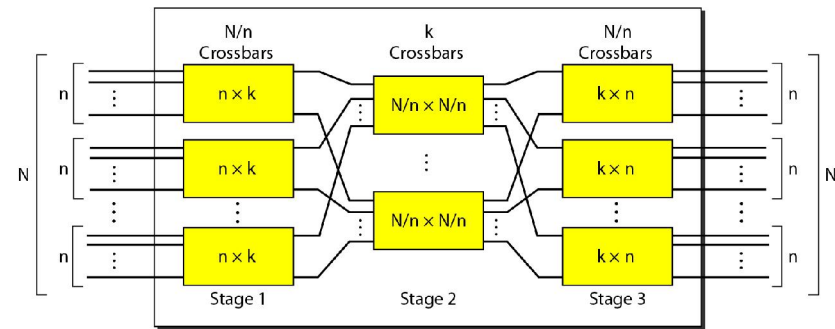
- No call setup phase, better if few packets to be sent
- More flexible
  - ✓ Routing can be used to avoid congested parts of the network
  - ✓ Communication can go on even if any node fails
- Packets may arrive out-of-order at destination



# Switches in circuit-switched network



*Crossbar switch with three inputs and four outputs*



*Multistage switch*

# Switches in packet-switched network

