SWITCHING

Differentiate between a Hub, Switch and Router

- **HUB** - **In a hub**, a frame **is** passed along or "broadcast" to every one of its ports. It doesn't matter that the frame is only destined for one port. The ***hub has no way of distinguishing which port*** a frame should be sent to. (***Physical Layer***).
- **SWITCH** - A switch is able to handle the data and ***knows the specific addresses to send the message***. It can decide which computer is the message intended for and send the message directly to the right computer. The efficiency of switch has been greatly improved, thus providing a ***faster network speed***. (***Data Link Layer***).

Differentiate between a Hub, Switch and Router

- **ROUTER** - Router is actually a small computer that can be programmed to handle and ***route the network traffic***. It usually ***connects at least two networks together***, such as two LANs, two WANs or a LAN and its ISP network.
- Routers ***can calculate the best route*** for sending data and communicate with each other by protocols.
- ***Network Layer***

Network Switching

- In large networks, there can be multiple paths from sender to receiver.
- The switching technique will decide the best route for data transmission.

The switching technique is used to connect the systems for making one-to-one communication.

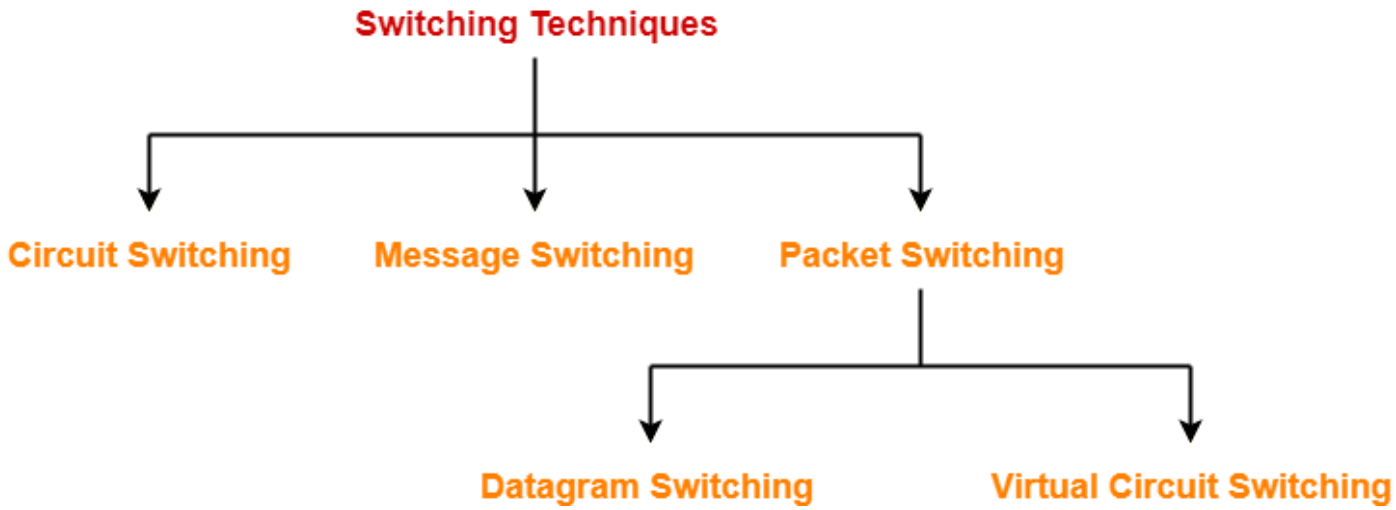
Network Switching

- 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. Others are used only for routing.

Methods of switching

Traditionally, there are three methods of switching,

- ***Circuit switching***
- ***Packet switching***
- ***Message switching***



Switching in TCP/IP Layers

Switching can happen at several layers in TCP/IP.

Switching at Physical Layer:

- Only circuit switching
- No packets exchanged.
- The switches at the physical layer allow signals to travel in one path or another.

Switching at Data Link Layer:

- Packet switching
- Here packet means frames or cells.
- Packet switching in DLL normally done using the ***virtual-circuit*** approach.

Switching in TCP/IP Layers

Switching at Network Layer:

- Packet switching.
- Either a virtual-circuit approach or the Datagram approach can be used.
- ***Currently, the internet uses a datagram approach.***

Switching at Application Layer:

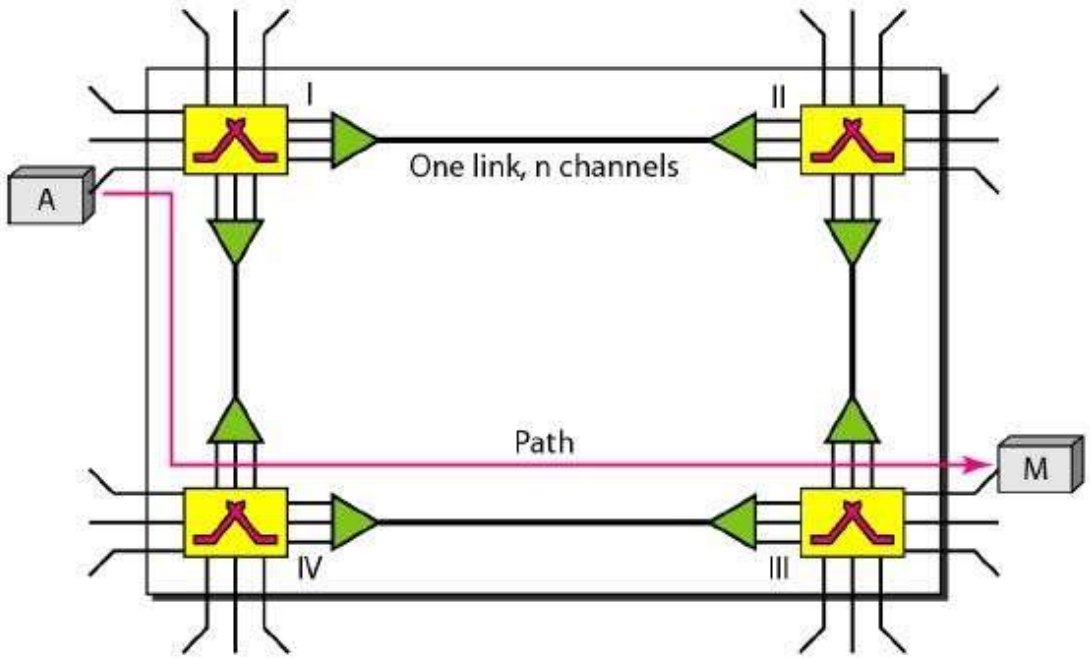
- Only have message switching.
- Communication at the application layer occurs by exchanging messages.

Circuit-Switched Networks

- It consists of a set of switches connected by physical links.
- A connection between two stations is a dedicated path between 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

A circuit-switched network is made of a set of switches connected by physical links, in which each link is divided into ‘n’ channels.

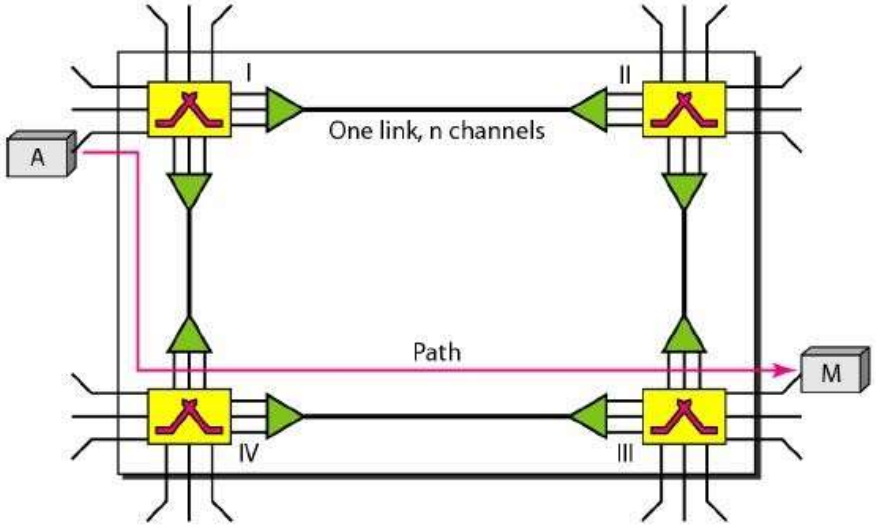


Circuit-Switched Networks

The end systems, such as computers or telephones, are directly connected to a switch.

SETUP PHASE

When the end system A needs to communicate with the end system M, system A needs to request a connection to M that must be accepted by all switches as well as by M itself.

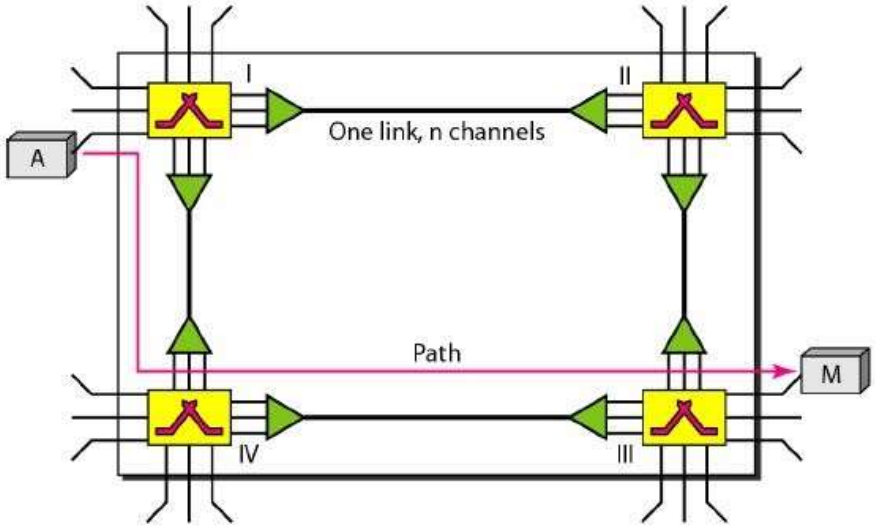


Circuit-Switched Networks

The end systems, such as computers or telephones, are directly connected to a switch.

DATA TRANSFER PHASE

A circuit (channel) is reserved on each link and the combination of circuits or channels defines the dedicated path. After a dedicated path made of connected circuits (channels) is established, the ***DATA TRANSFER PHASE*** can take place.

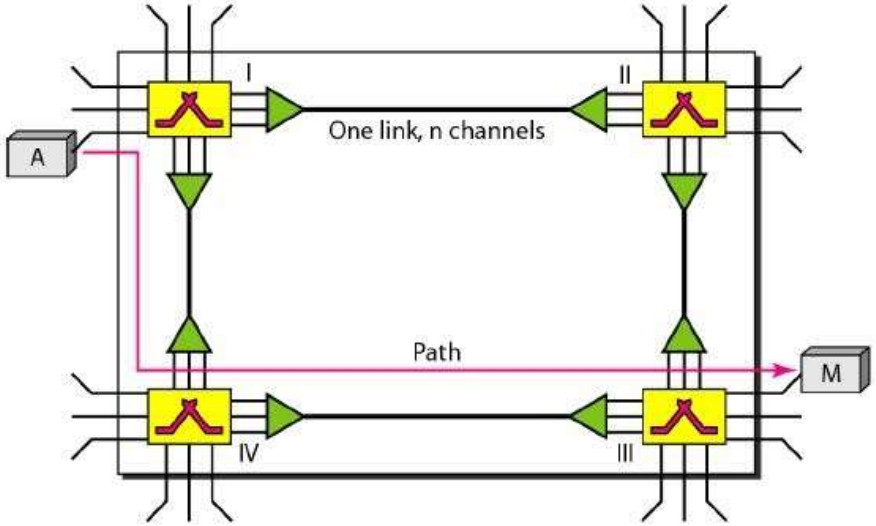


Circuit-Switched Networks

The end systems, such as computers or telephones, are directly connected to a switch.

TEAR-DOWN PHASE

After all the data have been transferred, the circuits are torn down.



Circuit-Switched Networks

- Circuit switching takes place at the physical layer.
- Before starting the stations must ***make a reservation for the resources*** to be used during the communication. Resources include channels, switch buffers, switch processing time, and switch input/output ports. ***This reservation should be maintained until the teardown phase.***
- Data transferred are not packetized (The physical layer transfers signals).
- There is no addressing involved during data transfer. There is end-to-end addressing used during the setup phase.

Efficiency and Delay

Efficiency:

- Circuit-switched networks are not as efficient as the other two types of networks.
- Resources are allocated during the entire duration of the connection.
- These resources are unavailable to other connections.

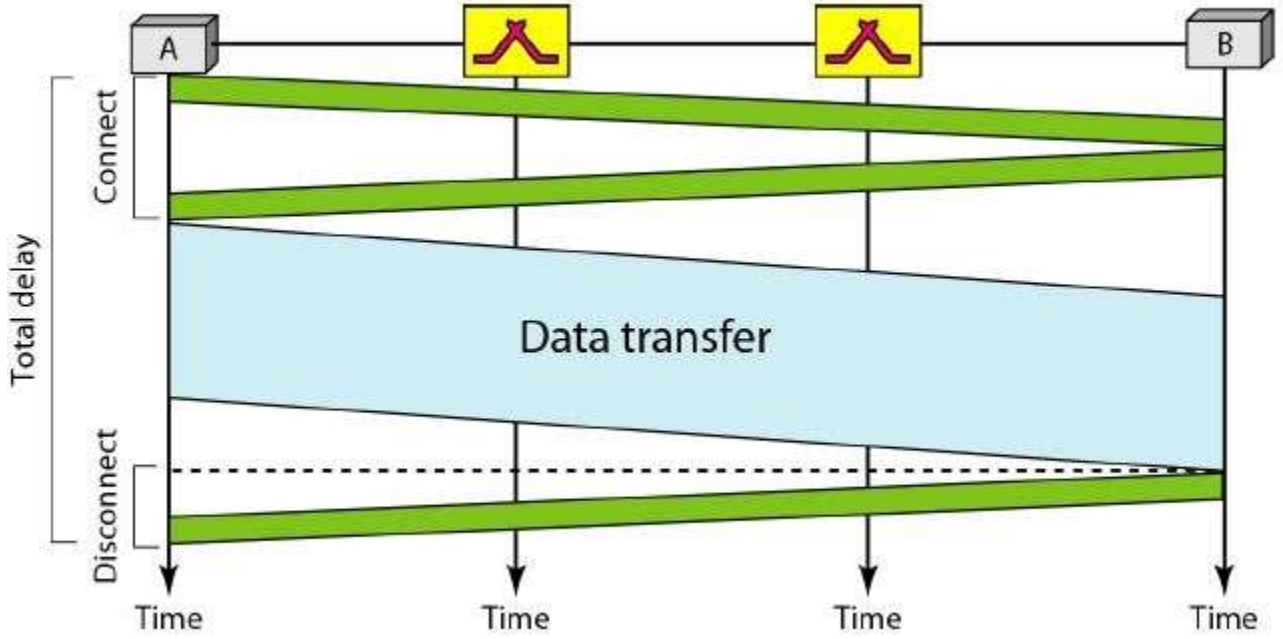
Delay:

- The delay in this type of network is minimal.
- During data transfer, the data are not delayed at each switch.
- The resources are allocated for the duration of the connection.

Delay

There is no waiting time for each switch.

The total delay is due to the time needed to ***create the connection, transfer data, and disconnect the circuit***.



Packet Switching

- The message needs to be divided into packets of fixed or variable size.
- The size of the packet is determined by the network and the governing protocol.

In a packet-switched network, there is no resource allocation; resources are allocated on demand.

Packet Switching

In packet switching,

- No resource allocation for a packet.
- No reserved bandwidth on the links.
- No scheduled processing time for each packet.
- Resources are allocated on demand.
- Allocation is done on an FCFS basis.
- The received packet must wait if there are other packets being processed.
- The lack of reservations may create delays.

Packet Switching

We have two types of packet-switched networks:

Datagram Networks

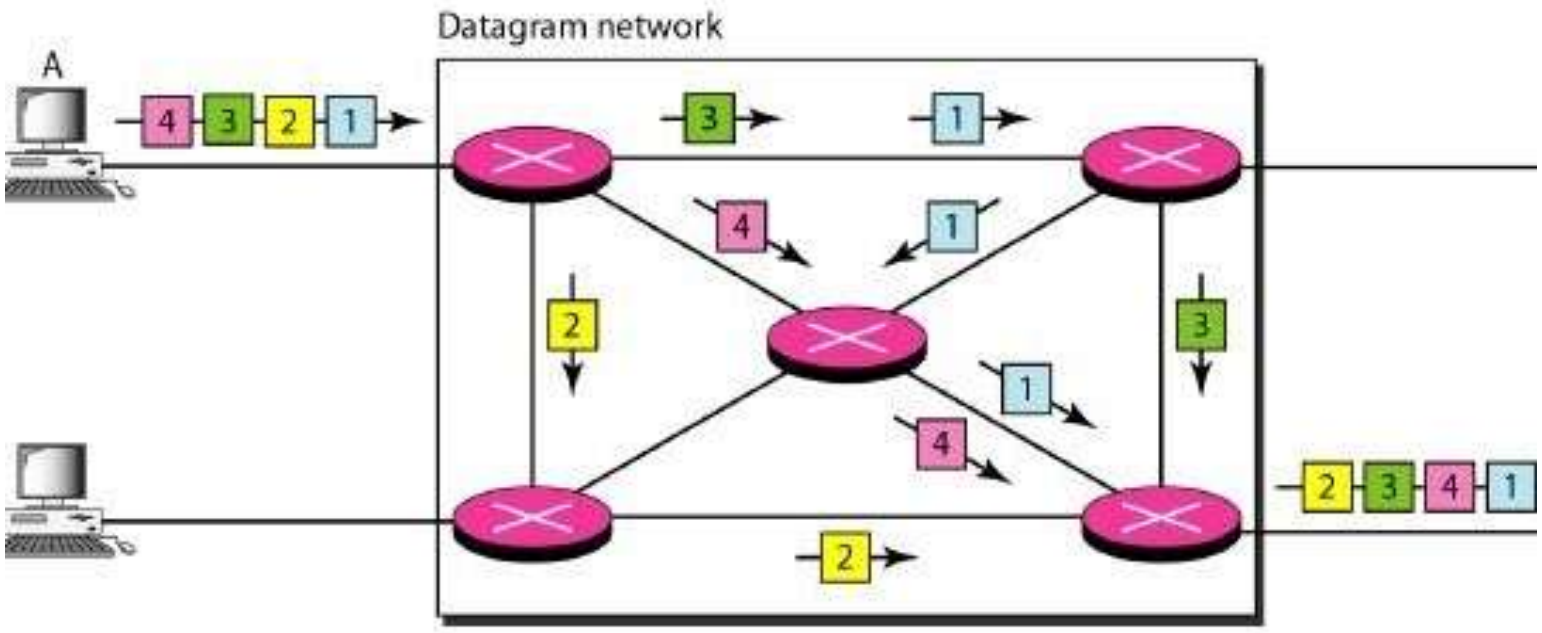
Virtual-Circuit networks

Datagram Networks

- Each packet is treated independently of all others.
- Even if a packet is part of a multi-packet transmission the network treats it as though it existed alone.
- Packets in this approach are referred to as ***datagrams***.
- Datagram switching is normally done at the network layer.

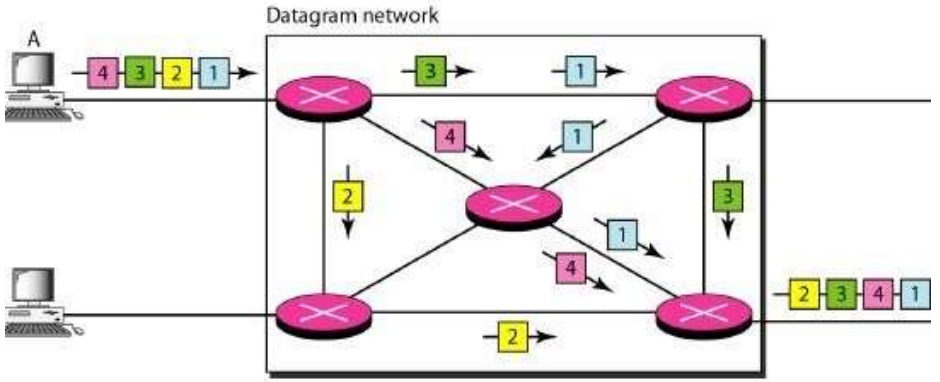
Datagram Networks

A datagram network with four switches is given below.



Datagram Networks

- All four packets belong to the same message.
- But , may travel different paths to reach their destination.
- Arrives at their destination out of order.
- Different delays for each packets.
- Packets may also be lost or dropped because of the lack of resources.



Datagram Networks

- The datagram networks are sometimes called ***connectionless networks***.
- The term connectionless here means that ***the switch does not keep information about the connection state.***

Datagram Networks

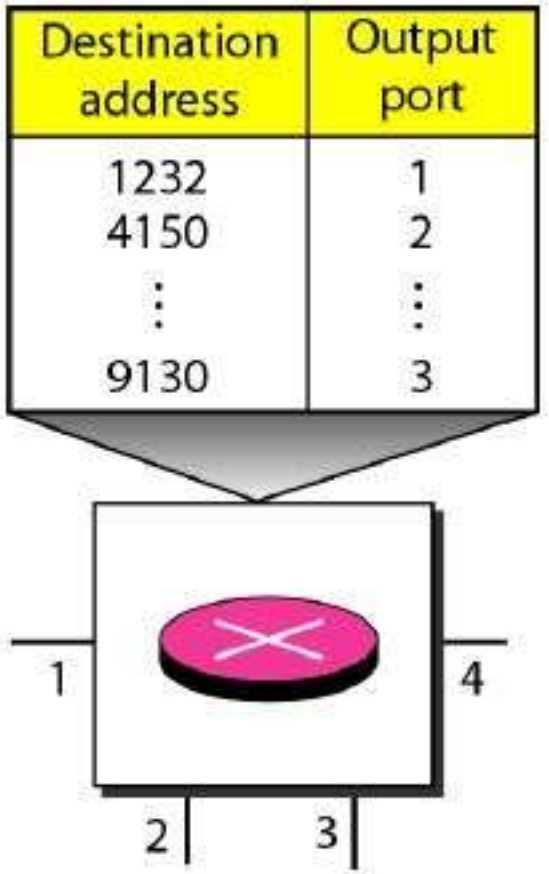
Routing Table:

- There are no setup or teardown phases.
- The packets are routed to their destinations in a datagram network using ***routing tables.***
- Each switch has a routing table that is based on the destination address.
- The routing tables are dynamic and are updated periodically.

The destination addresses and the corresponding forwarding output ports are recorded in the tables.

Datagram Networks: Routing Table

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



Destination address:

- Every packet in a datagram network carries a header.
- Contains the destination address of the packet among other information.

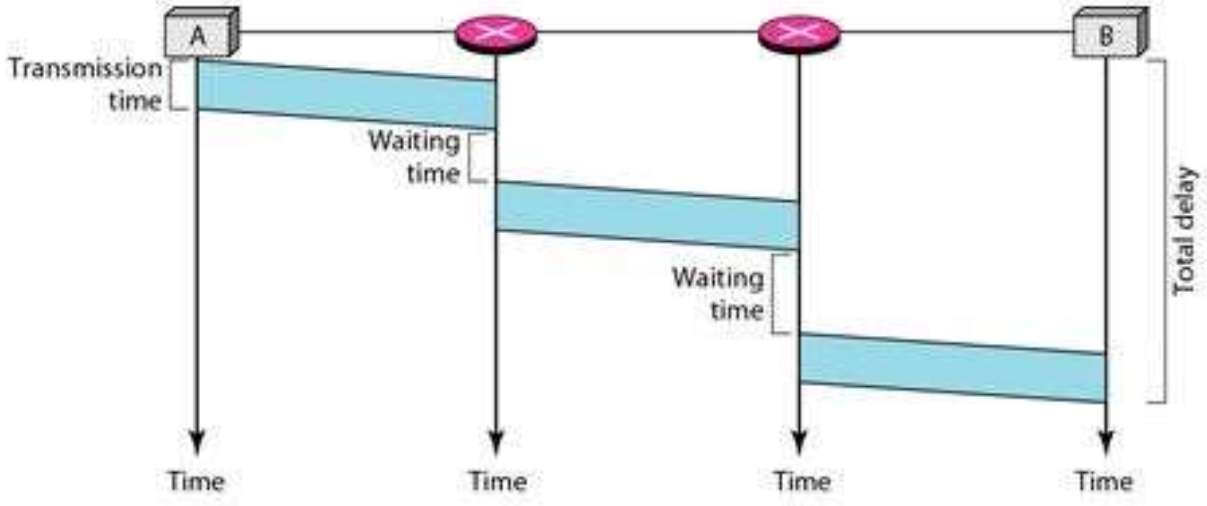
Efficiency and Delay

- The ***efficiency*** of a datagram network is better than that of a circuit-switched network;
- Resources are allocated only when there are packets to be transferred.

If a source sends a packet and there is a delay of a few minutes before another packet can be sent, the resources can be reallocated during these minutes for other packets from other sources.

Efficiency and Delay

- There may be a ***greater delay*** in the datagram network than in the virtual-circuit network.
- There are no setup and tear-down phases.
- Each packet may experience a wait at a switch before it is forwarded.

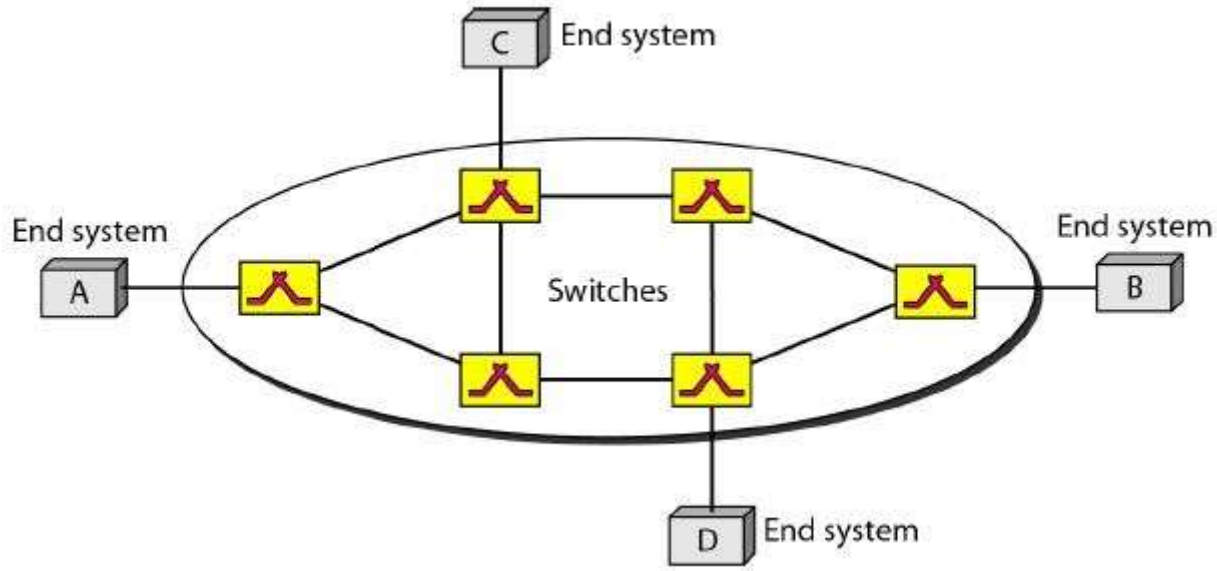


Total Delay = $3T + 3\tau + w_1 + w_2$

Virtual-Circuit Networks

- It is a cross between a circuit-switched network and a datagram network.
- It has some characteristics of both.
  - There are setup and teardown phases in addition to the data transfer phase.
  - Resources can be allocated during the setup phase or on-demand.
  - As in a datagram network, data is packetized and each packet carries an address in the header. The address in the header has local jurisdiction, not end-to-end jurisdiction.
  - All packets follow the same path established during the connection.

Virtual-Circuit Networks



Virtual-Circuit Networks

Addressing

- In a VC network, two types of addressing are involved:
  - Global Addressing
  - Local Addressing (Virtual-Circuit Identifier)

Virtual-Circuit Networks

Global Addressing:

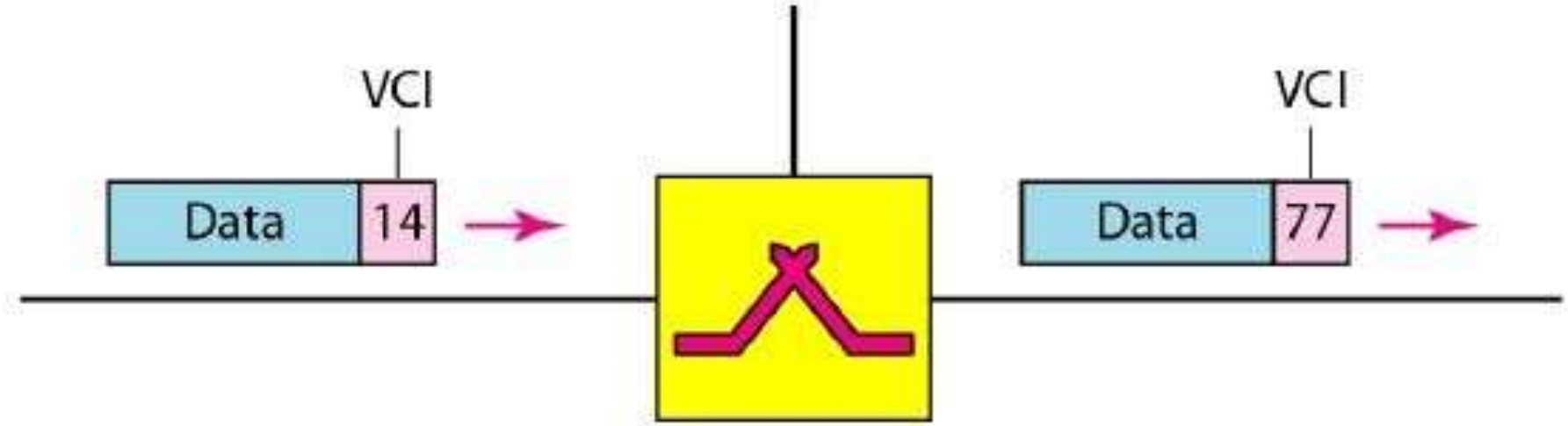
- A source or a destination needs to have a global address.
- An address that can be unique in the scope of the network or internationally if the network is a part of an international network.
- A global address in a virtual circuit network is used only to create a VCI.

Virtual-Circuit Networks

Virtual-Circuit Identifier:

- The identifier that is actually used for data transfer is called the VCI or label.
- Unlike a global address, VCI is a small number.
- It has only a switch scope.
- It is used by a frame between two switches.

Virtual-Circuit Networks



When a frame arrives, it has a VCI; when it leaves it has a different VCI.

Virtual-Circuit Networks

Three Phases

- Setup Phase
- Data Transfer Phase
- Teardown Phase

Virtual-Circuit Networks

Data Transfer Phase

To transfer a frame from a source to a destination, all switches need to have a table entry for this virtual unit.

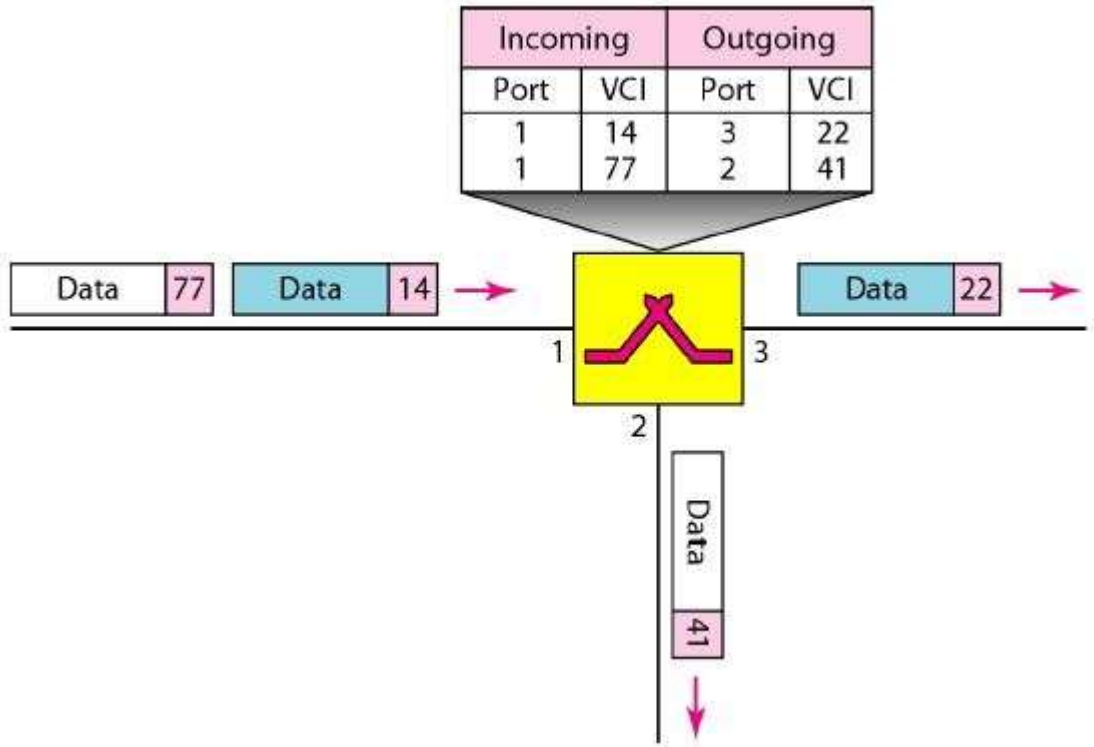
It has four columns,.

i.e. a switch holds four pieces of information for each virtual circuit that is already set up.

Virtual-Circuit Networks

Data Transfer Phase

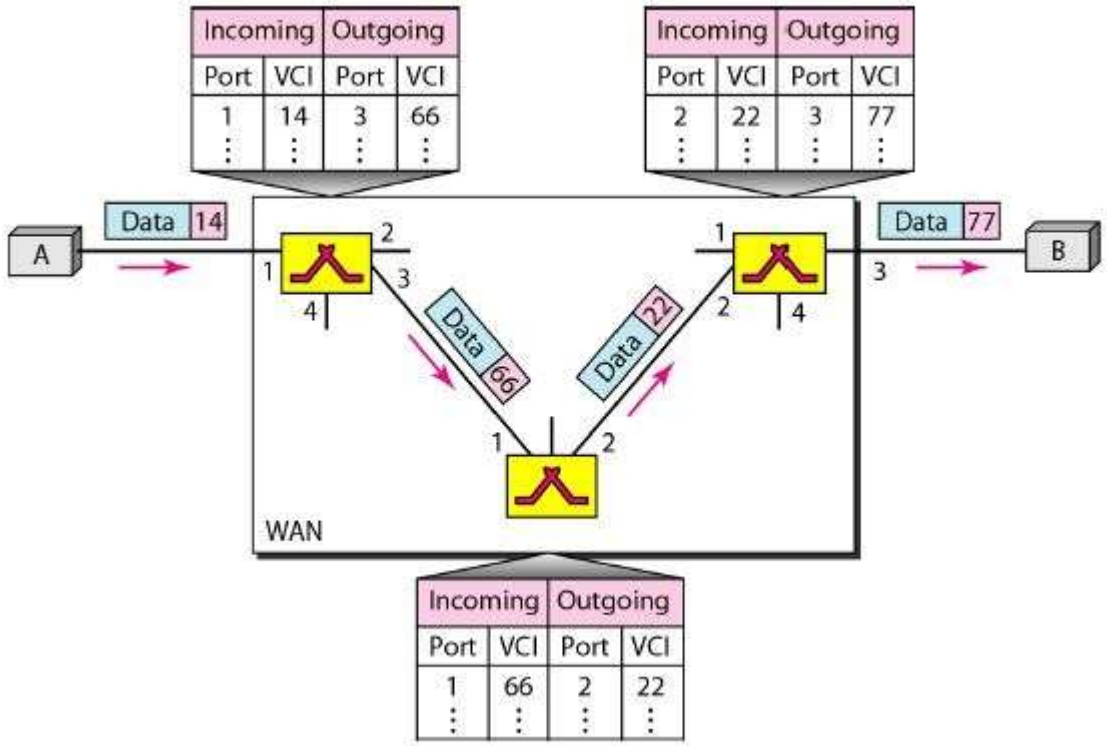
A switch and its corresponding table.



Virtual-Circuit Networks

Data Transfer Phase

Source to Destination data transfer and how the VCI changes during the trip.



Virtual-Circuit Networks

Setup Phase

Here, a switch creates an entry for a virtual circuit.

Suppose A wants to create a VC to B, two steps are required:

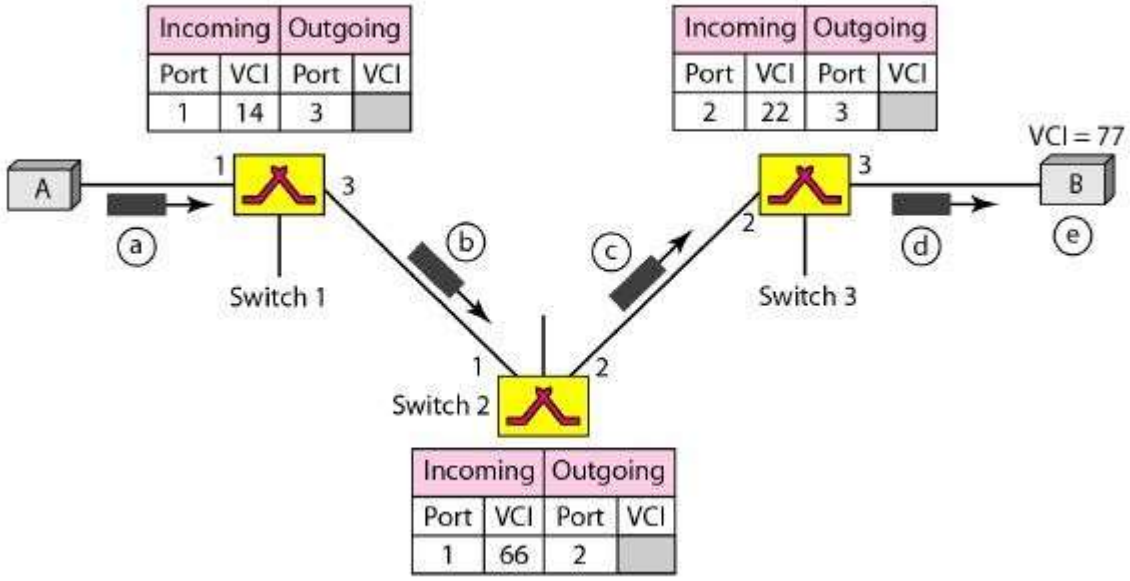
The setup request

The acknowledgment.

Virtual-Circuit Networks

Setup Phase

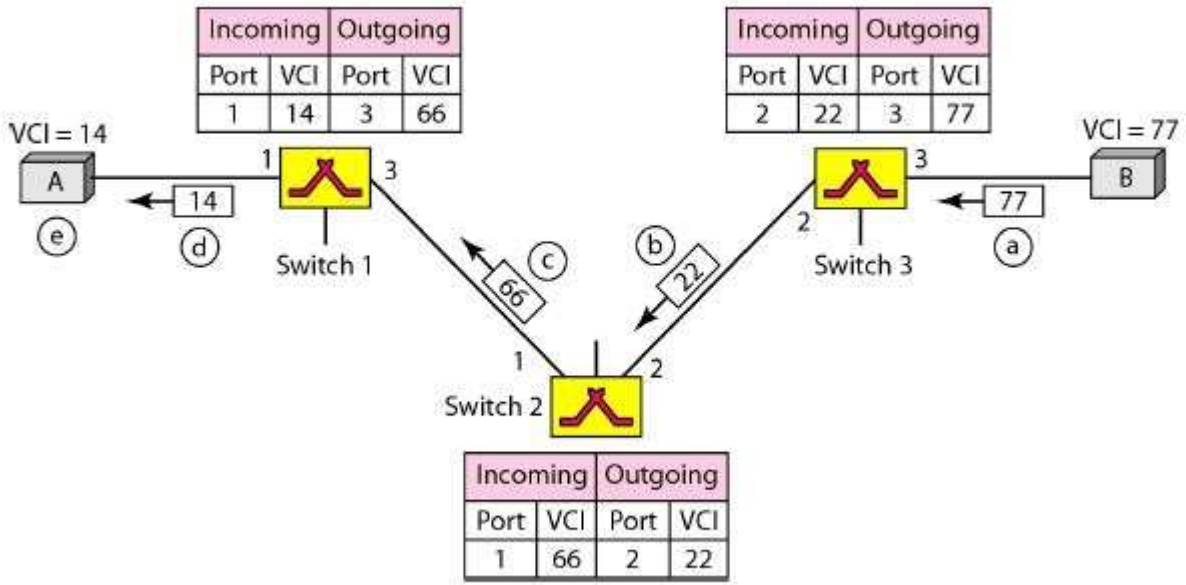
Setup Request: A setup request frame is sent from the source to the destination.



Virtual-Circuit Networks

Setup Phase

Acknowledgment: A special frame called the acknowledgment frame, completes the entries in the switching table.



Virtual-Circuit Networks

Efficiency

- Resource reservation
- On demand

Resource allocation is on demand.

The source can check the availability of the resources, without actually reserving it.

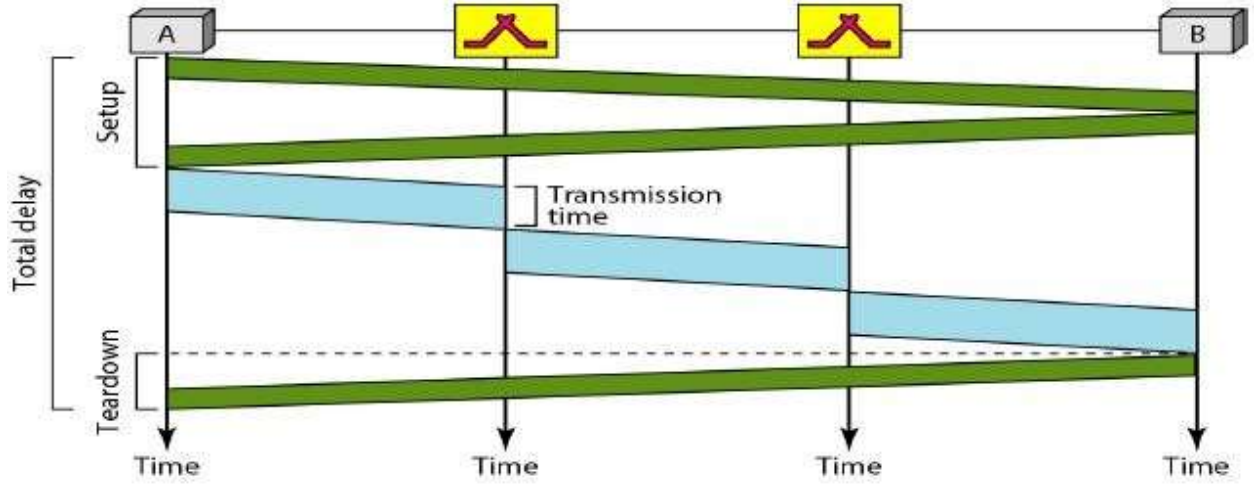
Virtual-Circuit Networks

Efficiency

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.

Virtual-Circuit Networks

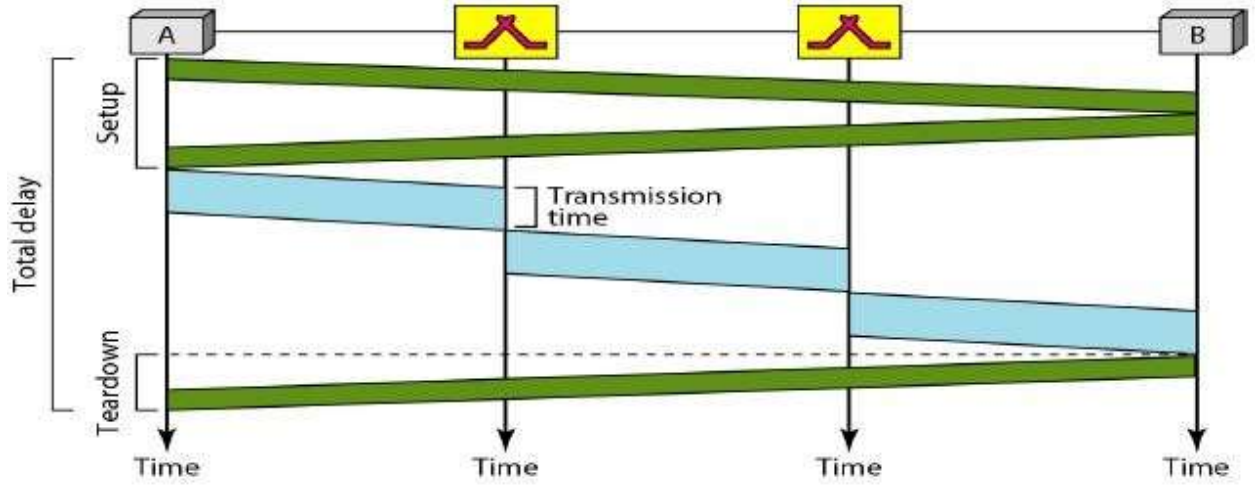
Delay



Total Delay = 3T + 3τ + setup delay + teardown delay

Virtual-Circuit Networks

Delay



Total Delay = 3T + 3τ + setup delay + teardown delay

Structure of a Switch

Structure of Circuit Switches

1. Space-Division Switch
2. Time-Division Switch

Structure of a Switch

Space-Division Switch

The paths in the circuit are separated from one another spatially.

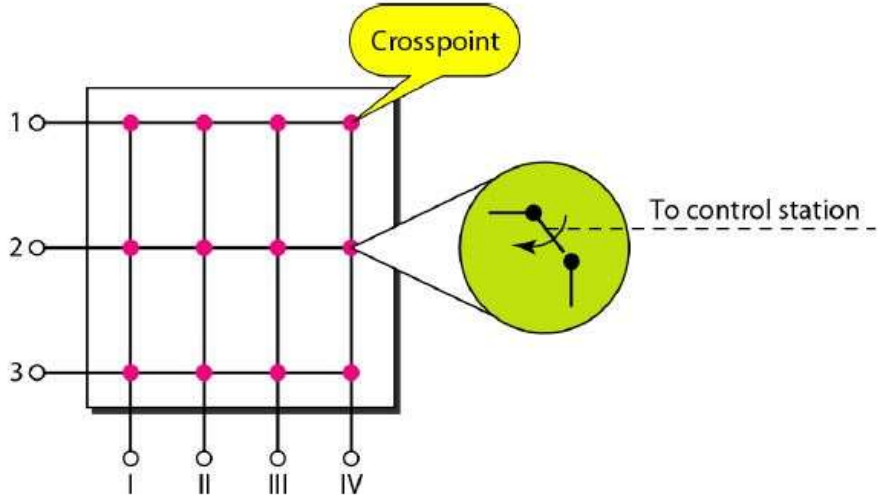
It has evolved through a long history of many designs,

1. Crossbar Switch

A crossbar switch connects ***n*** inputs to ***m*** outputs in a grid, using electronic micro switches at each **crosspoint**.

The major limitation is number of crosspoints required.

To connect ***n*** inputs to ***m*** outputs using a crossbar switch requires ***n x m*** crosspoints.



Structure of a Switch

Space-Division Switch

1. Multistage Switch

The solution to the limitations of the crossbar switch is the multistage switch.

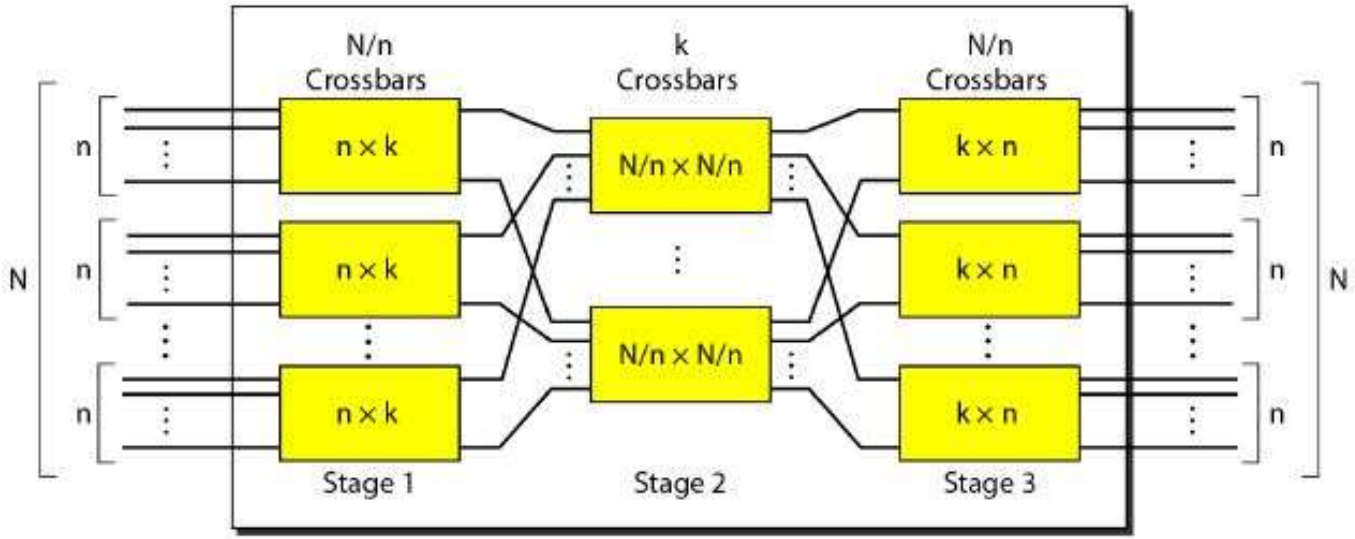
It combines crossbar switches in several (normally 3) stages.

In a single crossbar switch only one row or column (one path) is active for any connection. So we need ***N x N*** crosspoints.

If we can allow multiple paths inside the switch, we can decrease the number of crosspoints.

Each crosspoints in the middle stage can be accessed by multiple crosspoints in the first or third stage.

Structure of a Switch



Space-Division Switch

1. Multistage Switch

We can calculate the total number of crosspoints as follows:

$$\frac{N}{n(n \times k)} + k\left(\frac{N}{n} \times \frac{N}{n}\right) + \frac{N}{n}(k \times n)$$

$$= \boldsymbol{2kN + k\left(\frac{N}{n}\right)^2}$$

In a three-stage switch, the total number of crosspoints is

$$\boldsymbol{2kN + k\left(\frac{N}{n}\right)^2}$$

Which is much smaller than the number of crosspoints in a single-stage switch (N^2).

Structure of a Switch

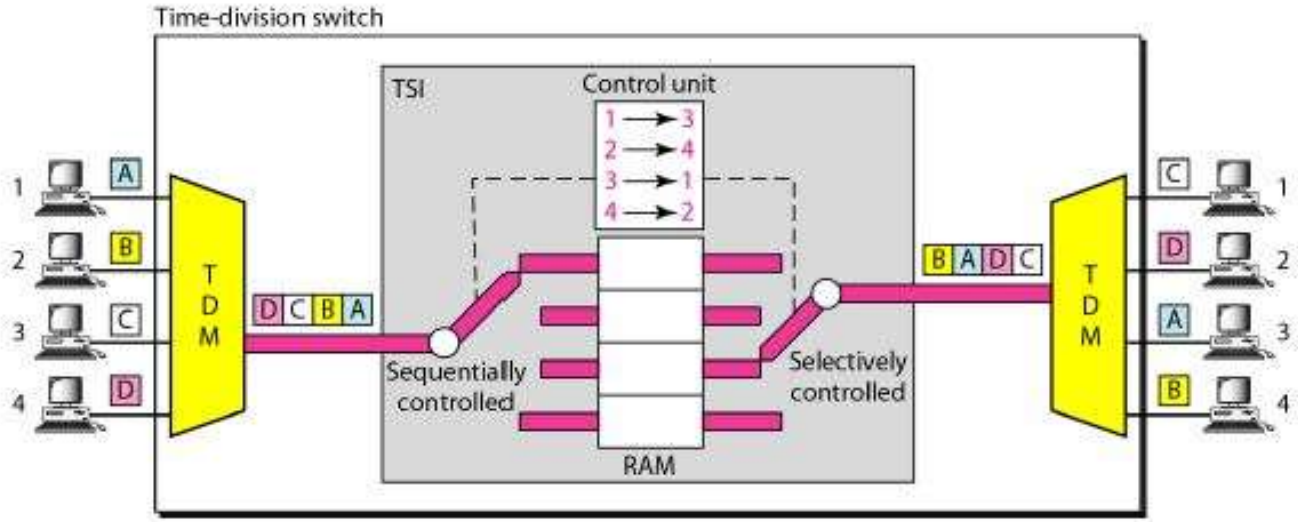
Time-Division Switch

It uses TDM inside a switch.

The most popular technology is called time-slot interchange.

Time-Slot Interchange

1. A TDM Multiplexer
2. A TDM DE multiplexer
3. A TSI consisting of RAM with several memory locations.



Structure of a Switch

Structure of Packet switches

A packet switch has four components:

1. Input ports.
2. Output ports.
3. The Routing processor.
4. The Switching fabric.