

# **BROADBAND AND HIGH SPEED NETWORKS**

# 2

## Switching

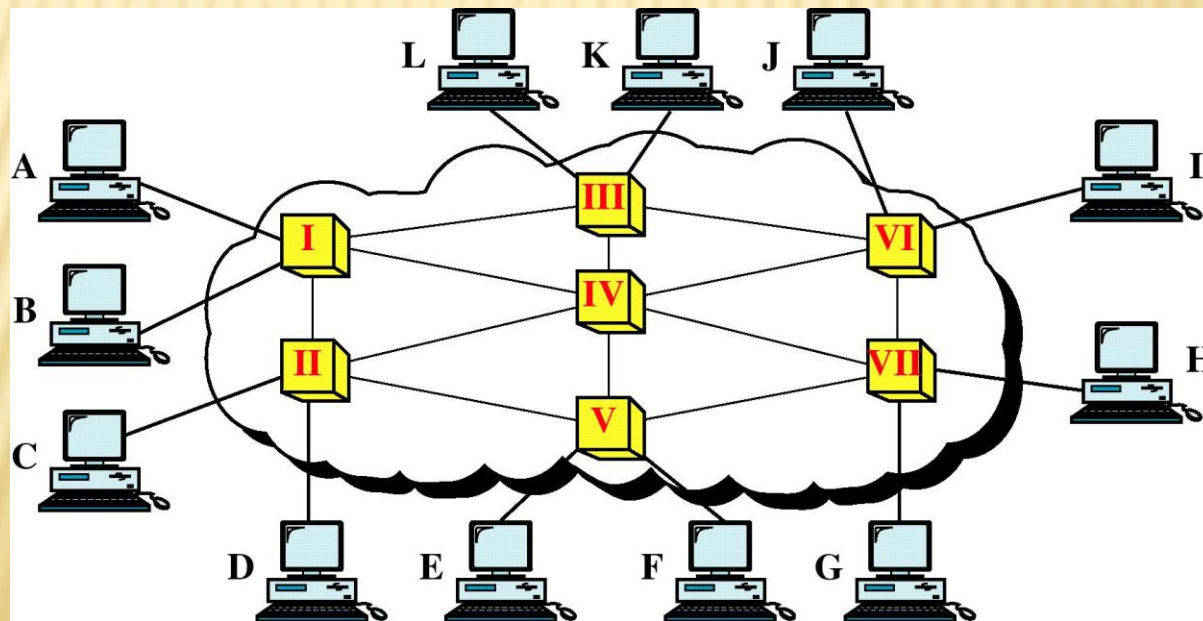
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# SWITCHING

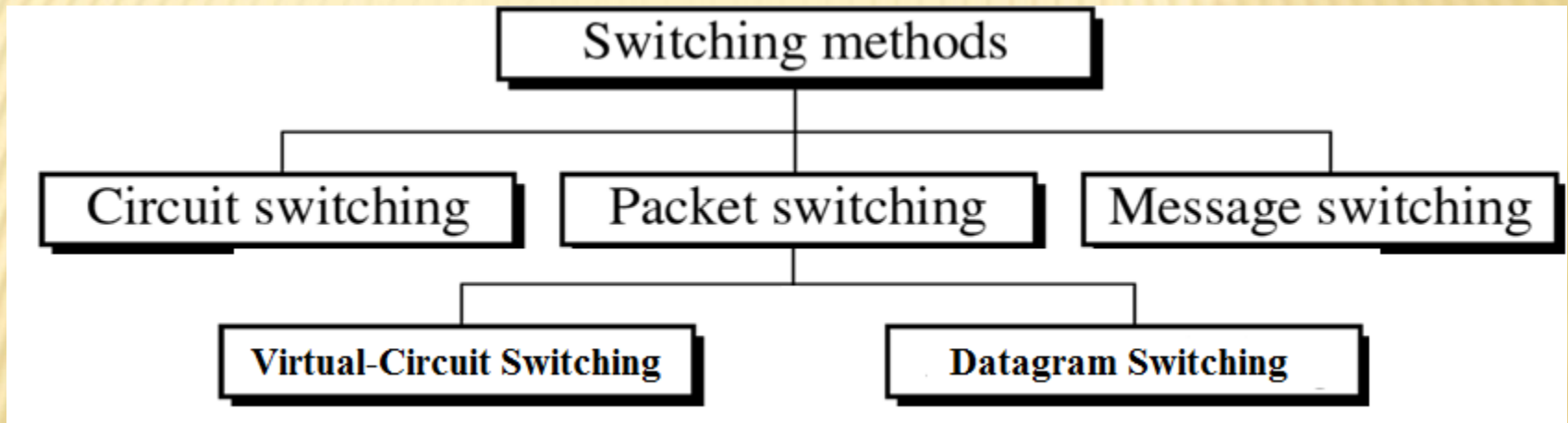
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A switch is a mechanism that allows us to interconnect links to form a larger network. A switch is a multi-input, multi-output device, which transfers packets from an input to one or more outputs.

A switched network consists of a series of interlinked nodes, called switches. Switches are devices capable of creating temporary connections between two or more devices linked to the switch. In a switched network, some of these nodes are connected to the end systems (computers or telephones, for example). Others are used only for routing.



# SWITCHING NETWORK CATEGORIES



# CIRCUIT-SWITCHED NETWORK

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 (channels).
- Each link is normally divided by using FDM or TDM into  $n$  channels .

**Time-division multiplexing (TDM)** is a method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line so that each signal appears on the line only a fraction of time in an alternating pattern.

**Frequency-division multiplexing (FDM)** is a technique by which the total bandwidth available in a communication medium is divided into a series of non-overlapping frequency sub-bands, each of which is used to carry a separate signal. These sub-bands can be used independently with completely different information streams, or used dependently in the case of information sent in a parallel stream.

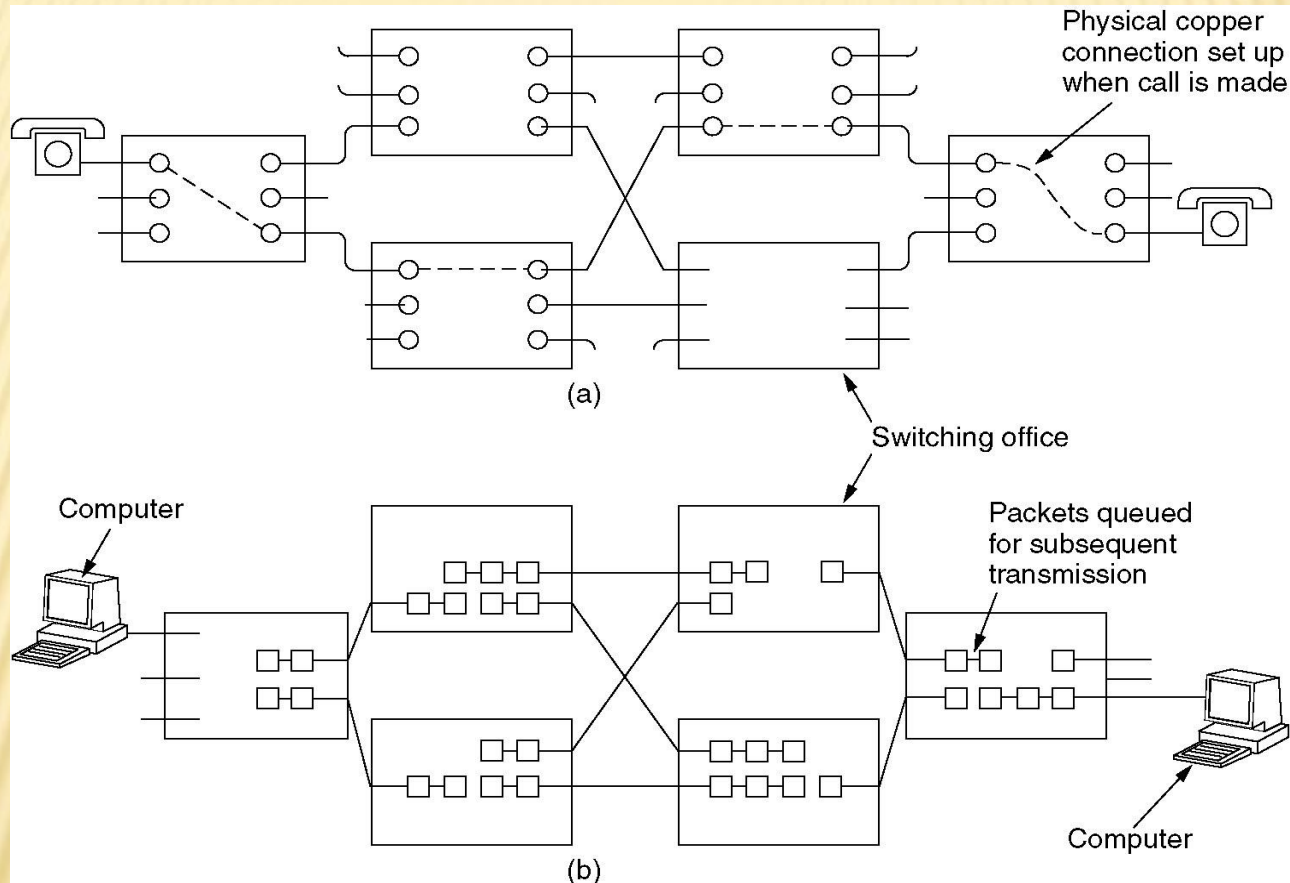
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The actual communication in a circuit-switched network requires three phases:

- Connection setup,
  - Data transfer, and
  - Remove connection.
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- Circuit switching takes place at the physical layer.
    - Before starting communication, the stations must make a reservation for the resources to be used during the communication.  
These resources, such as channels (bandwidth in FDM and time slots in TDM), switch buffers, switch processing time, and switch input/output ports, must remain dedicated during the entire duration of data transfer until the teardown phase.
  - Data transferred between the two stations are not packetized (physical layer transfer of the signal). The data are a continuous flow sent by the source station and received by the destination station, although there may be periods of silence.
  - No addressing involved during data transfer. The switches route the data based on their occupied band (FDM) or time slot (TDM). There is end-to-end addressing used during the setup phase.

# PACKET-SWITCHED NETWORK

- ❖ **Packet-switched Network** is a digital networking communications method that groups all transmitted data into suitably sized blocks, called packets. Variable-bit-rate data streams (sequences of packets) delivered over a shared network. When traversing network adapters, switches, routers and other network nodes, packets are buffered and queued, resulting in variable delay and throughput depending on the traffic load in the network.
- ❖ Packet switching contrasts with circuit switching, a method which sets up a limited number of dedicated connections of constant bit rate and constant delay between nodes for exclusive use during the communication session. In case of traffic fees, for example in cellular communication services, circuit switching is characterized by a fee per time unit of connection time, even when no data is transferred, while packet switching is characterized by a fee per unit of information.



**(a) Circuit switching**

**(b) Packet switching**



# PACKET-SWITCHING NETWORKS

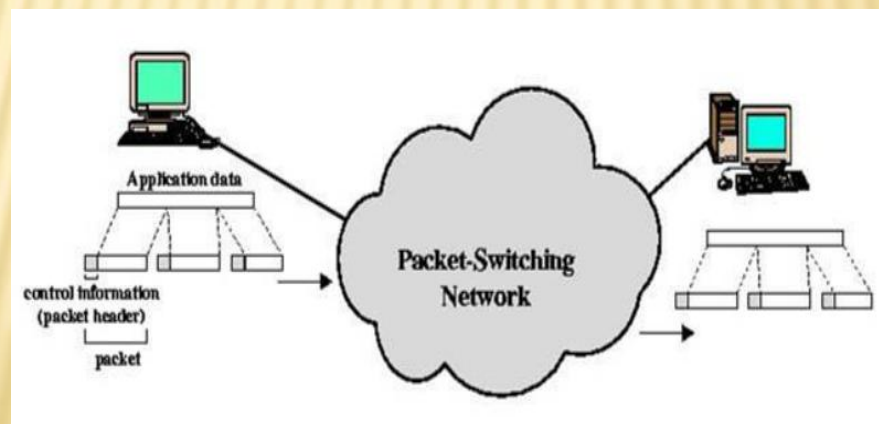
- ❑ One of the few effective technologies for long distance data communications
- ❑ Frame relay and ATM are variants of packet-switching

## Advantages:

- flexibility, resource sharing, robust, responsive

## Disadvantages:

- Time delays in distributed network.
- Need for routing and congestion control



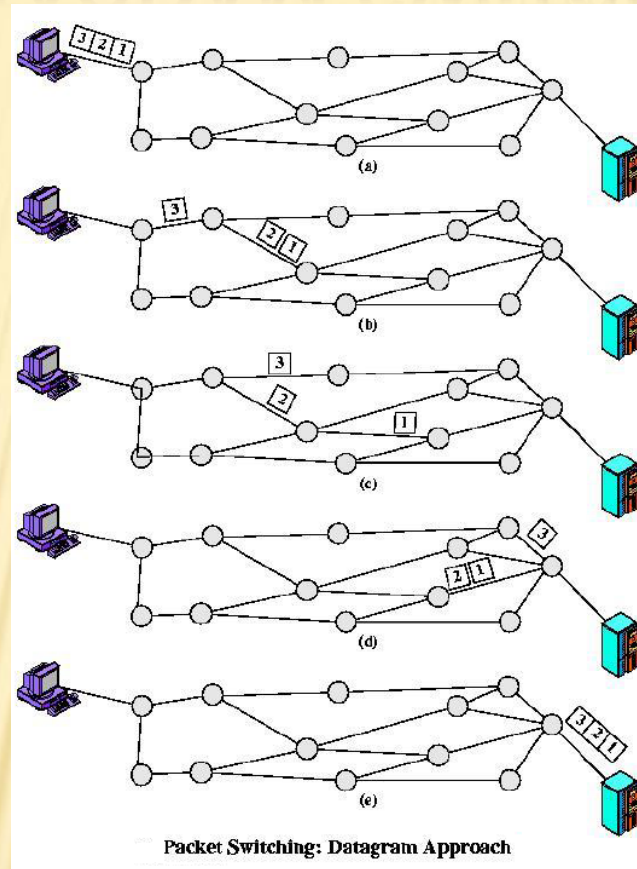
**The Use of Packets**

# TWO MAJOR PACKET SWITCHING MODES :

**(1) connectionless packet switching, also known as datagram switching:**

Each packet includes complete addressing or routing information. The packets are routed individually, sometimes resulting in different paths and out-of-order delivery.

# DATAGRAM SWITCHING



## Datagram

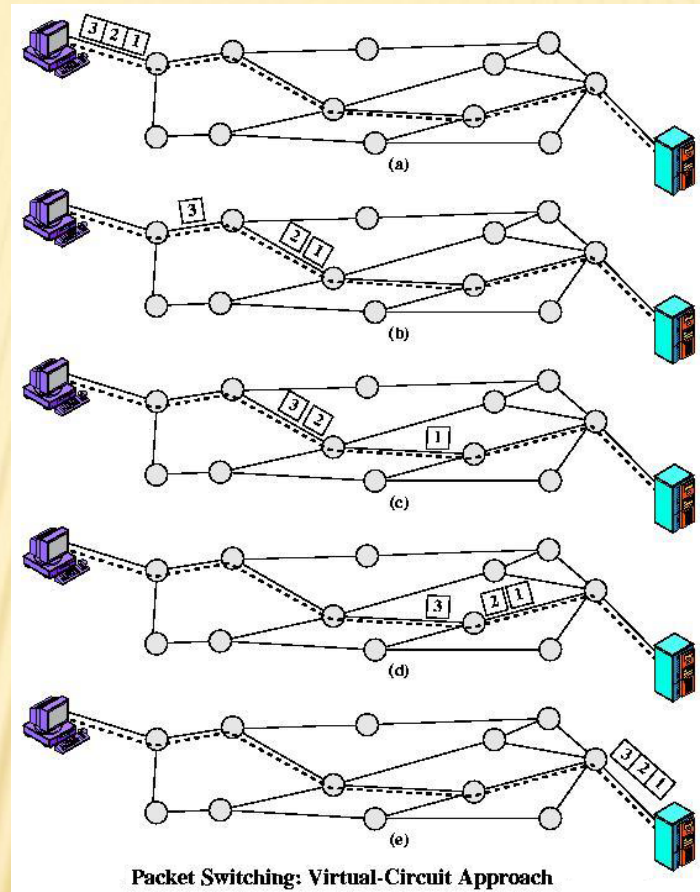
- ❖ Each packet sent independently of the others
- ❖ No call setup
- ❖ More reliable (can route around failed nodes or congestion)

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## **(2) connection-oriented packet switching, also known as virtual circuit switching**

A connection is defined and pre allocated in each involved node during a connection phase before any packet is transferred. The packets include a connection identifier rather than address information, and are delivered in order.

# VIRTUAL CIRCUIT SWITCHING



## Virtual circuit

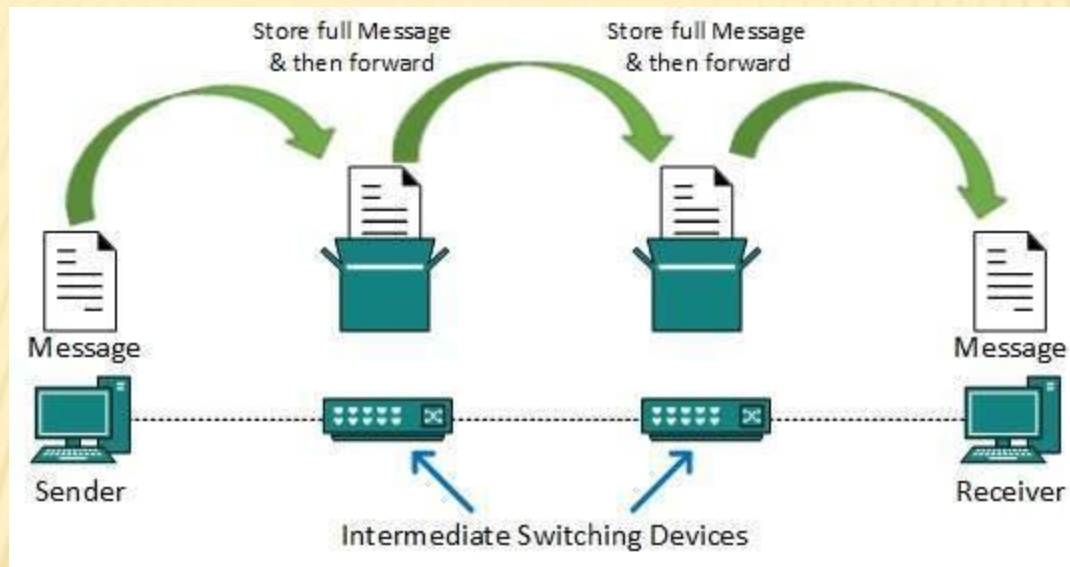
- ❖ Fixed route established before any packets sent
- ❖ No need for routing decision for each packet at each node

# MESSAGE SWITCHING

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**Message Switched Network:** are nowadays mostly implemented over packet-switched or circuit-switched data networks. Each message is treated as a separate entity and contains addressing information, and at each switch this information is read and the transfer path to the next switch is decided.

Depending on network conditions, a conversation of several messages may not be transferred over the same path. Each message is stored before being transmitted to the next switch. Because of this it is also known as a 'store-and-forward' network. Email is a common application for Message Switching. A delay in delivering email is allowed unlike real time data transfer between two computers.

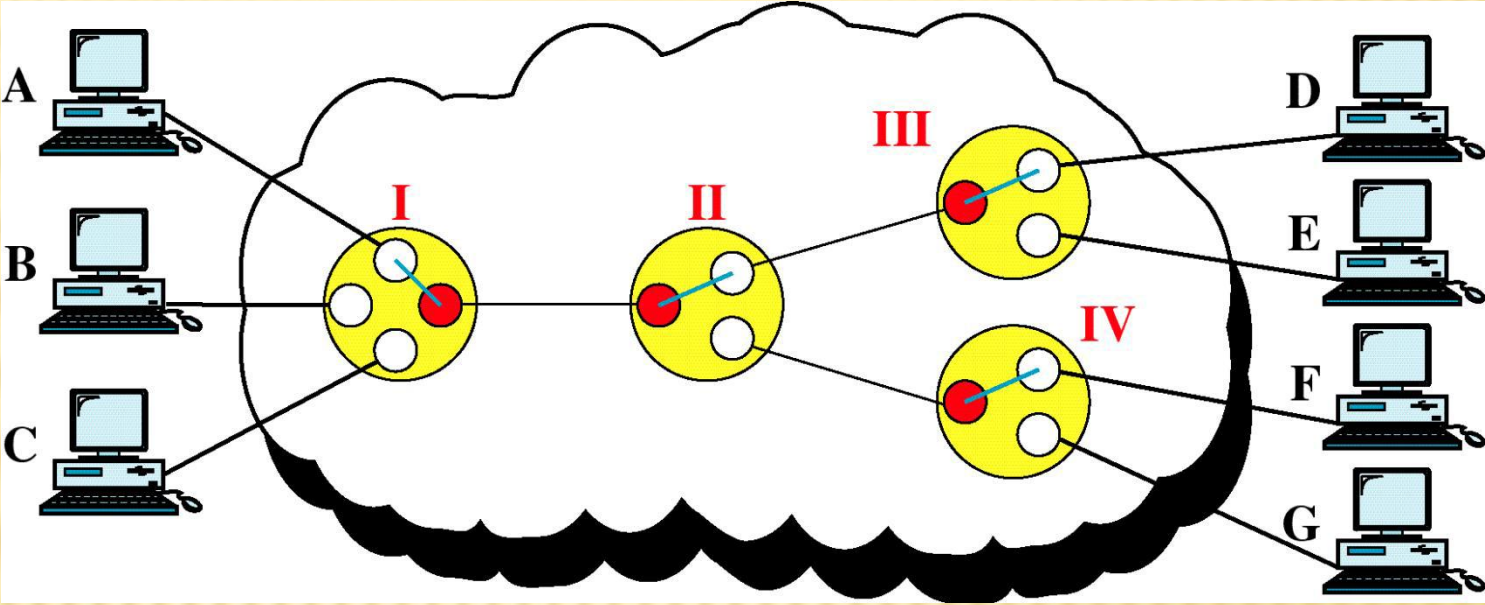


## Message Switching

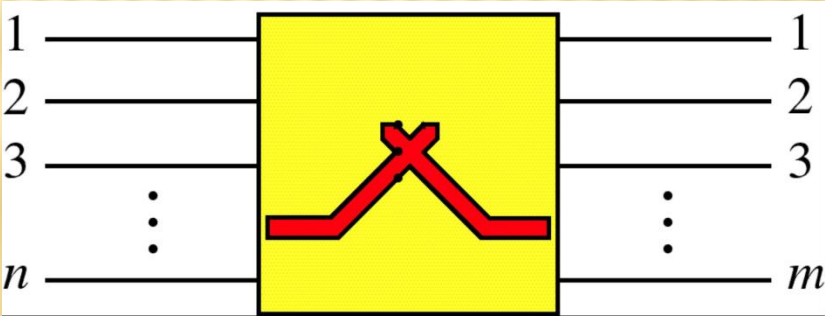
The network diagram shows a source node **A** connected to a network of nodes **B**, **C**, **D**, **E**, **F**, **G**, and **H**. Node **A** is connected to **B**. Node **B** is connected to **C** and **D**. Node **C** is connected to **E** and **F**. Node **D** is connected to **F**. Node **E** is connected to **G**. Node **F** is connected to **G**. Node **G** is connected to **H**. A yellow path is shown from **A** to **C** to **E** to **G**, with an arrow pointing to node **G** labeled "To G". A blue path is shown from **A** to **D** to **F** to **H**, with an arrow pointing to node **H** labeled "To H".

- Entire messages sent from point to point
- Each node stores and forwards message
- Messages can have different priorities
- reduces congestion
- messages can be broadcast

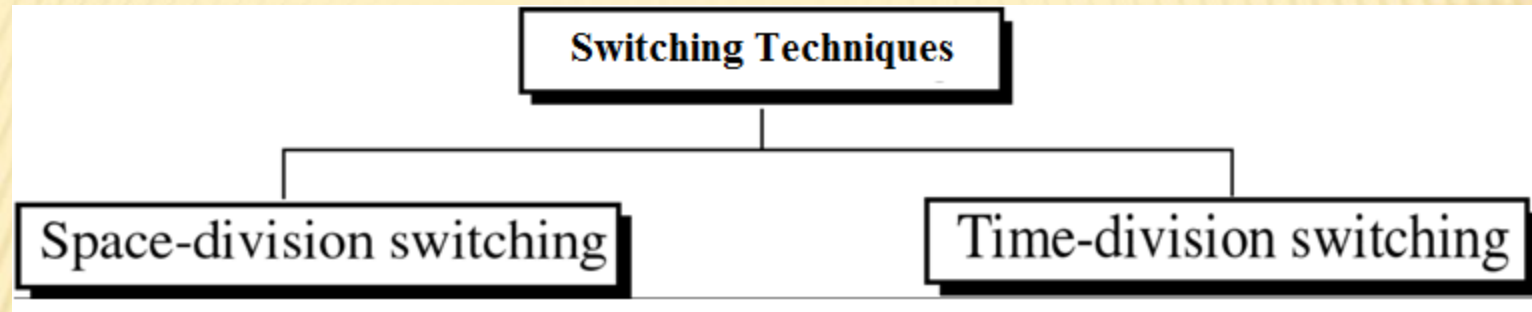
# CIRCUIT-SWITCHED NETWORK



Switch







**Space-division switching** : paths in the circuit are separated from each other spatially.

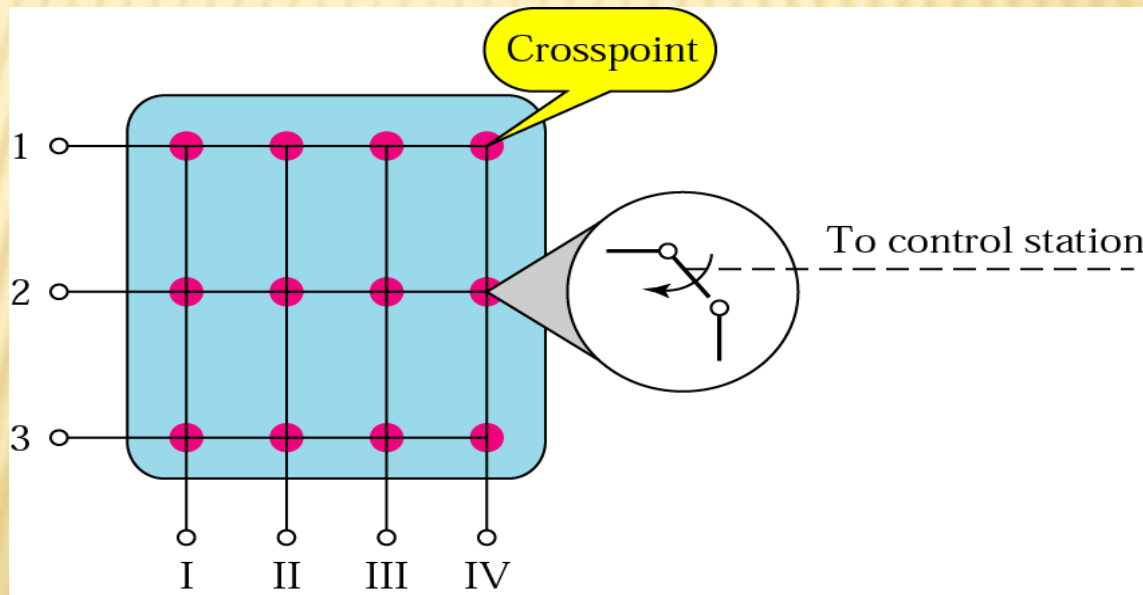
**Time-division switching** : uses time-division multiplexing to achieve switching. Two methods used are:

- Time-slot interchange (TSI) changes the order of the slots based on the desired connection.
- TDM bus

# SPACE DIVISION SWITCH

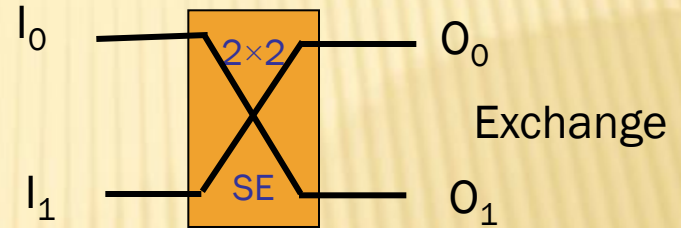
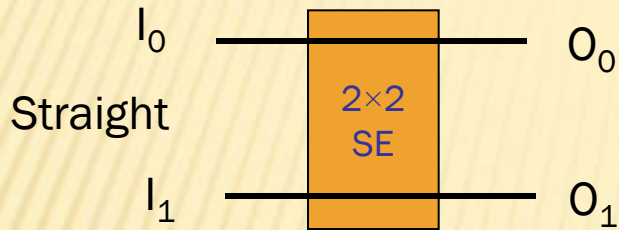
## CROSSBAR SWITCH

- ❖ Crossbar switch connects  $n$  inputs to  $m$  outputs in a grid, using electronic micro-switches (transistors) at each cross-point.
- ❖ Limitation is the number of cross-points required.

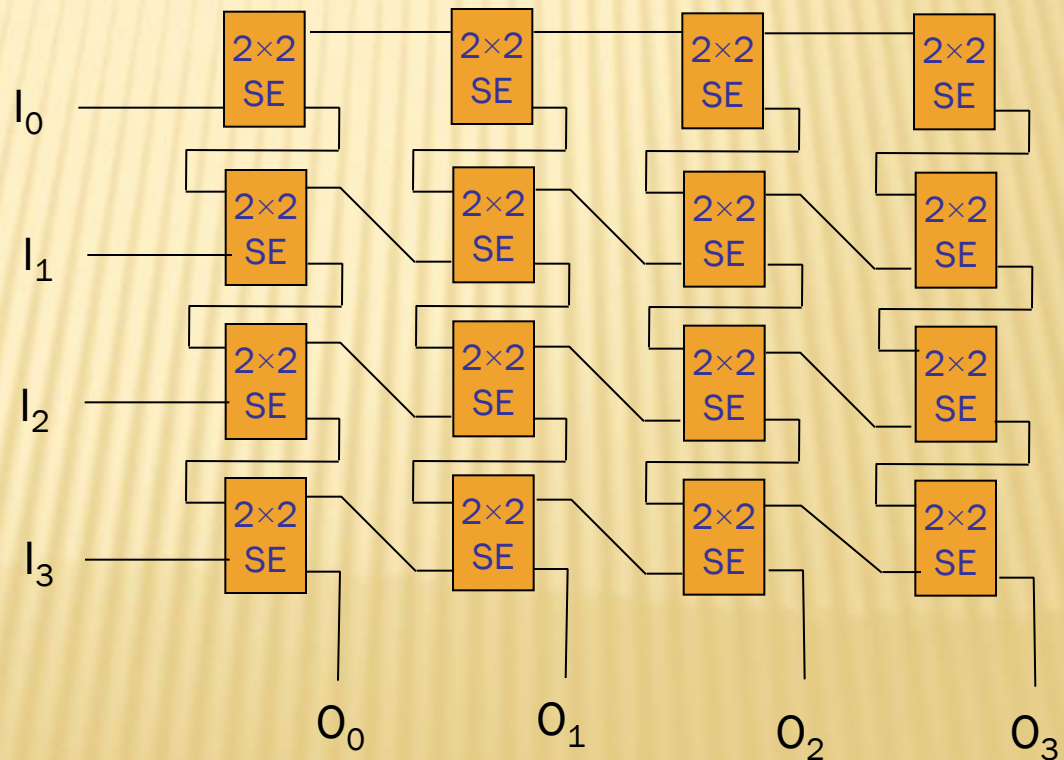


# CROSSBAR IMPLEMENTATION

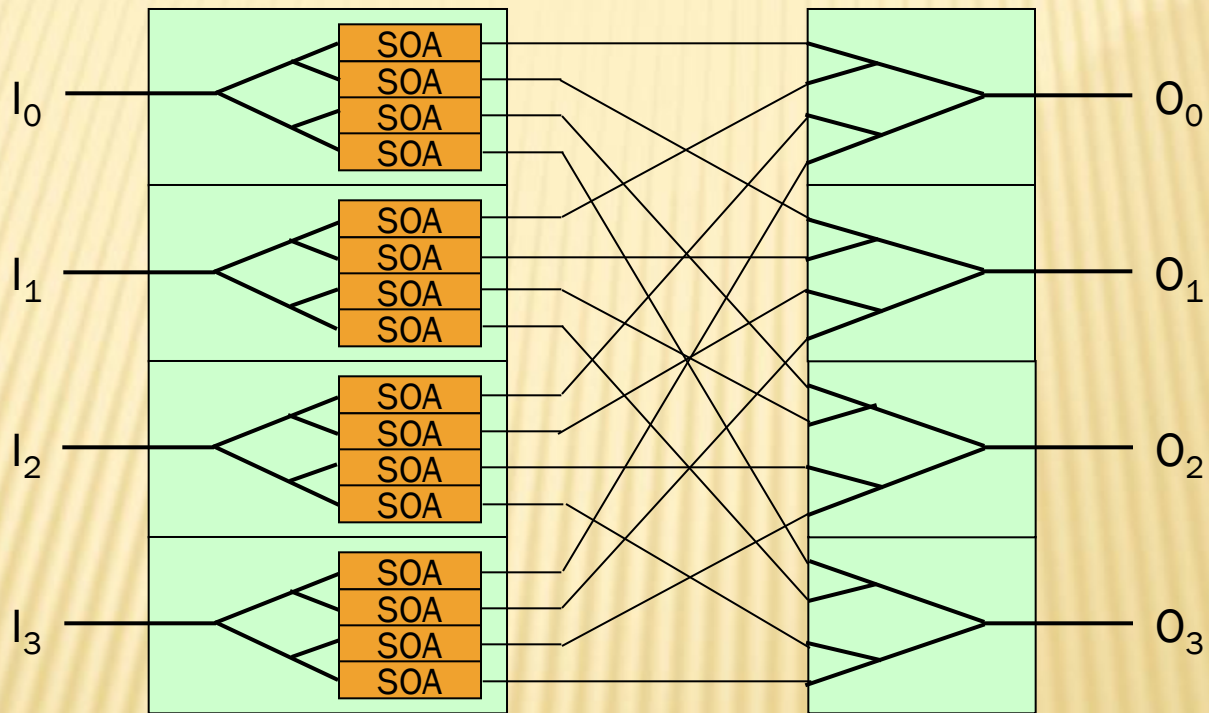
## 2×2 Switching element



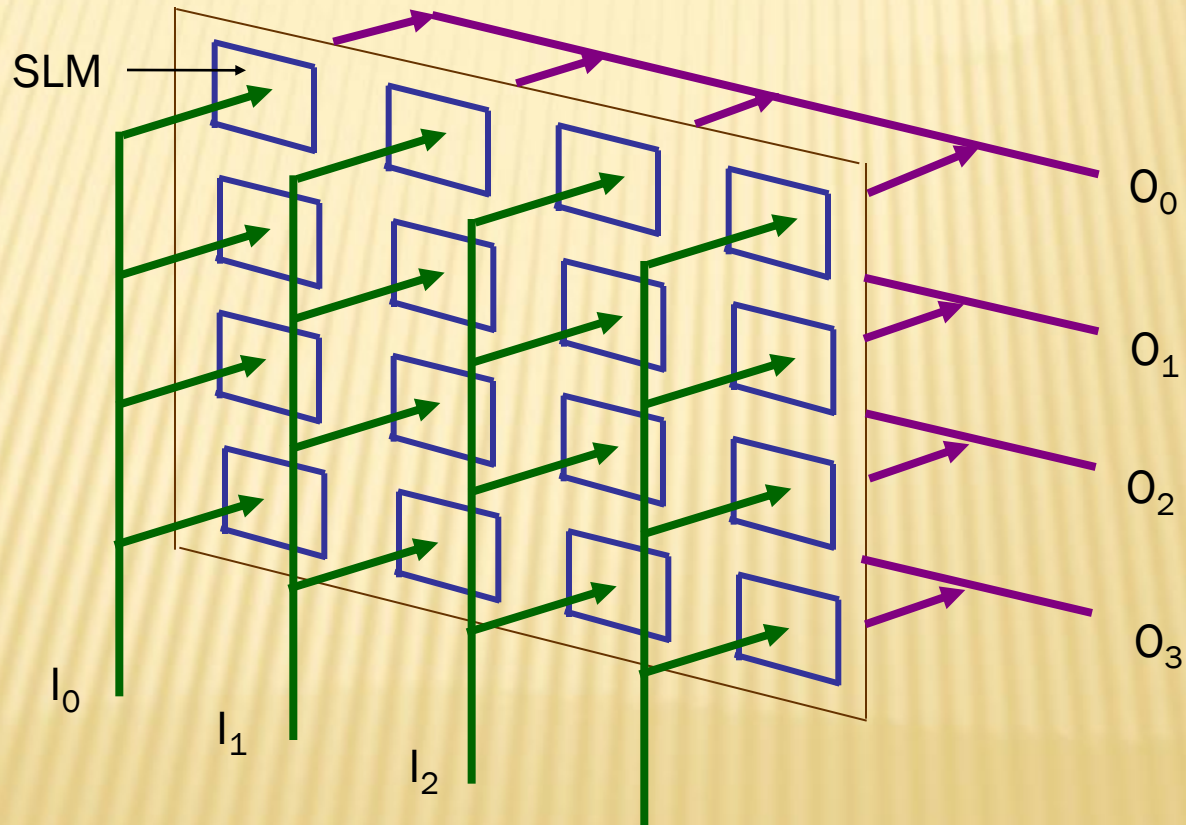
4×4 crossbar switch  
based on 2×2 Switching  
elements



## 4×4 CROSSBAR SWITCH BASED ON SEMICONDUCTOR OPTICAL AMPLIFIER (SOA)

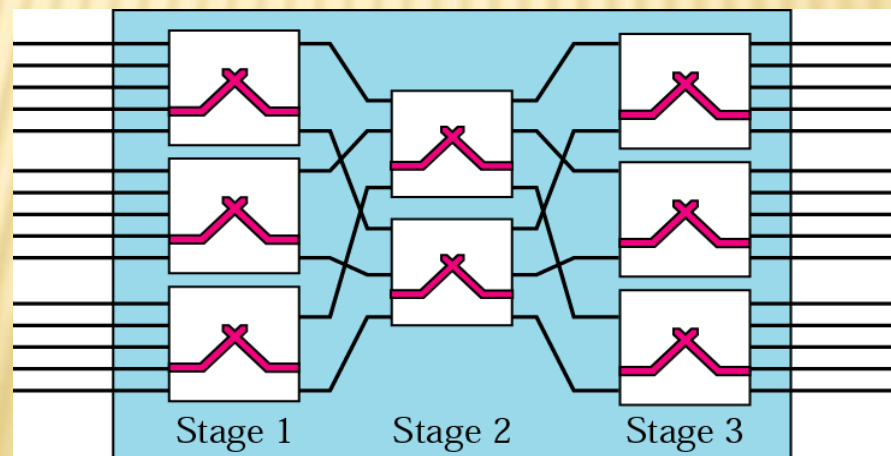


# 4×4 CROSSBAR SWITCH BASED ON SPATIAL LIGHT MODULATOR (SLM)

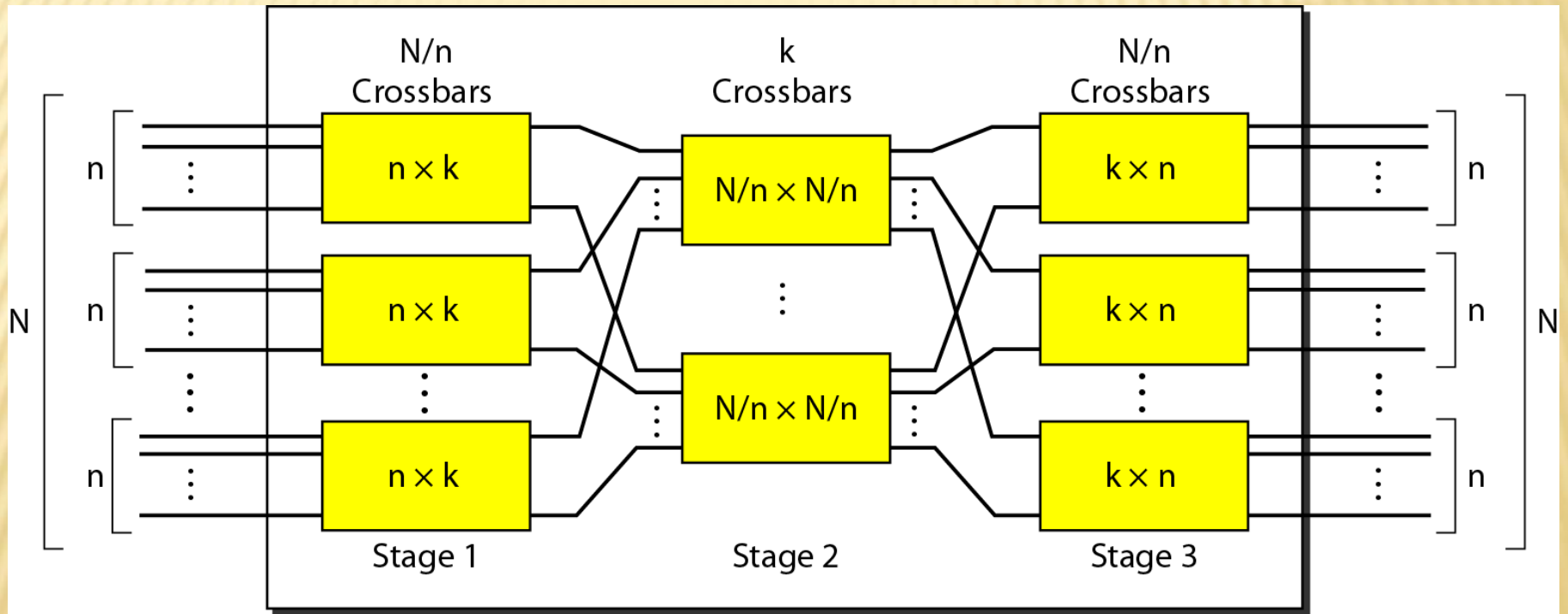


# MULTISTAGE SWITCH

- ✘ Multistage switch combines crossbar switches in several stages.
- ✘ Design of a multistage switch depends on the number of stages and the number of switches required (or desired) in each stage.
- ✘ Normally, the middle stages have fewer switches than do the first and last stages.

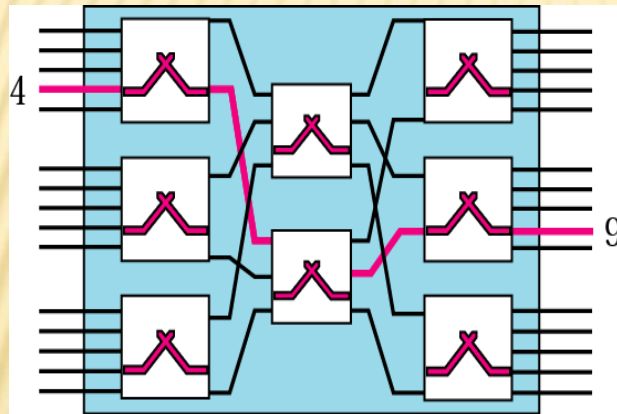


# Multistage switch

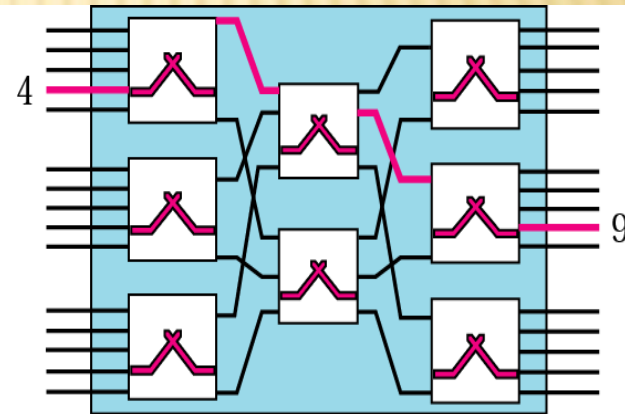


# MULTIPLE SWITCHING PATHS

- ✘ Multiple paths are available in multistage switches.
- ✘ Blocking refers to times when two inputs are looking for the same output. The output port is blocked.



a. First option



b. Second option