

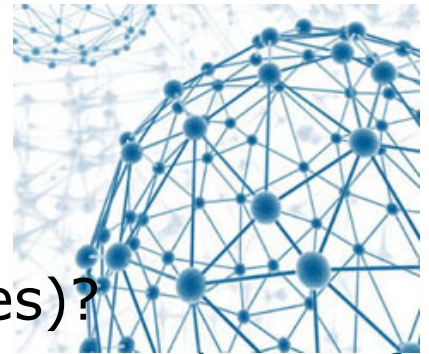


# Chapter 8: Switching

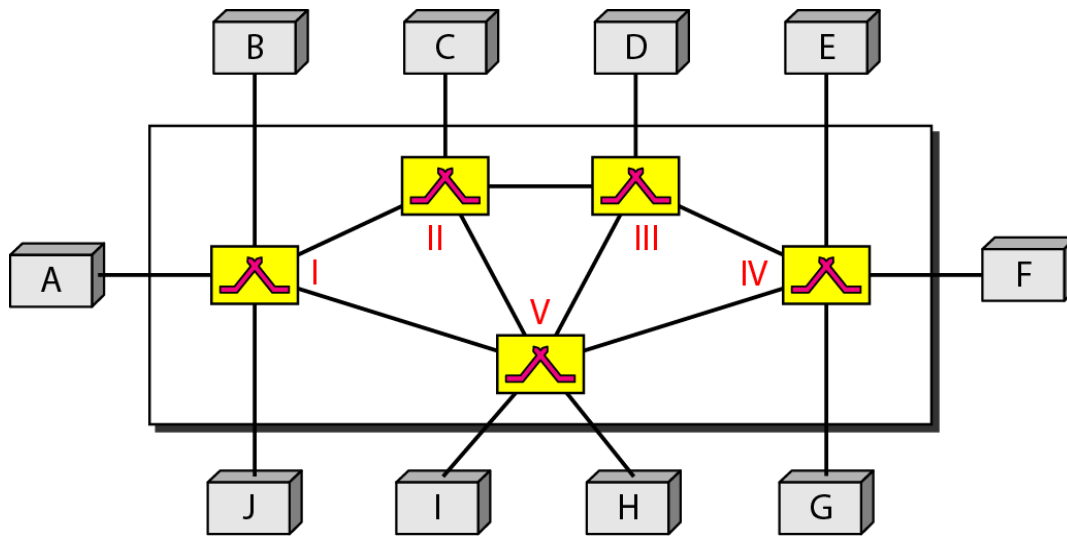
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## Outline

- Network
  - is a set of connected devices
- How to connect them (devices)?
  - point-to-point connection between each pair of all devices (mesh topology)
  - point-to-point connection between a central device and every other device (star topology)  
→ impractical
  - multipoint connection
- A better solution is **switching**
  - switched network



**Figure 8.1** *Switched network*



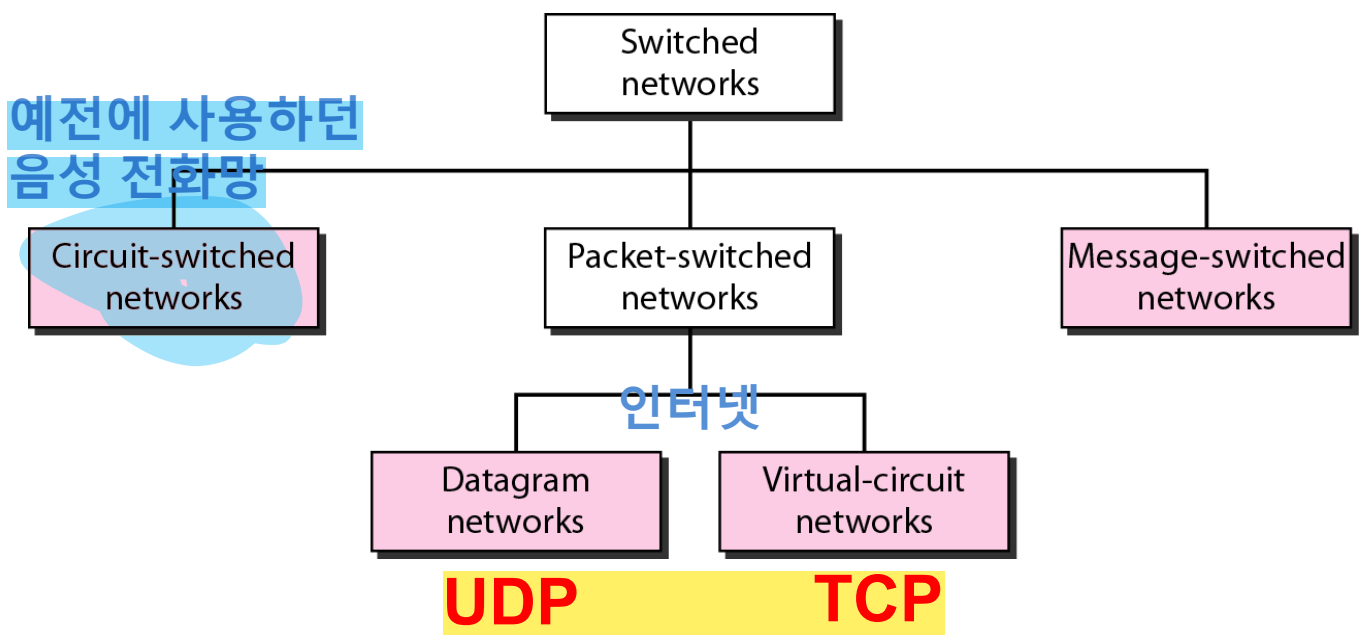
## Outline (continued)

- 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
  - some of switches are connected to the end systems (computers, telephones, etc.) and others are connected to the other switches (those are used only for routing)

## ● Switching

- to create temporary connections between two or more devices linked to the switch
- is performed in several layers
  - Circuit-switching : in physical layer
  - Packet-switching : in data-link and network layers
  - Message-switching : in application layer

**Figure 8.2** *Taxonomy of switched networks*



Switching can happen at several layers of the TCP/IP protocol suite: at the physical layer, at the data-link layer, and at the network layer.

## ● Circuit Switching

- Connection-oriented networks
- Physical layer
- No packetizing
- Low efficiency, less delay

## ● Packet Switching

- Connectionless networks
- Network layer
- Packetizing (sequence # is required)
- High efficiency, more delay

## ● Structure of a Switch

## 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

# Three Phases

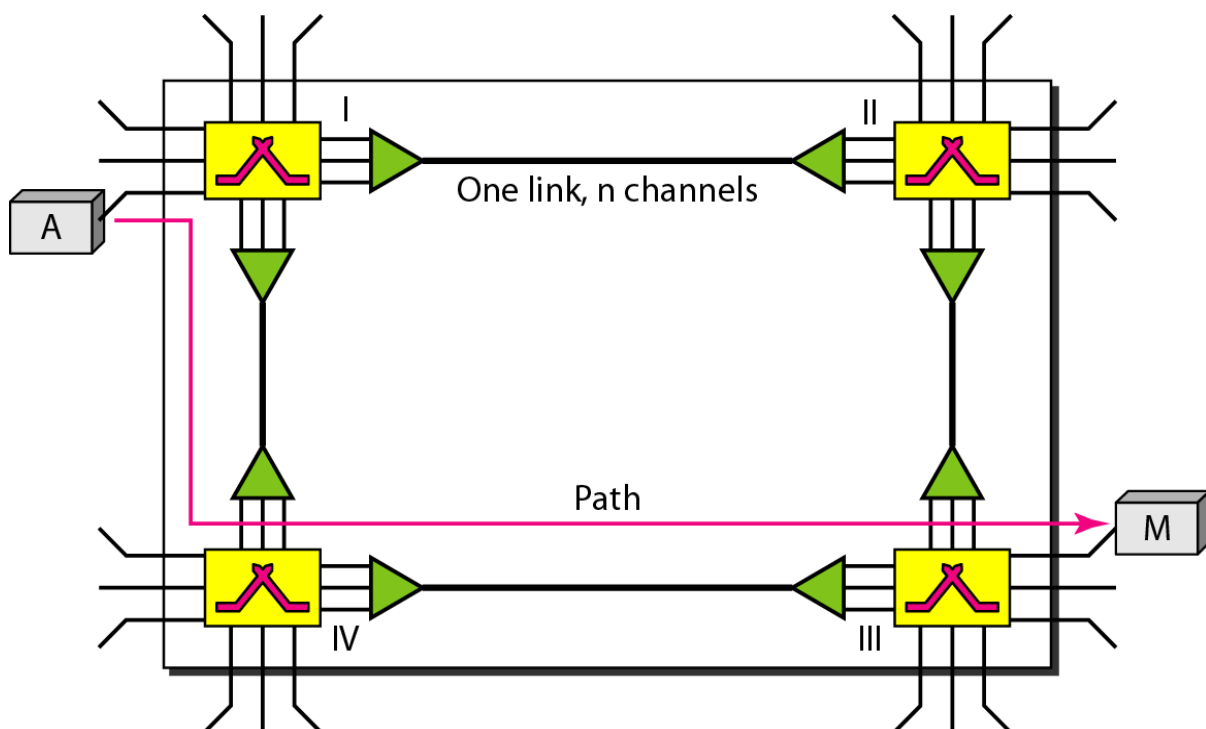
- Setup phase
- Data transfer
- Teardown phase

## Note

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

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.

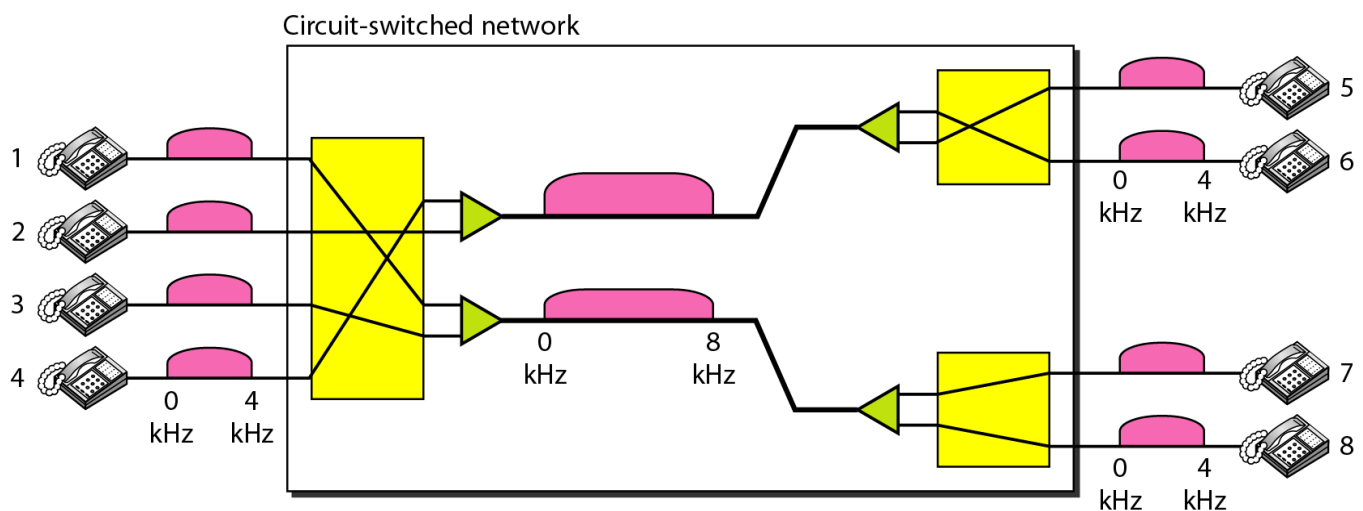
**Figure 8.3** *A trivial circuit-switched network*



## Example 8.1

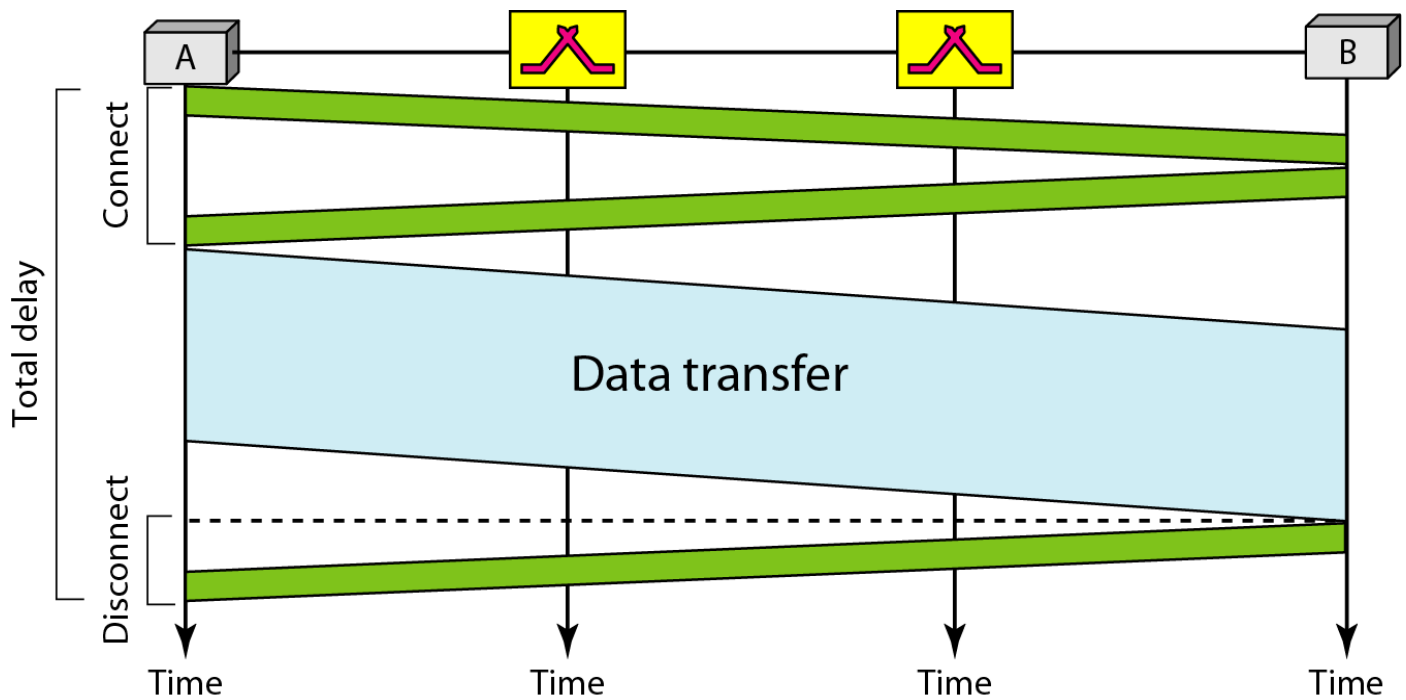
*As a trivial example, let us use a circuit-switched network to connect eight telephones in a small area. Communication is through 4-kHz voice channels. We assume that each link uses FDM to connect a maximum of two voice channels. The bandwidth of each link is then 8 kHz. Figure 8.4 shows the situation. Telephone 1 is connected to telephone 7; 2 to 5; 3 to 8; and 4 to 6. Of course the situation may change when new connections are made. The switch controls the connections.*

**Figure 8.4** *Circuit-switched network used in Example 8.1*



**Figure 8.6** Delay in a circuit-switched network

Low efficiency, less delay



**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.*

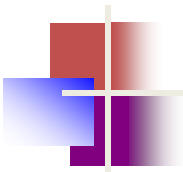
Topics discussed in this section:

Routing Table

Efficiency

Delay

Datagram Networks in the Internet

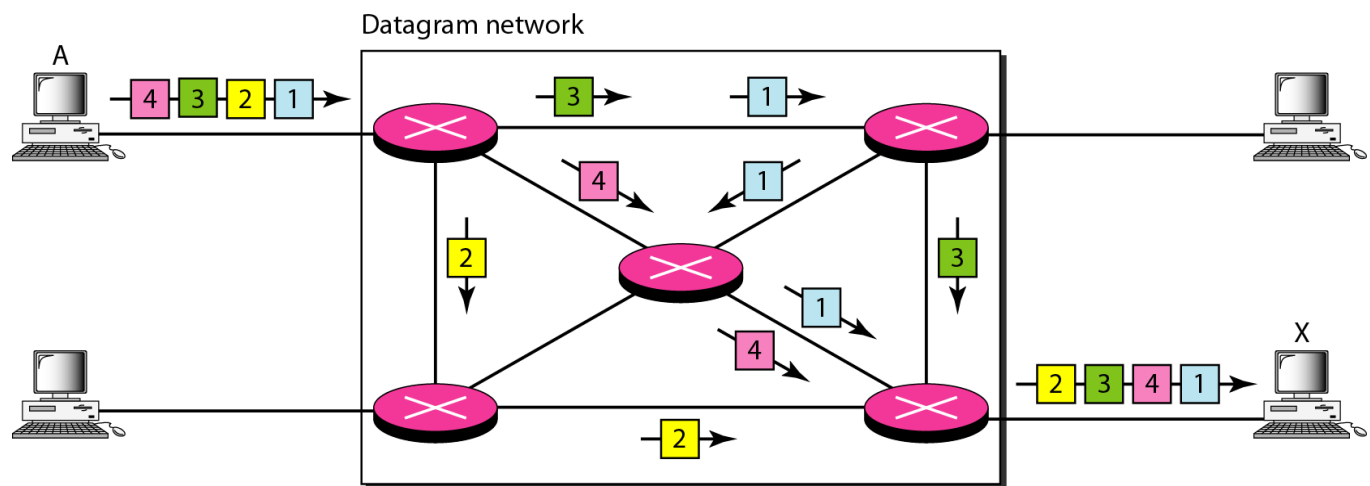


### *Note*

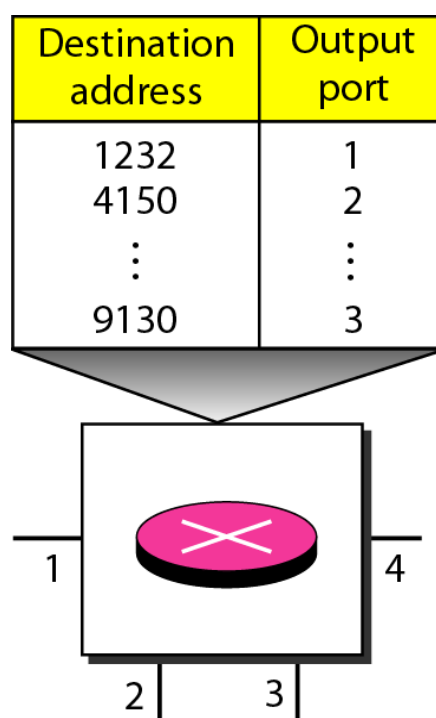
**In a packet-switched network, there is no resource reservation; resources are allocated on demand.**



**Figure 8.7** *A datagram network with four switches (routers)*



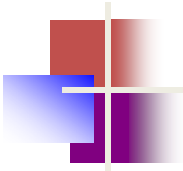
**Figure 8.8** *Routing table in a datagram network*





*Note*

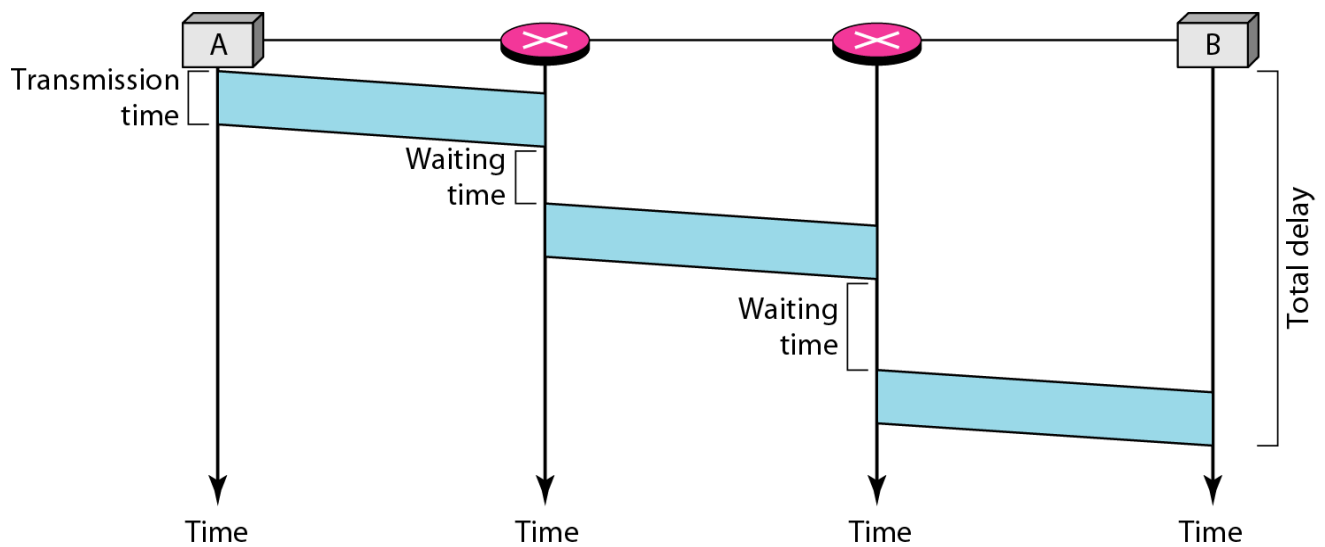
**A switch in a datagram network uses a routing table that is based on the destination address.**



*Note*

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

**Figure 8.9** *Delay in a datagram network*



**Note**

**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 Networks

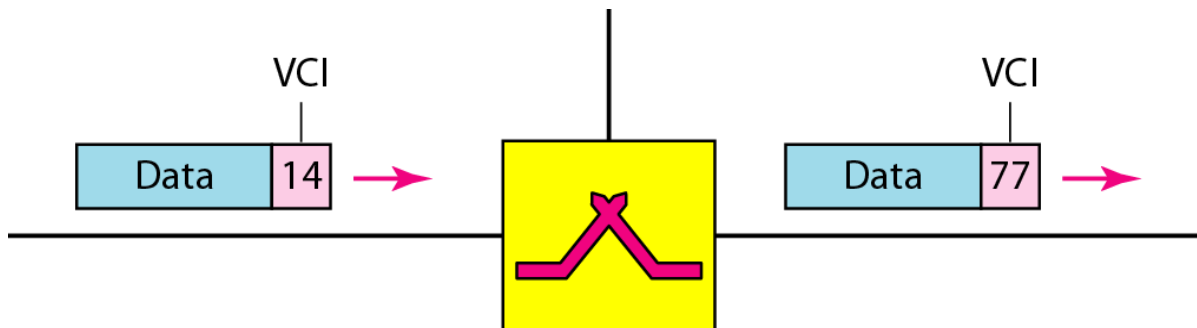
### ● Characteristics

- as in a c-s, there are setup and teardown phases
- resources can be allocated during the setup phase or on demand
- data are packetized and each packet carries an address in the header
  - global and local addresses
- all packets follow the same path established during the connection
- **v-c network is implemented in the data link layer**  
**c-s network is implemented in the physical layer**  
**datagram network is implemented in the network layer**

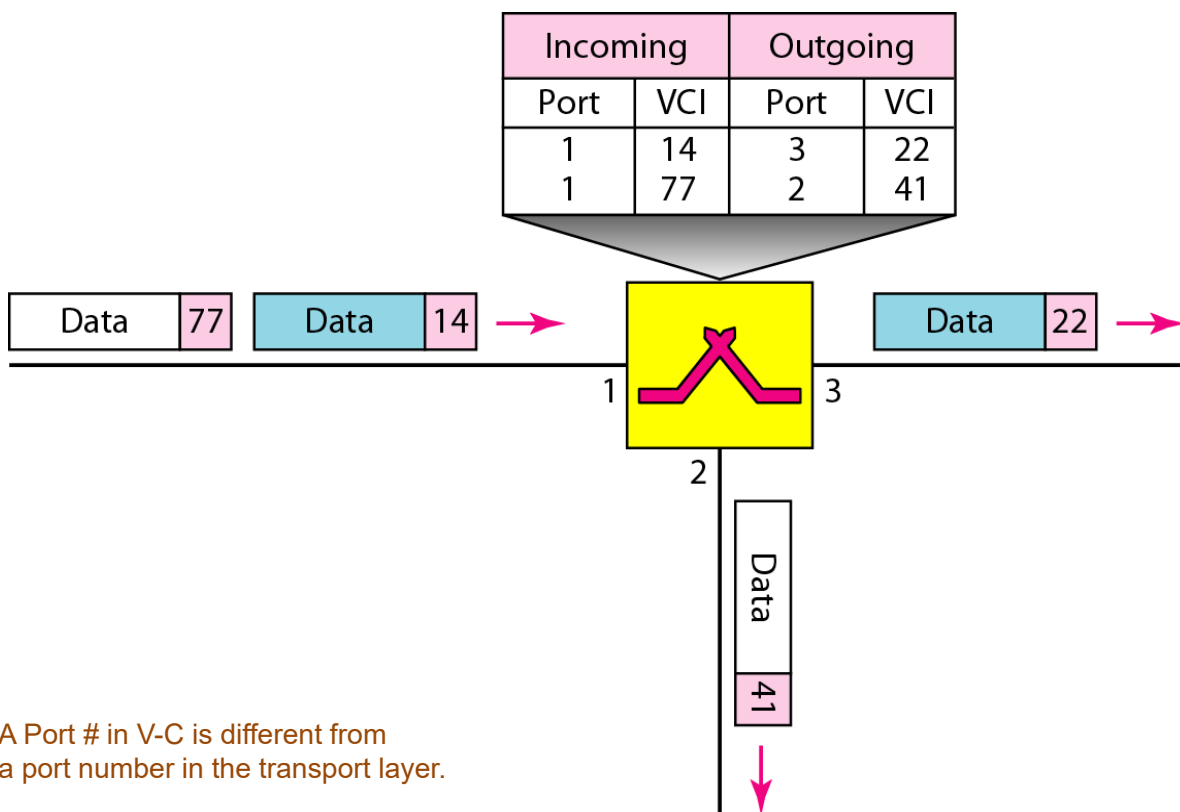
### ● Addressing

- global address
  - used only to create a v-c identifier
- virtual-circuit identifier
  - small number that has only switch scope
  - used by a frame between two switches

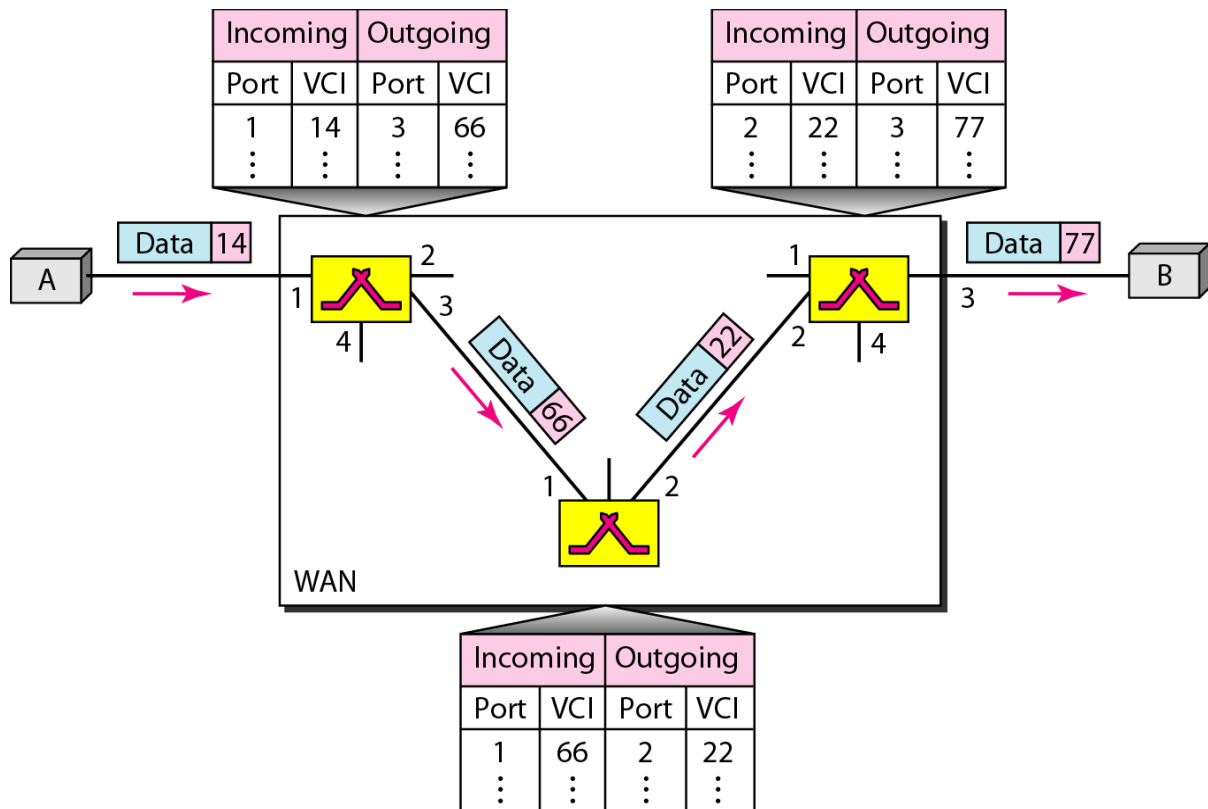
**Figure 8.11** *Virtual-circuit identifier*



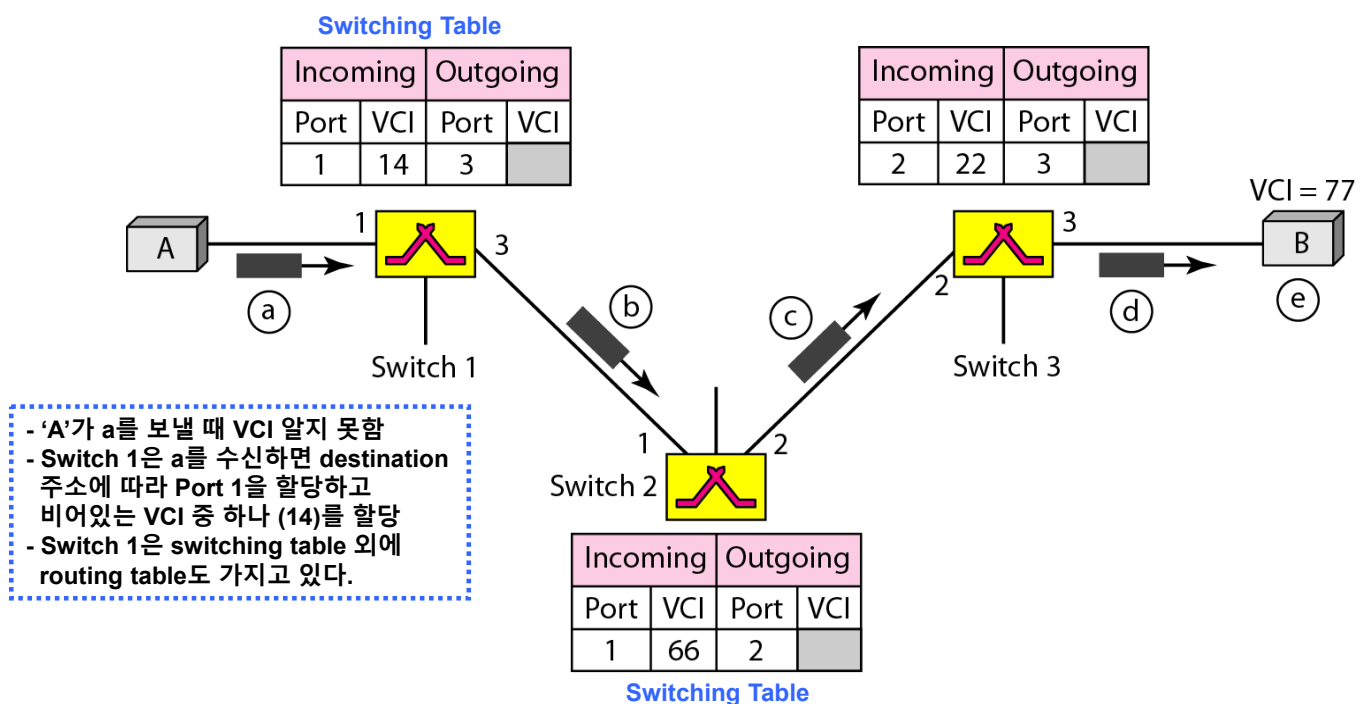
**Figure 8.12** *Switch and tables in a virtual-circuit network*



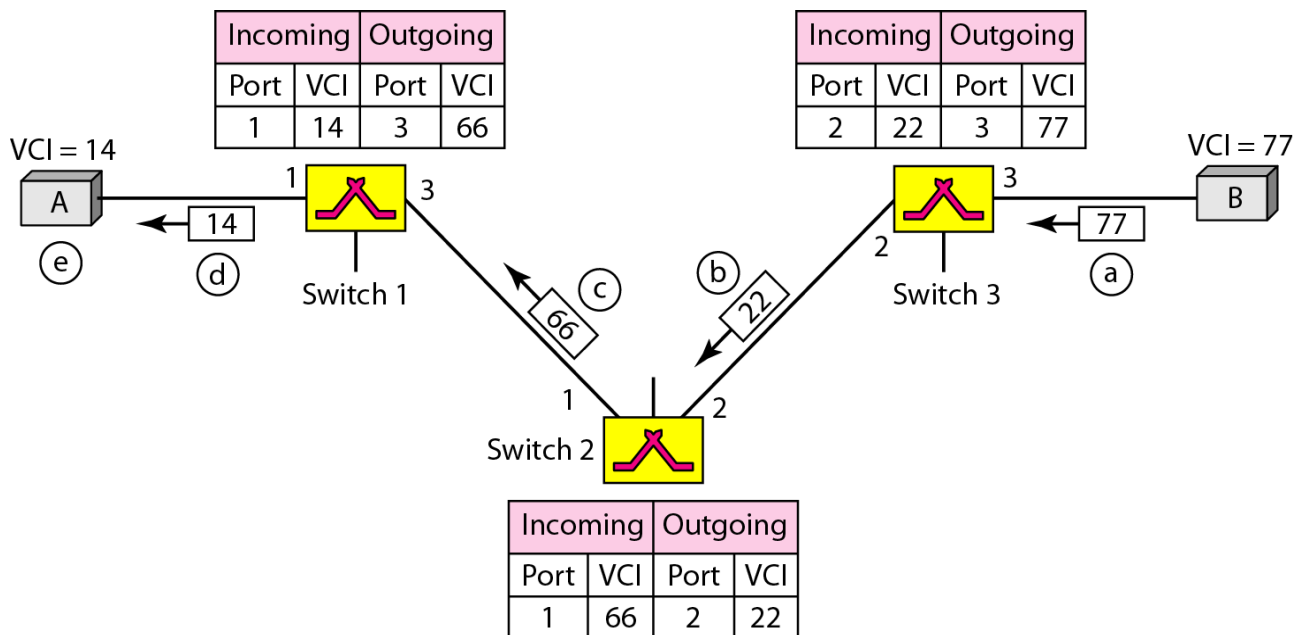
**Figure 8.13** *Source-to-destination data transfer in a virtual-circuit network*



**Figure 8.14** *Setup request in a virtual-circuit network*



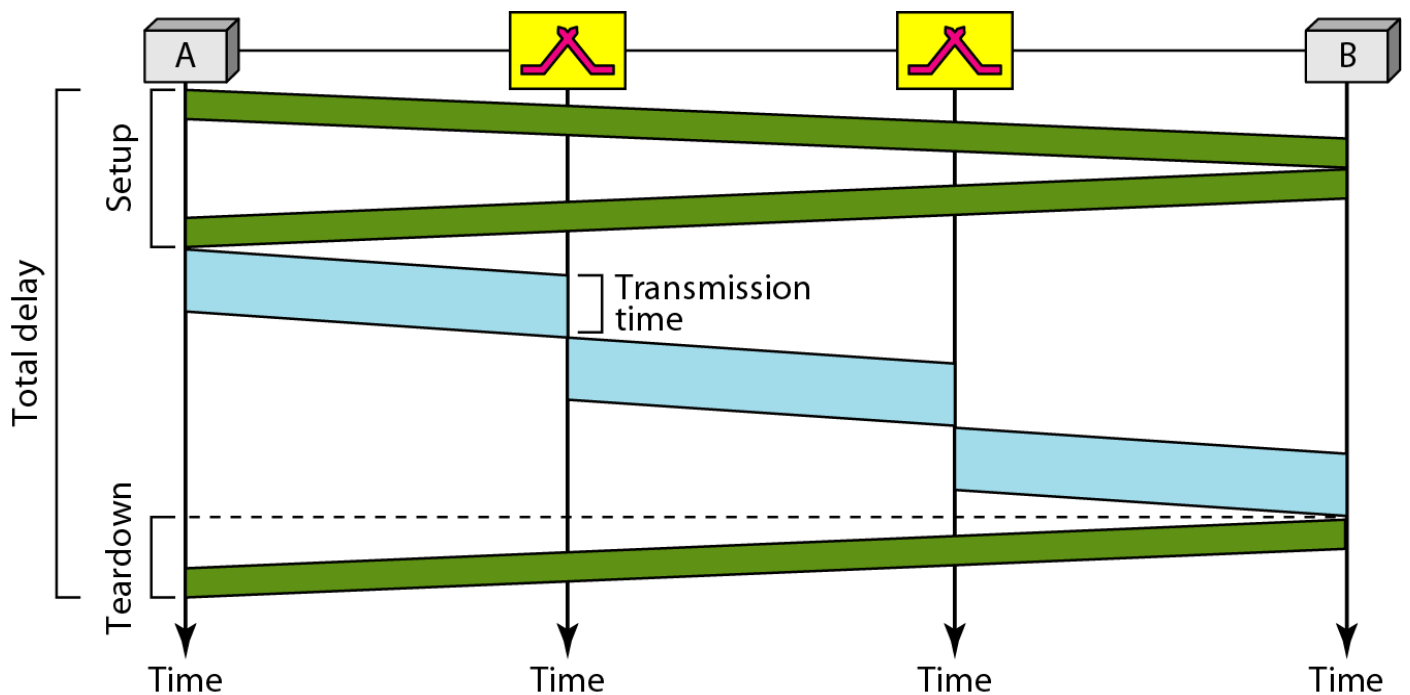
**Figure 8.15** *Setup acknowledgment in a virtual-circuit network*



**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.

**Figure 8.16** *Delay in a virtual-circuit network*



**Note**

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



## 8-4 STRUCTURE OF A SWITCH

*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:*

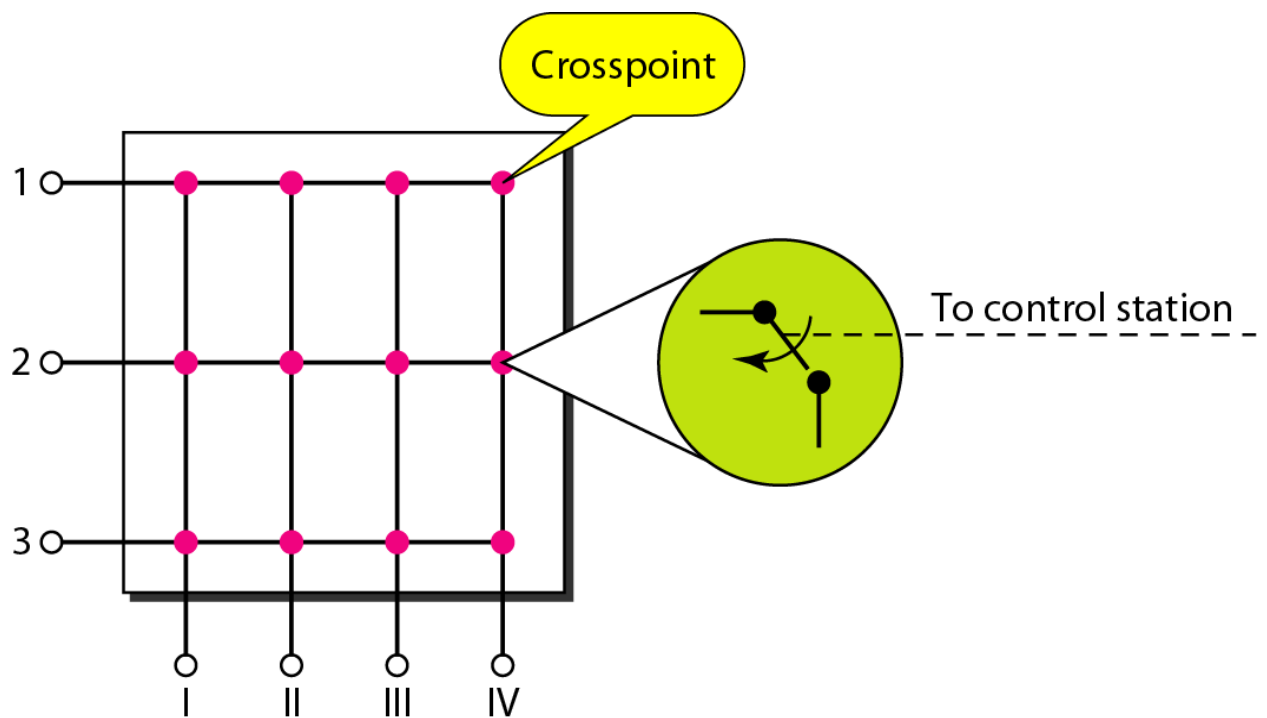
Structure of Circuit Switches

Structure of Packet Switches

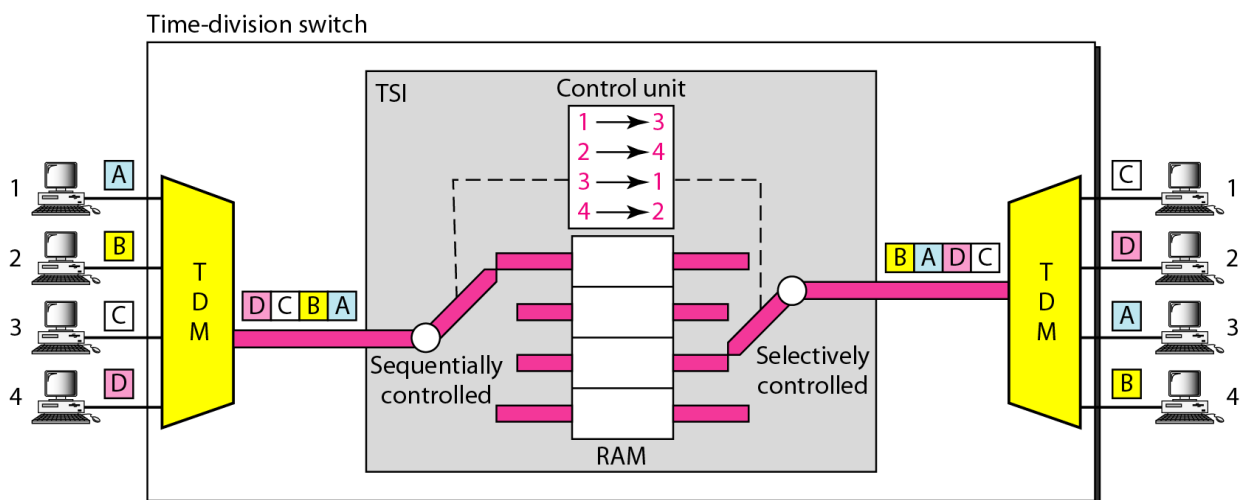
### 8.4.1 Structure of Circuit Switches

- Circuit switching today can use either of two technologies: the space-division switch or the time-division switch

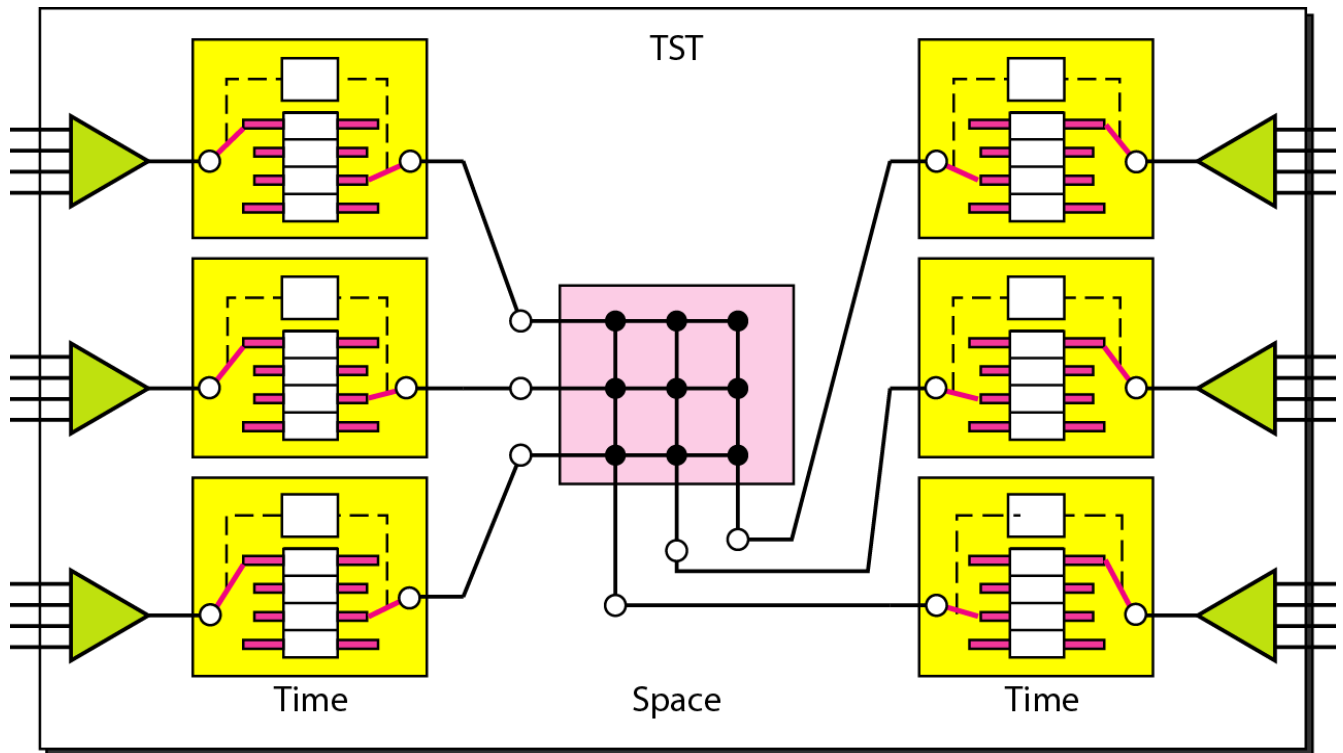
**Figure 8.17** *Crossbar switch with three inputs and four outputs*



**Figure 8.19** *Time-slot interchange*



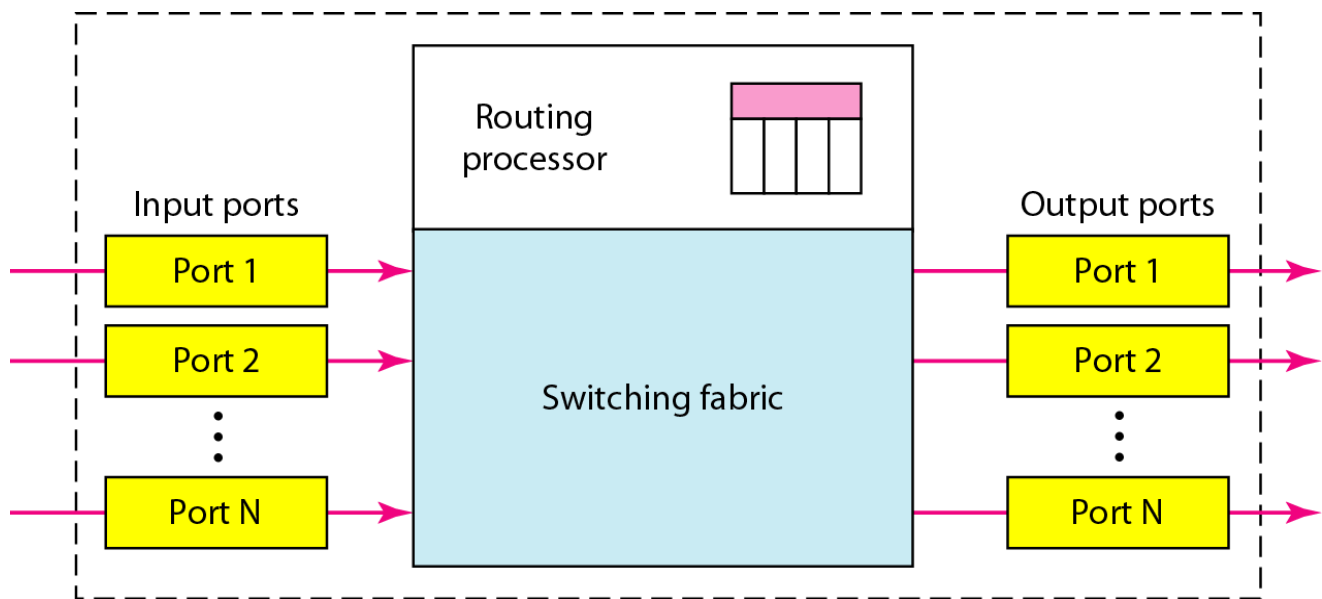
**Figure 8.20** *Time-space-time switch*



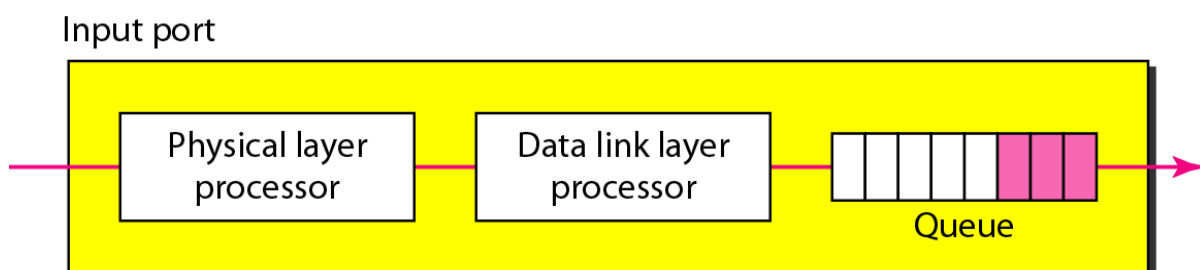
## 8.4.2 Structure of Packet Switches

- 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
  - the switching fabric

**Figure 8.21** *Packet switch components*



**Figure 8.22** *Input port*



**Figure 8.23** *Output port*

