

Data Communications and Networking Fourth Edition

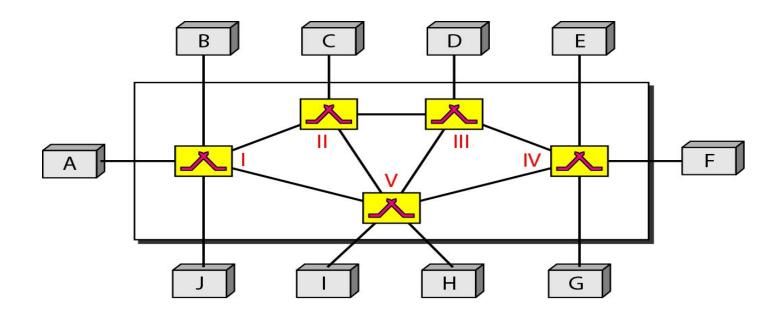
Chapter 8Switching



Switching

Switching

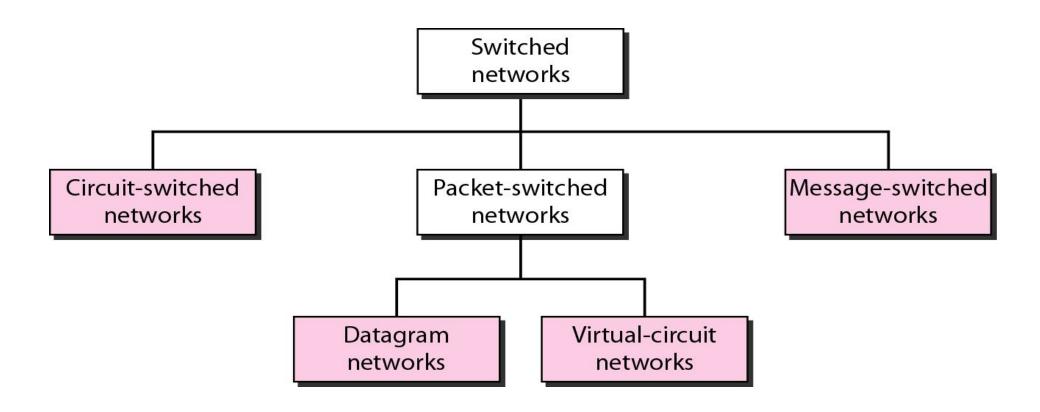
Switches are devices capable of creating temporary connections between two or more devices linked to the switch.





Switching

Figure 8.2 Taxonomy of switched networks





8-1 CIRCUIT-SWITCHED NETWORKS

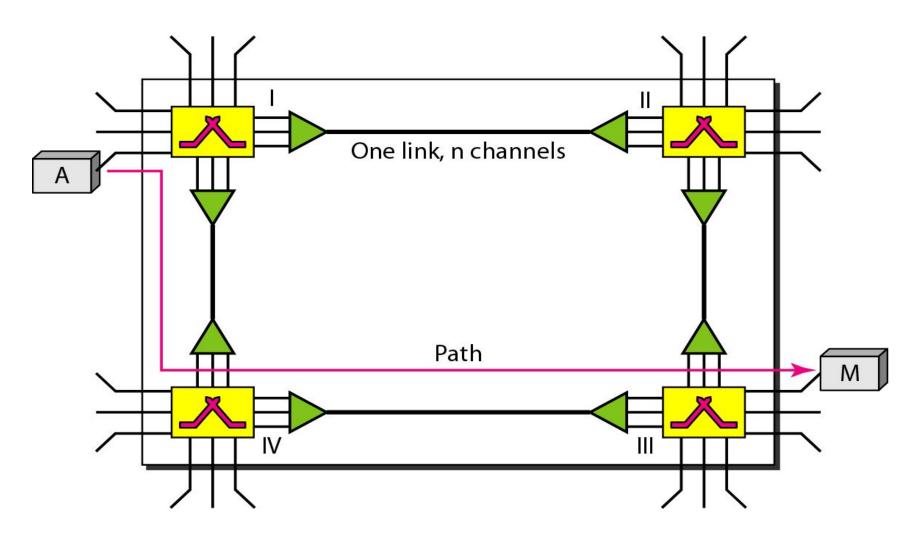
A circuit-switched network consists of a set of switches connected by physical links. A connection between two stations is a dedicated path made of one or more links. However, each connection uses only one dedicated channel on each link. Each link is normally divided into n channels by using FDM or TDM.

Topics discussed in this section:

Three Phases
Efficiency
Delay

Circuit-Switched Technology in Telephone Networks

Figure 8.3 A trivial circuit-switched network





A trivial circuit-switched network

- When end system A needs to communicate with sys. M
 - Setup Phase; System A needs to request a connection to M that must be accepted by all switches as well as by M itself.
 - A channel is reserved on each link, and the combination of channels defines the dedicated path.
 - Data transfer; After the dedicated path made of connected channels is established, data transfer can take place.
 - Teardown Phase; After all data have been transferred, the circuits are torn down.



Note

In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data transfer until the teardown phase.



Efficiency & delay

Efficiency

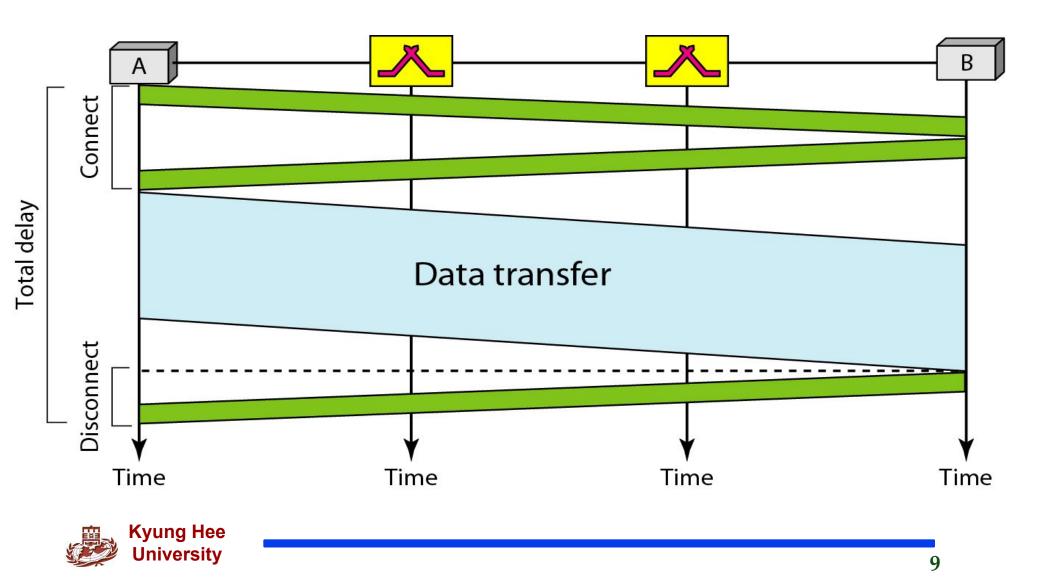
- Circuit switched networks are not as efficient as the other two types of networks because resources are allocated during the entire duration of the connection.
- These resources are unavailable to other connections.

Delay

- Although a circuit-switched network normally has low efficiency, 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.



Figure 8.6 Delay in a circuit-switched network



Note

Switching at the physical layer in the traditional telephone network uses the circuit-switching approach.



8-2 DATAGRAM NETWORKS

In data communications, we need to send messages from one end system to another. If the message is going to pass through a packet-switched network, it 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.

Topics discussed in this section:

Routing Table
Efficiency
Delay
Datagramn Networks in the Internet



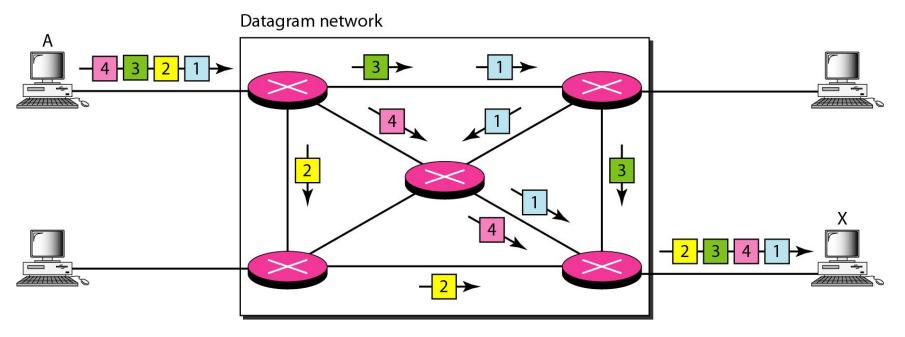
In a packet-switched network, there is no resource reservation; resources are allocated on demand.



Datagram network

- ☐ In datagram network, each packet is treated independently of all others.
 - Even if a packet is part of a multipacket transmission, the network treats it as though it existed alone.

Figure 8.7 A datagram network with four switches (router)





Routing table

Figure 8.8 Routing table in a datagram network

Destination address	Output port
1232 4150 : 9130	1 2 :. 3
1 4	
2	3

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

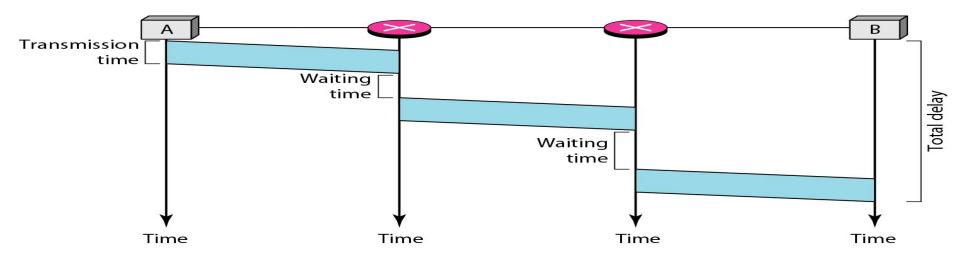
The efficiency of a datagram network is better than that of a circuit-switched network; resources are allocated only when there are packets to be transferred.



Delay

- There may be greater delay in a datagram network than in a virtual-circuit network.
 - ♦ Total delay = 3T + 3τ+ w₁ + w₂
 Where, T=Transmission time, τ = Propagation delay, w=Waiting time

Figure 8.9 Delay in a datagram network







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



8-3 VIRTUAL-CIRCUIT NETWORKS

A virtual-circuit network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both.

Topics discussed in this section:

Addressing
Three Phases
Efficiency
Delay

Circuit-Switched Technology in WANs



Virtual-Circuit Network

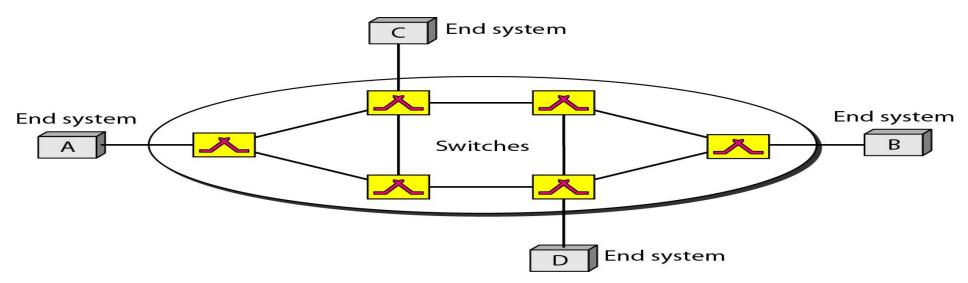
- Characteristics of Virtual-circuit network
 - As in a circuit-switched network, there are setup and teardown phases in addition to the data transfer phase.
 - Resources can be allocated during the setup phase, as in a circuit -switched network, or on demand, as in a datagram network.
 - As in a datagram network, data are packetized and each packet carries an address (local jurisdiction) in the header.
 - As in a circuit network, all packets follow the same path established during the connection.
 - A virtual-circuit network is normally implemented in the data link layer, while a circuit-switched network is implemented in the physical layer and a datagram network in the network layer.



Virtual-Circuit Network

- □ The virtual-circuit network has switches that allow traffic from sources to destinations.
- □ A source or destination can be a computer, packet switch, or other device that connects other network.

Figure 8.10 Virtual-circuit network



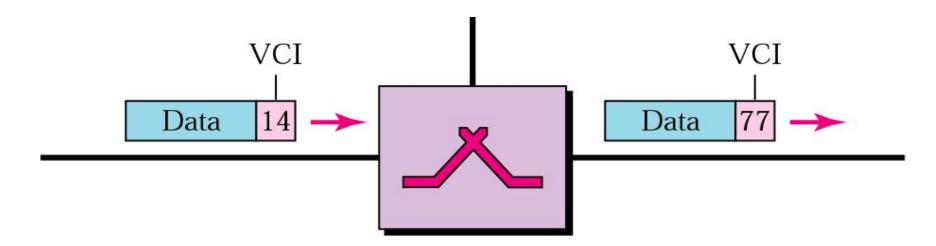
Global Addressing

- In virtual circuit networks,
 - A global address that can be unique in the scope of the WAN or international network.
 - global addressing in virtual circuit networks is used only to create a virtual circuit identifier.



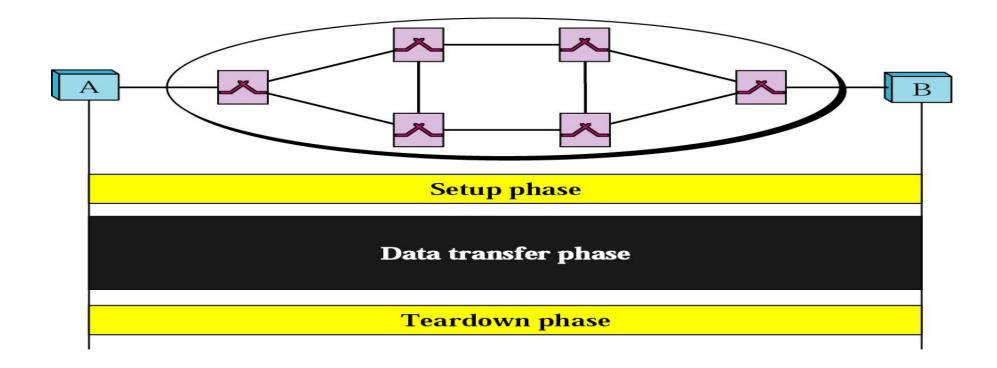
Virtual Circuit Identifier (VCI)

- VCI is actually used for data transfer.
- VCI (Virtual Circuit Identifier)
 - is a small number that only has switch scope,
 - it is used by a frame between two switches.
- Each switch can use its own unique set of VCIs



Three Phases

- ☐ To communicate, a source and destination need to go through three phases
 - setup, data transfer, teardown





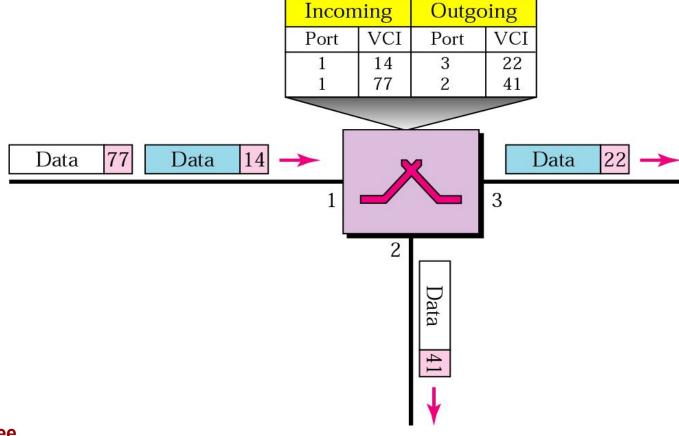
Three Phases

- In the setup phase, the source and destination use their global addresses to help switches make table entries for the connection.
- In the teardown phase, the source and destination inform the switches to erase the corresponding entry.
- Data phase occurs between these two phases.



Data Transfer Phase

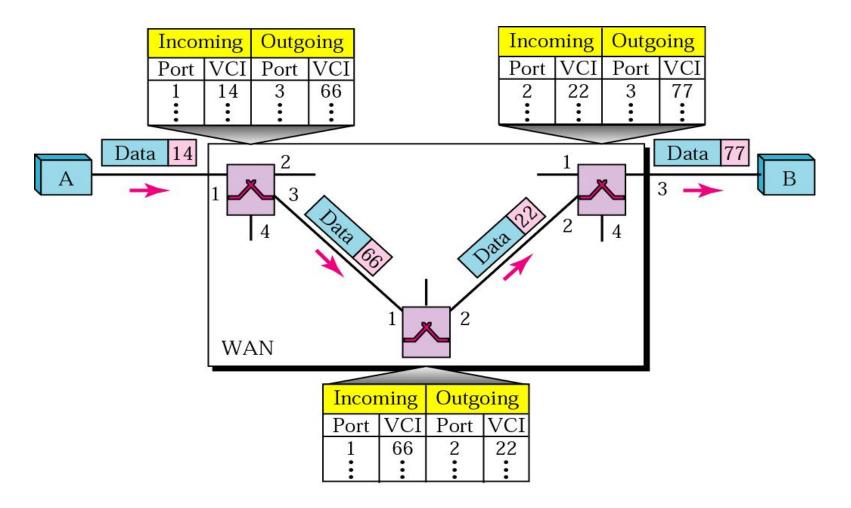
To transfer a frame from a source to its destination, all switches need to have a table entry for this virtual circuit.





Data Transfer Phase (cont'd)

Source-to-destination data Transfer





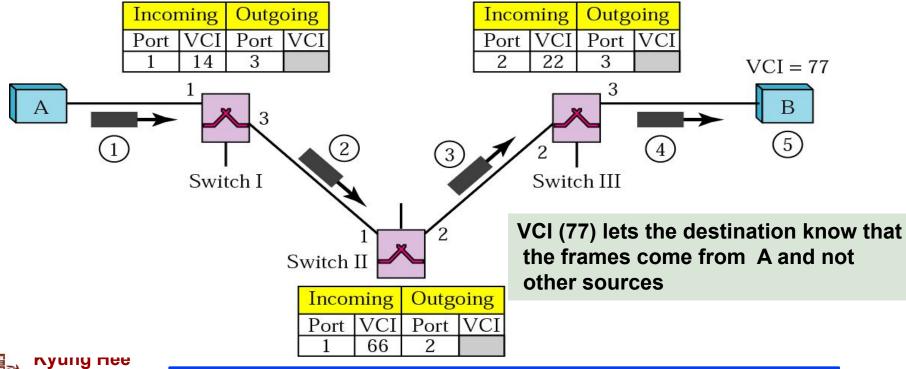
Setup Phase

- How does a switch create an entry for a virtual circuit?
 - Switched virtual circuit (SVC) approach
 - Suppose source A needs to create a virtual circuit to B.
 - Two steps are required;
 - the setup request and the acknowledgment.



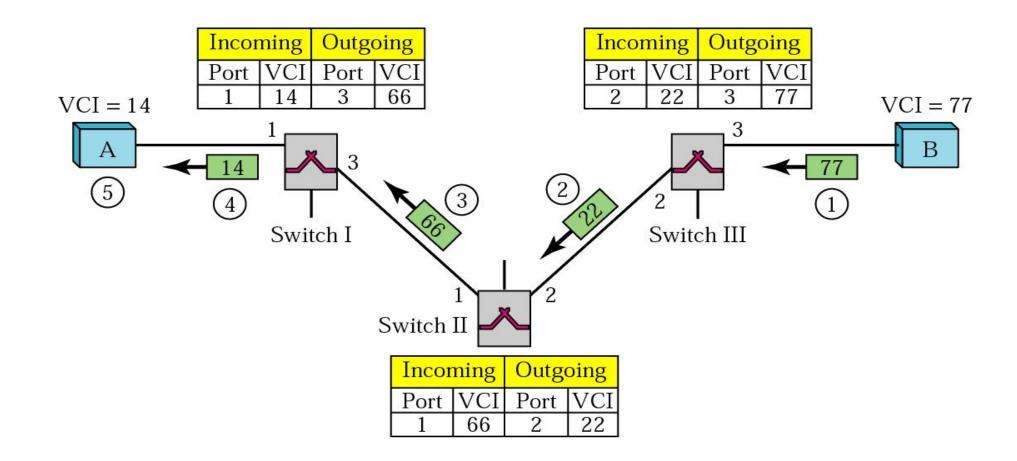
Switched Virtual Circuit (SVC)

- Creating temporary and short connection that exists only when data are being transferred between source and destination.
- Setup request



SVC (cont'd)

SVC setup acknowledgment





Teardown Phase

- In this phase, source A, after sending all frames to B, sends a special frame called a teardown request.
- Destination B responds with a teardown confirmation frame.
- All switches erase the corresponding entry from their tables.

Efficiency

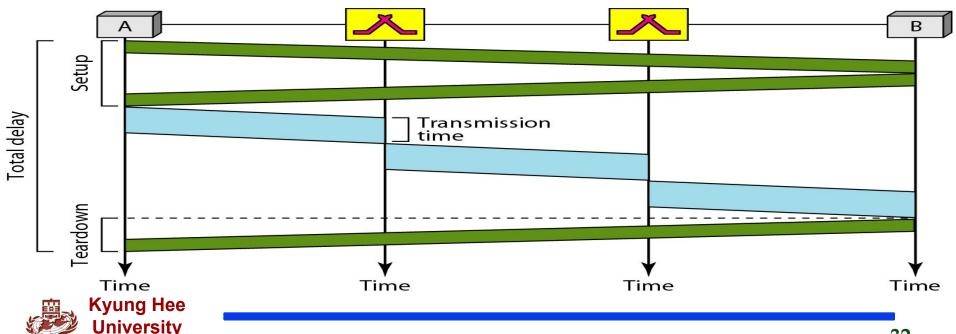
Note

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.



Delay in Virtual-circuit networks

- There is a one-time delay for setup and a one-time delay for teardown.
- If resources are allocated during the setup phase, there is no wait time for individual packets.
- Total delay time = 3T + 3 τ + setup delay + teardown time





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



84 STRUCTURE OF A SWITCH (Not

We use switches in circuit-switched and packet-switched networks. In this section, we discuss the structures of the switches used in each type of network.

Topics discussed in this section:

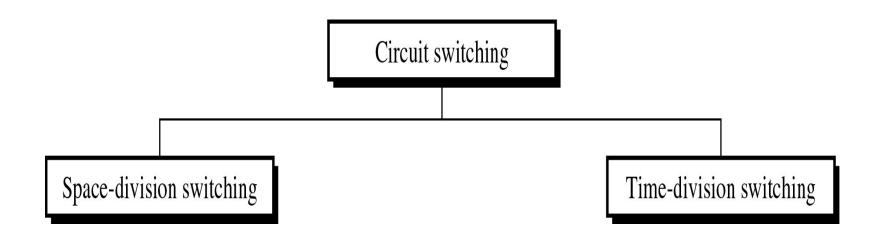
Structure of Circuit Switches Structure of Packet Switches



Important)

Circuit Switching(cont'd)

- Structure of Circuit Switching
 - ~ can use either two technologies.
- Switching





Circuit Switching(cont'd)

Space-Division Switches

the paths in the circuit are separated from each other spatially(crossbar switch)

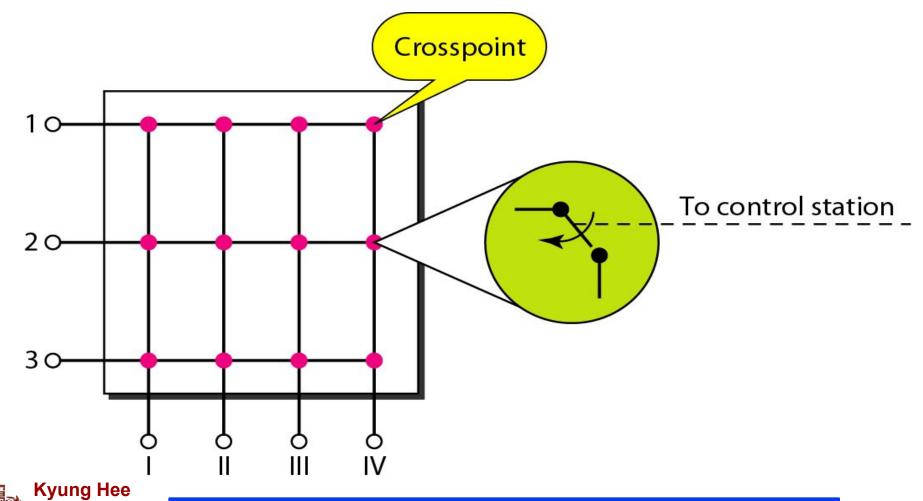
Crossbar switch

~ connect n input to m output in a grid, using electronic microswitch(transistor) at each crosspoint.



Figure 8.17 Crossbar switch with three inputs and four outputs

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- Limitation of crossbar switch
 - The number of switch (huge size)
 - : connect n inputs by m output
 - require n * m crosspoint.

(ex : 1000 input, 1000 output → 1,000,000 crosspoint)

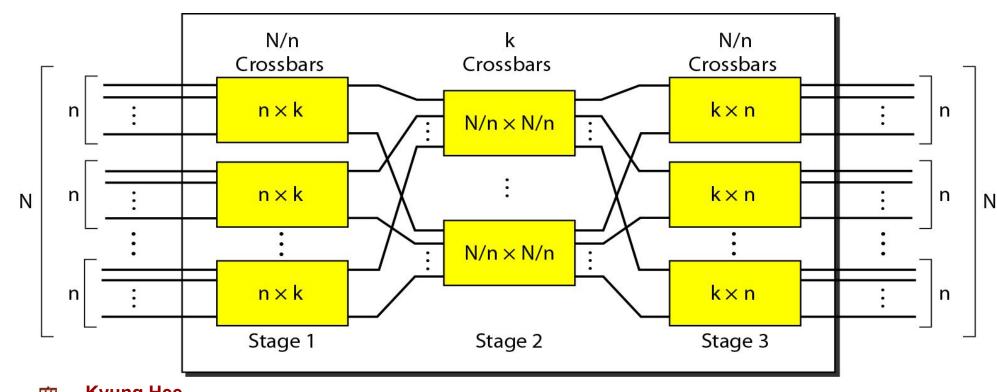
- inefficient
 - fewer than 25% of the crosspoints are in use at a given time.
 - the rest are idle



Multistage switch

~ combines crossbar switches in several (normally three) stages to solve the limitation of the crossbar switch.

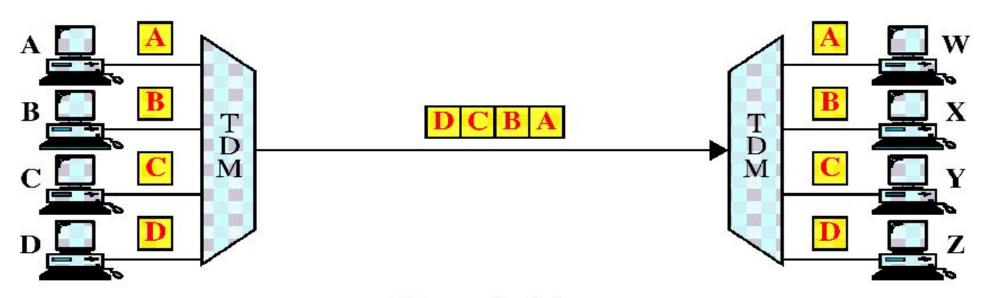
Figure 8.18 Multistage switch



- Time-Division Switch
 - uses Time-division multiplexing (TDM) inside a switch.
 - The most popular technology is called the time-slot interchange (TSI).
 - TSI changes the ordering of the slots based on the desired connections.



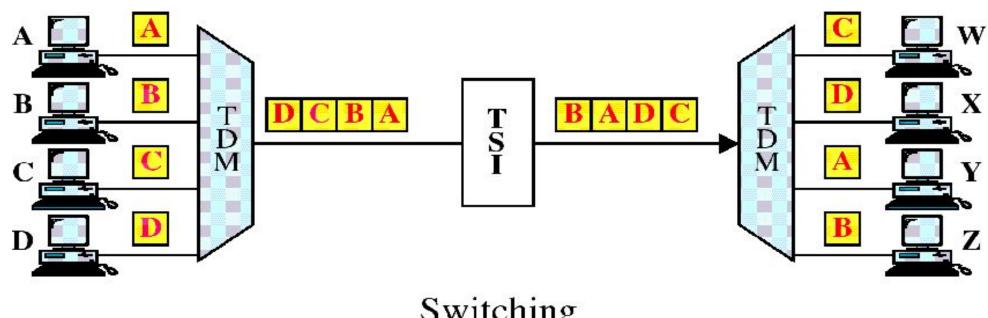
□ Time-division multiplexing without a time-slot interchange(TSI)



No switching



Time-division multiplexing with a time-slot interchange(TSI)

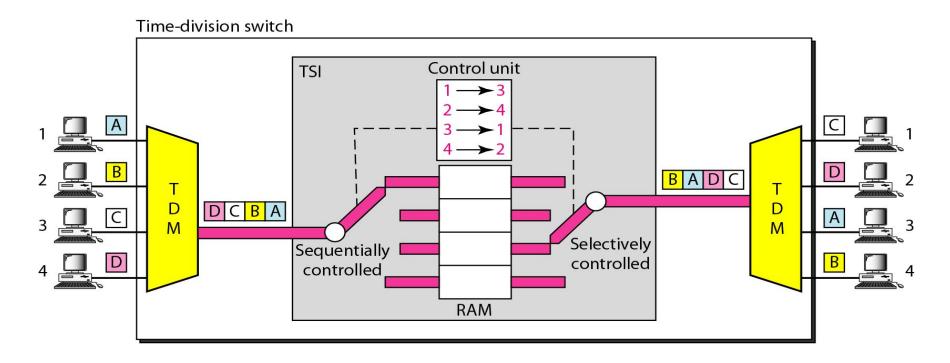






☐ TSI

Figure 8.19 Time-slot interchange

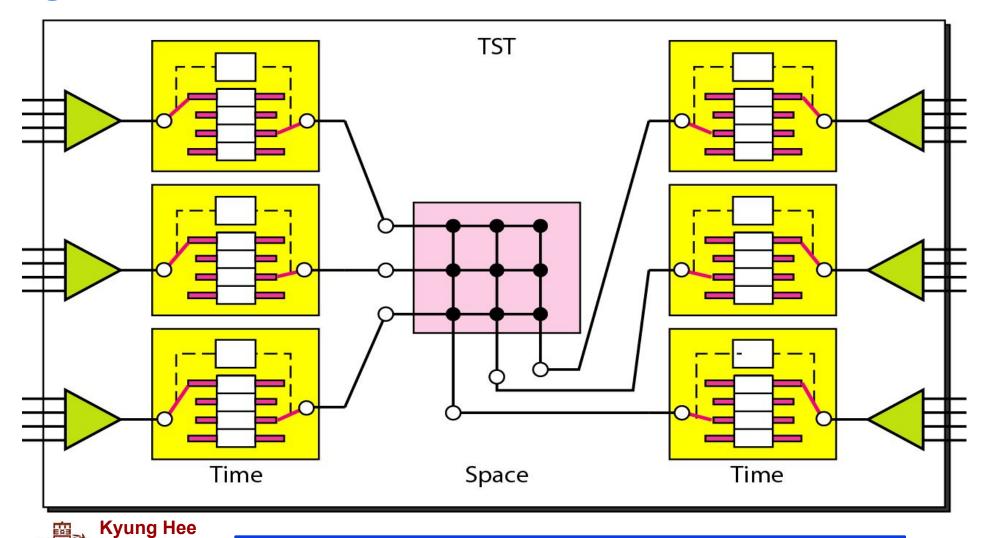


- Space-and Time-Division Switching Combinations
 - ~ combine space-division and time-division technology to take advantage of the best of both
 - TST(time-space-time)
 - TSST(time-space-space-time)
 - STTS(space-time-time-space)



Figure 8.20 Time-space-time switch

University



- A switch used in a packet-switched network has a different structure from a switch used in a circuit-switched network.
- A packet switch has four components;
 - input ports, output ports, the routing processor, and the switching fabric.

Figure 8.21 Packet switch components

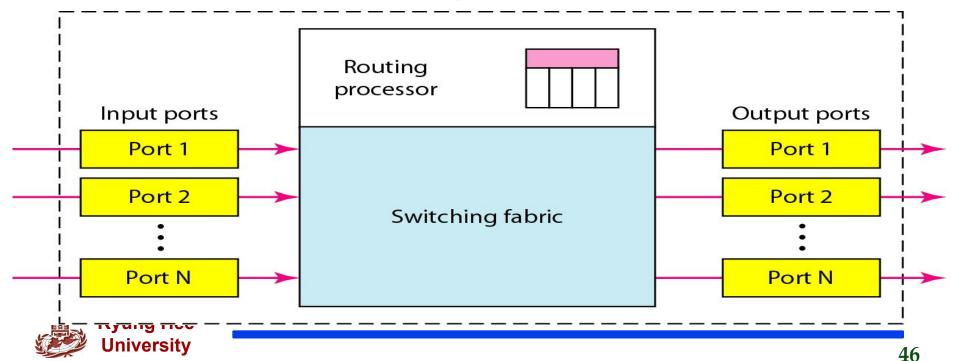


Figure 8.22 Input port

■ An input port performs the physical and data link functions of the packet switch.

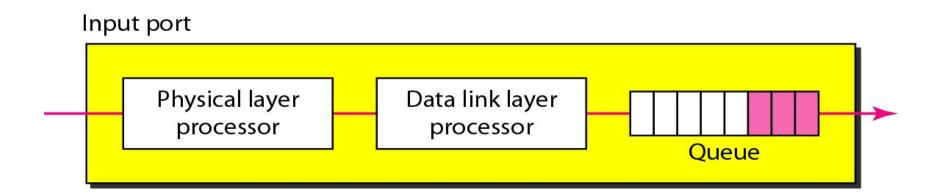
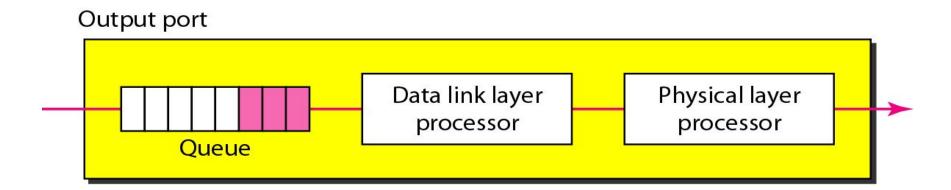




Figure 8.23 Output port

■ An output port performs the same functions as the input port, but in the reverse order.





- Routing Processor
 - The routing processor performs of the network layer.

- Switching fabrics
 - ♦ The most difficult task in a packet switch is to move the packet from the input queue to the output queue.
 - Today, packet switches are specialized mechanisms that use a variety of switching fabrics.
 - Crossbar switch : Simplest type of switching fabric is the crossbar switch.

Figure 8.24 A banyan switch

■ A banyan switch is a multistage switch with microswitches at each stage that route the packets based on the output port represented as a binary string.

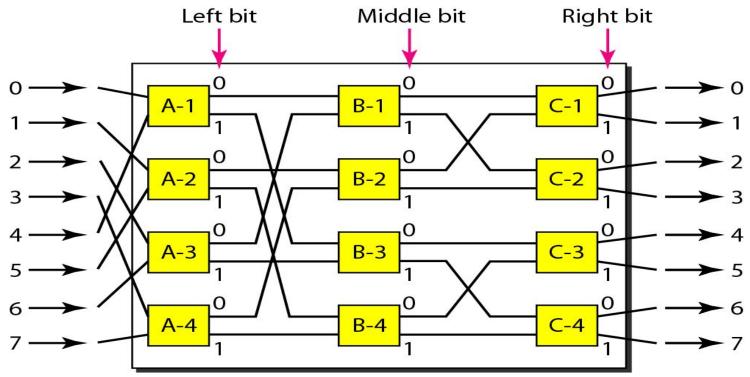
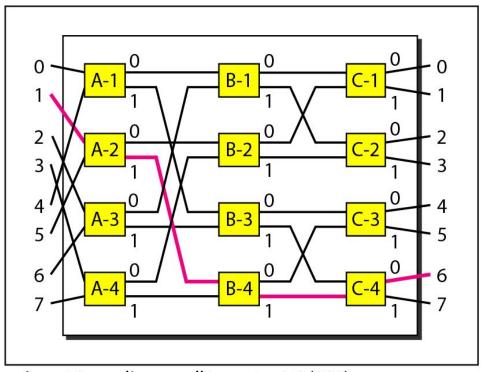




Figure 8.25 Examples of routing in a banyan switch



0 A-1 0 B-1 0 C-1 1 1 2 3 4 A-2 1 B-3 1 C-3 1 5 6 7 A-4 1 B-4 1 7

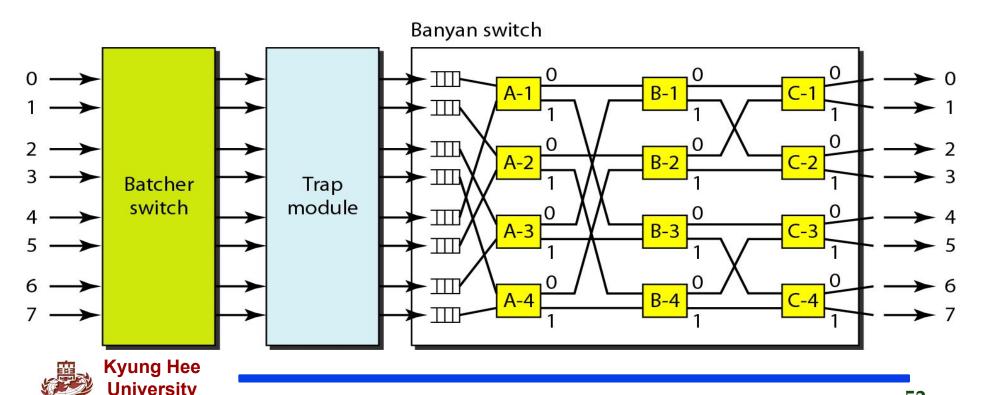
a. Input 1 sending a cell to output 6 (110)

b. Input 5 sending a cell to output 2 (010)



Figure 8.26 Batcher-banyan switch

■ Batcher-banyan switch has designed to solve the problem of banyan switch that comes before the banyan switch and sorts the incoming packets according to their final destination.



Summary (1)

- A switched network consists of a series of interlinked nodes, called switches; circuit switching, packet switching, and message switching.
- We can divide today's networks into three broad categories: circuit-switched networks, packet-switched networks, and messaged-switched. <u>Packet-switched networks</u> can also be divided into two subcategories: <u>virtual-circuit networks</u> and <u>datagram networks</u>.
- A circuit-switched network is made of a set of switches connected by physical links. In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data transfer phase until the teardown phase
- In packet switching, there is no resource allocation for a packet. This means that there is no reserved bandwidth on the links, and there is no scheduled processing time for each packet. Resourced are allocated on demand.



Summary (2)

- In a datagram network, each packet is treated independently of all others. Packets in this approach are referred to as datagrams, There are no setup or teardown phases.
- □ A virtual-circuit network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both.
- Circuit switching uses either of two technologies: the space-division switch or the time-division switch.
- □ A switch in a packet-switched network has a different structure from a switch used in a circuit-switched network. We can say that a packet switch has four types of components: input ports, output ports, a routing processor, and switching fabric.

Q & A



