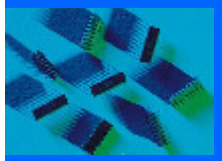


# Lecture 6
# Ethernet, Wireless LAN & Internetworking

Textbook: Ch.8, 13 and 15

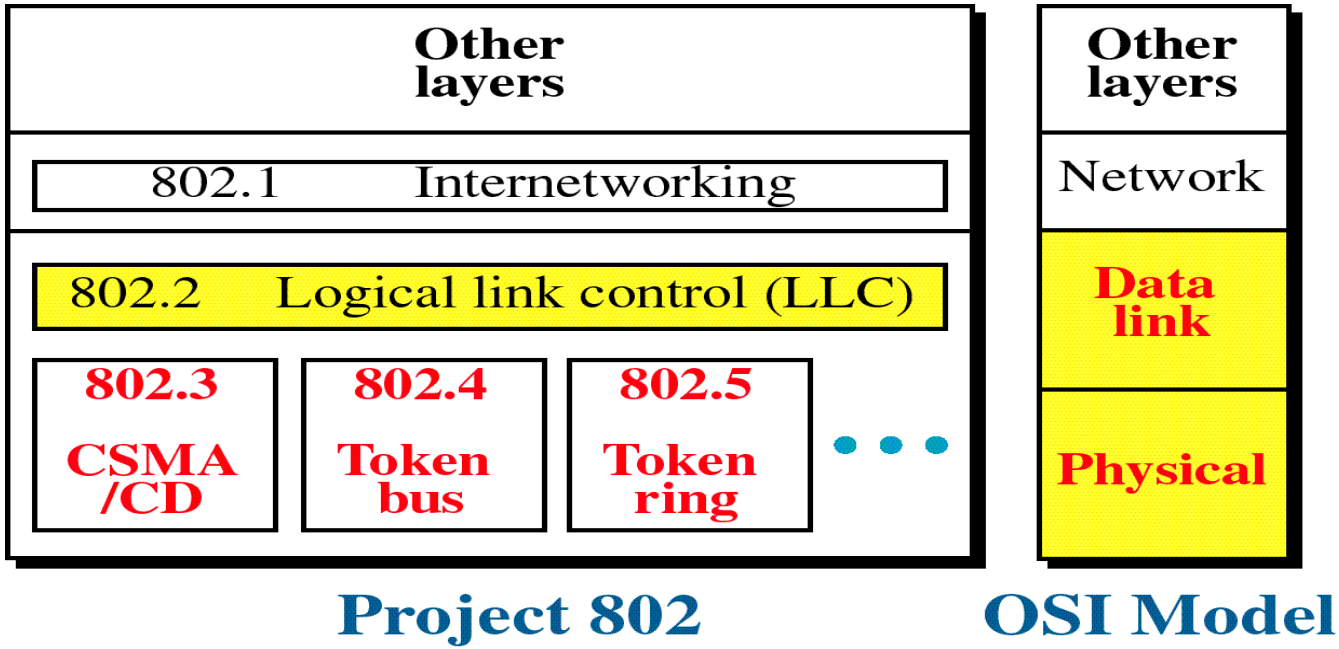
# Main Topics

- IEEE 802.3 Ethernet
- IEEE 802.11 Wireless LAN
- WAN & Internetworking
- Circuit-switched Network
  - Phases
  - Delay in a circuit-switched network
- Packet Switching
- Datagram Approach
  - Store-and-Forward operation
  - Delay in a datagram network
- Virtual Circuit Approach

# IEEE 802 Standard for LANs

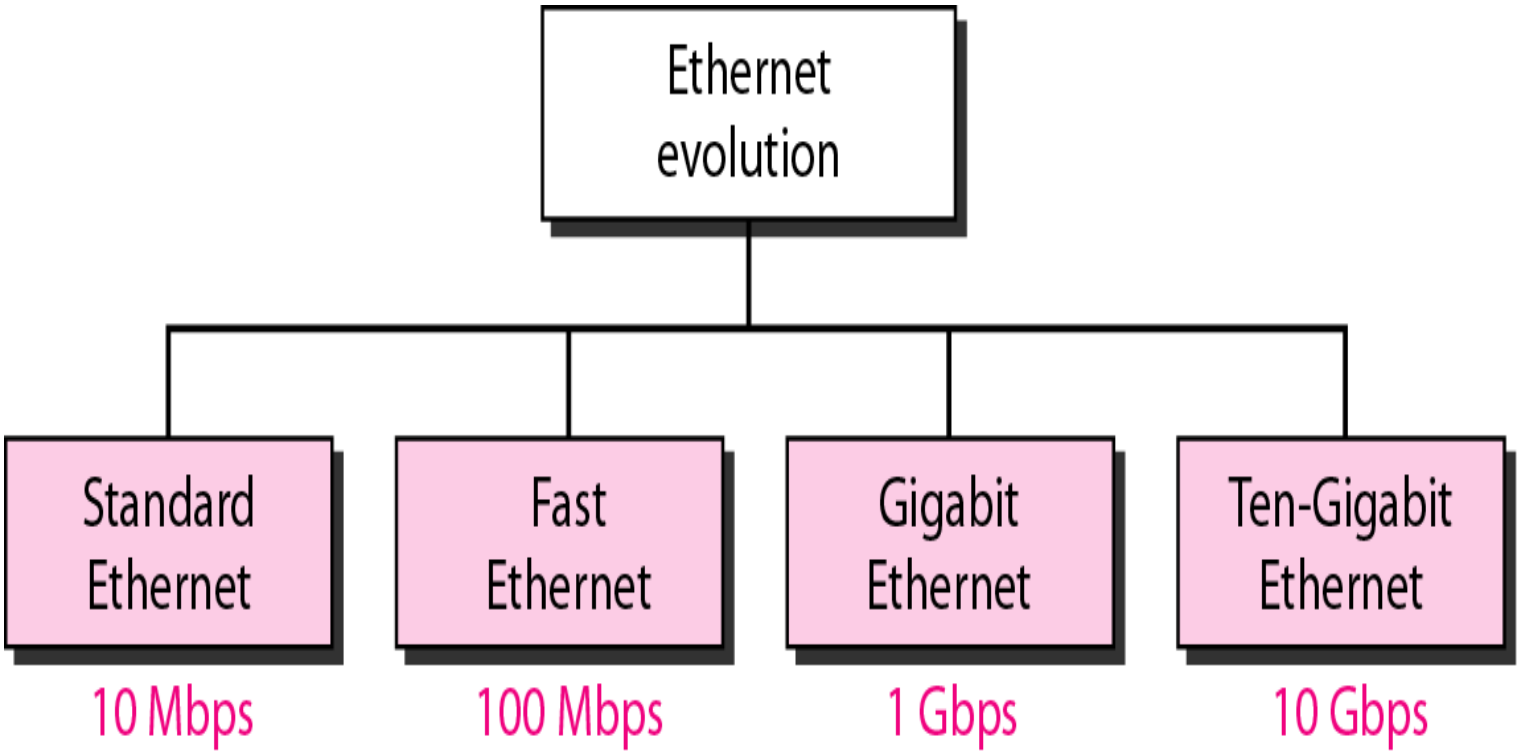
- *In 1985, the Computer Society of the IEEE started a project, called Project 802, to set standards to enable intercommunication among equipment from a variety of manufacturers.*

- *Project 802 is a way of specifying functions of the physical layer and the data link layer of major LAN protocols.*



# Standard Ethernet

- ***Ethernet evolution through four generations***



# Network Components of Ethernet

- **Communication controller card** ***(NIC, network interface card)*** in the station (computer) contains:
- **MAC unit** for such functions as encapsulation, error detection & execution of MAC algorithm
- **Transceiver :** transmitter and receiver in one unit ***(also called MAU, medium attachment unit) -*** part of the NIC
  - send & receive data from cable
  - detect occurrence of collisions

# MAC Protocol of Ethernet

- Bus topology with a broadcast channel (usually a coaxial cable)
- Access Method
  - 1-persistent CSMA/CD Bus ***(IEEE 802.3)***

# Frame Format of Ethernet

Preamble: 56 bits of alternating 1s and 0s.

SFD: Start frame delimiter, flag (10101011)

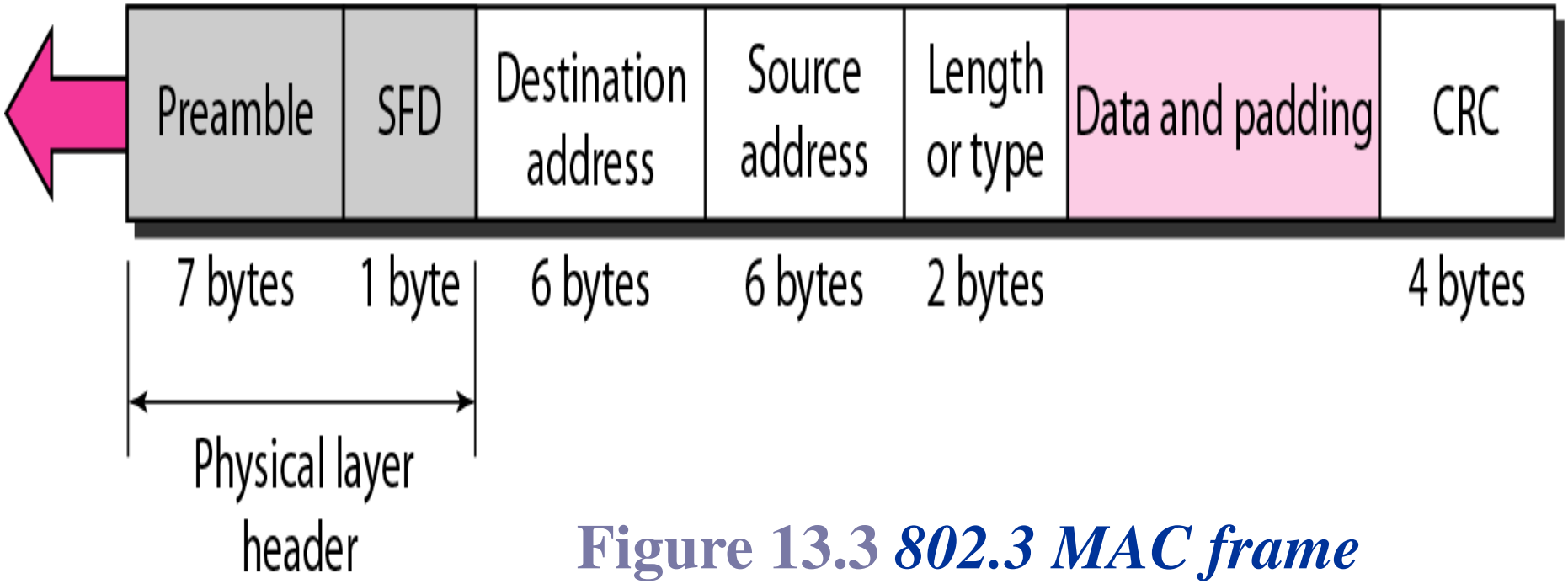
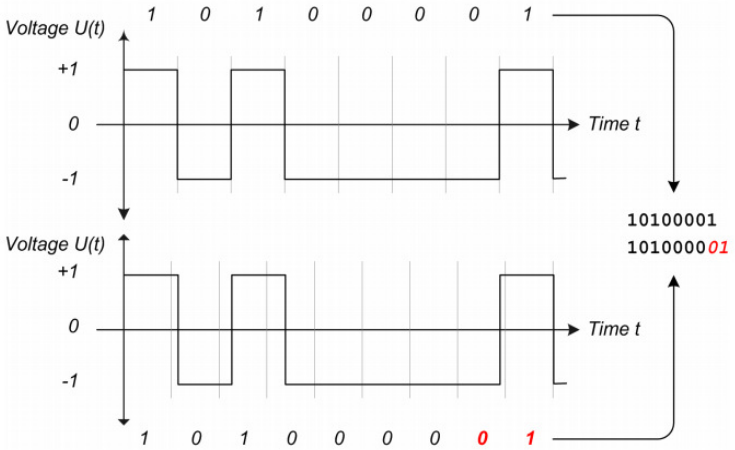



**Figure 13.3 *802.3 MAC frame***

# Ethernet Frame Format & Parameters

- Ethernet Frame contains seven fields:

1. **Preamble**
   - contains 7x(10101010) for bit synchronization




(with a little bit faster clock)

2. **Start of Frame Delimiter** (SFD)
   - 10101011 (also as a last chance for synchronization)
   - signals the beginning of the frame

# Ethernet Frame Fields

3. **Length** (or type)
   - the packet length **in bytes** (***excluding preamble and SFD***)

4. **Destination Address** (DA)
   - 6 bytes containing the ***physical address*** of the destination station or stations to receive the packet

5. **Source Address** (SA)
   - 6 bytes containing the physical address of the sender of the packet

# Ethernet Frame Fields

6. **Data**
   - carries data encapsulated from the upper-layer protocols
   - **data length: a *minimum* of 46 bytes and a *maximum* of 1500 bytes**
   - if length < minimum frame size, then dummy bytes are added (known as padding) in the data field

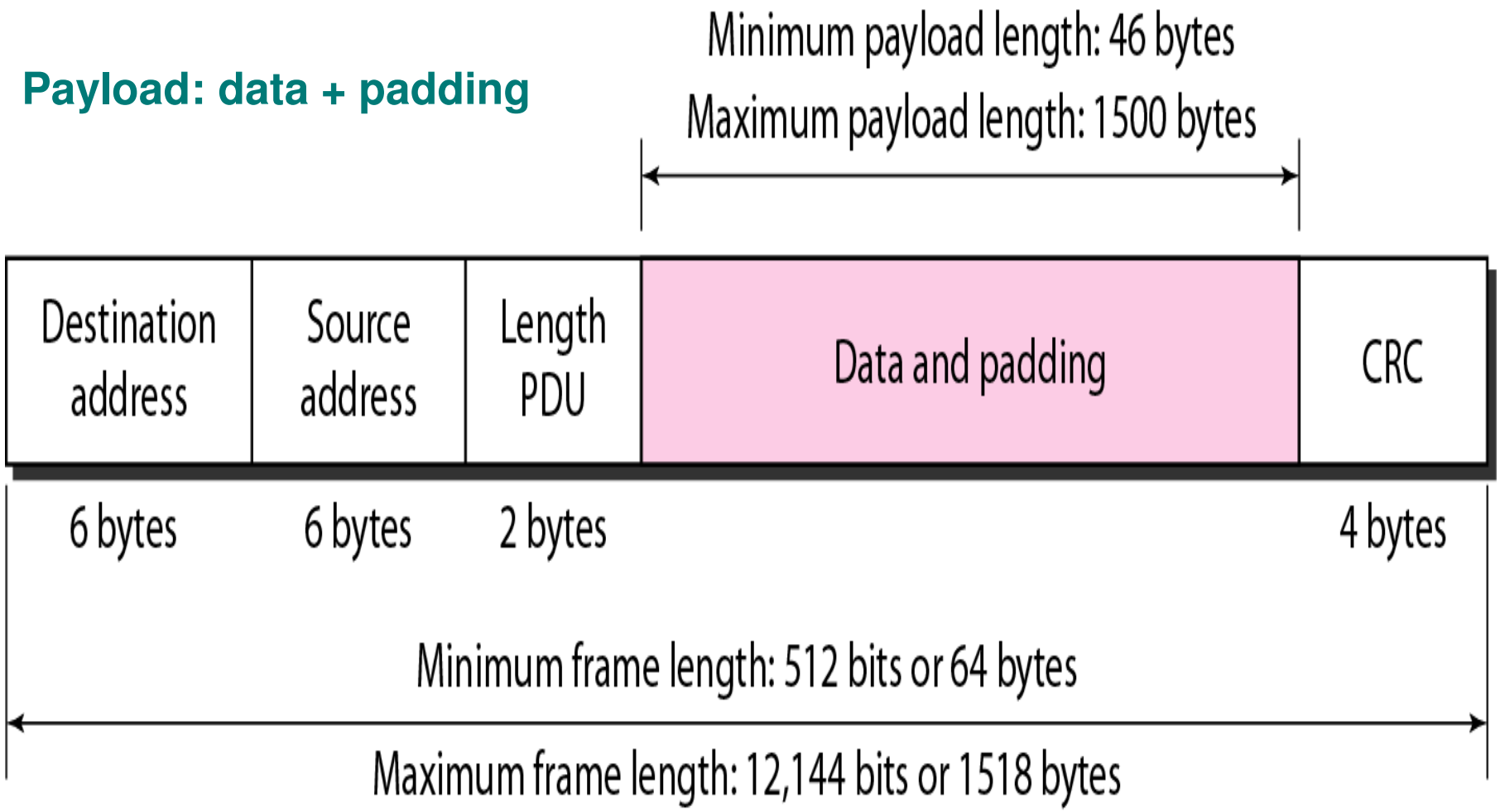
7. **CRC**
   - CRC-32 for error detection

# Ethernet Frame Length

- Minimum length:
  - Remember in CSMA/CD, a minimum length restriction is required for correct operation
- Maximum length:
  - Reduce the size of buffer in memory
  - Prevent one station from monopolizing the shared channel (using the channel too long)

**Frame length:**
**Minimum: 64 bytes (512 bits)**
**Maximum: 1518 bytes (12,144 bits)**

# Figure 13.5 *Minimum and maximum lengths*



# Wireless LAN - IEEE 802.11

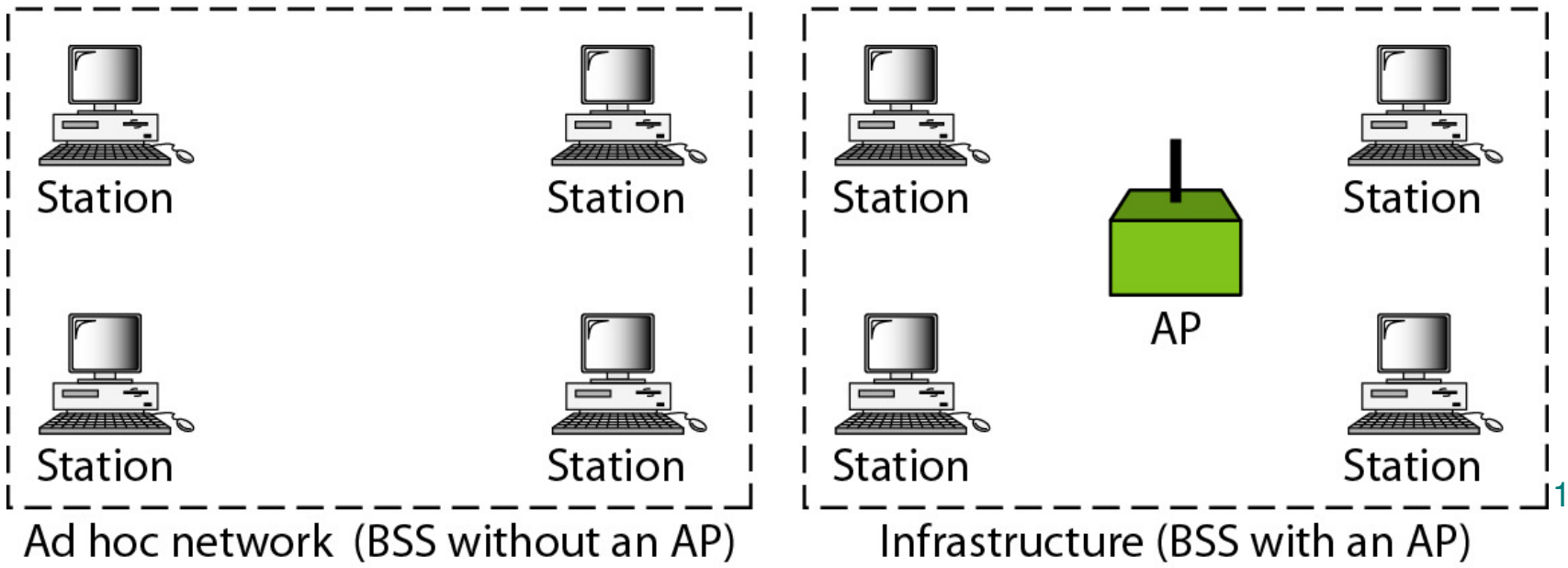
- IEEE 802.11 is the IEEE specifications for a wireless LAN.
- **Infrastructure** (architecture): uplink and downlink via the **access points** (base stations)
- **Transmission media**: Infrared or radio signal using spread spectrum techniques
- Use ***CSMA/CA*** (collision avoidance) protocol to organize the transmissions from mobile stations
- Wireless (radio) networks *cannot* use the CSMA/CD protocol (skip the details:15.1.3, p.438-439)

# Architecture of Wireless Network

- Two kinds of services: BSS and ESS
  - Basic Service Set (BSS)
    - It made up of stationary or mobile wireless stations.

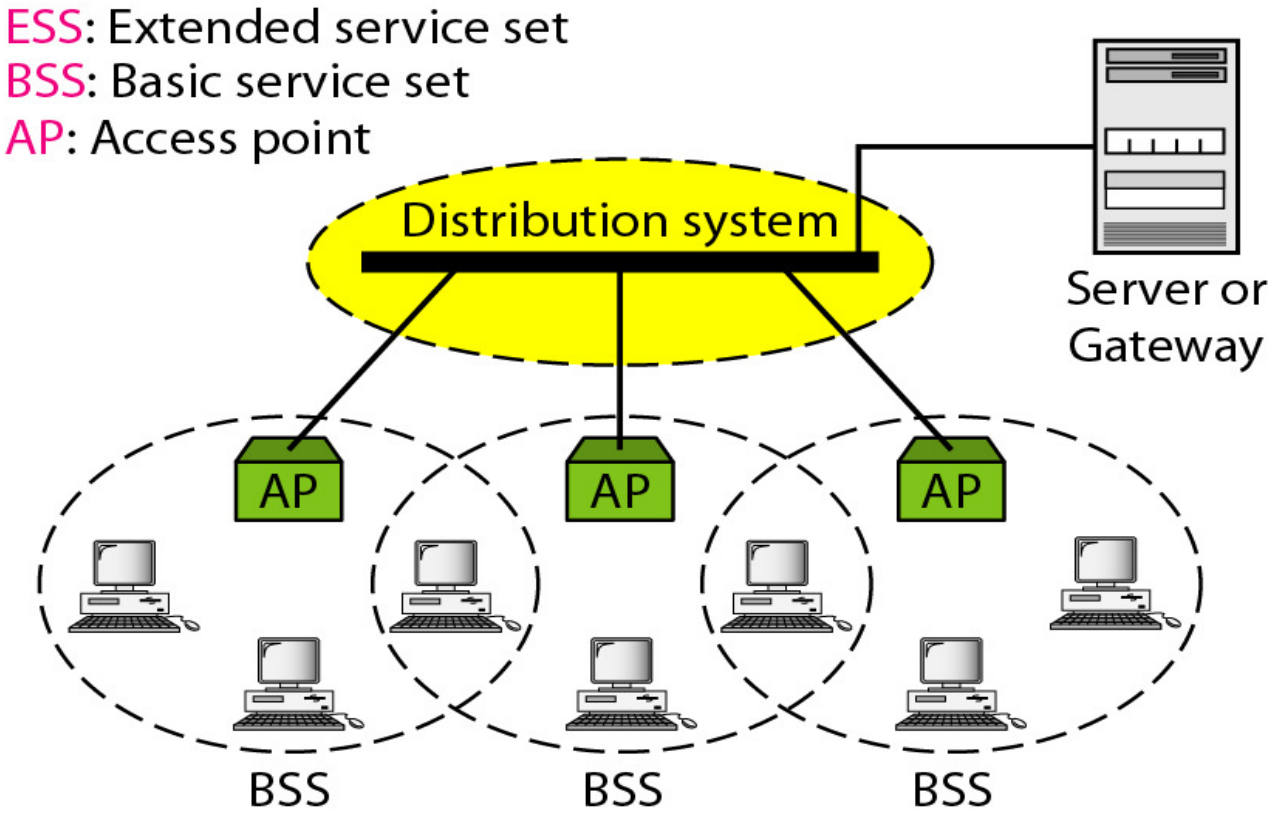
**A BSS without an AP is called an ad hoc network; a BSS with an AP is called an infrastructure network.**

BSS: Basic service set
AP: Access point

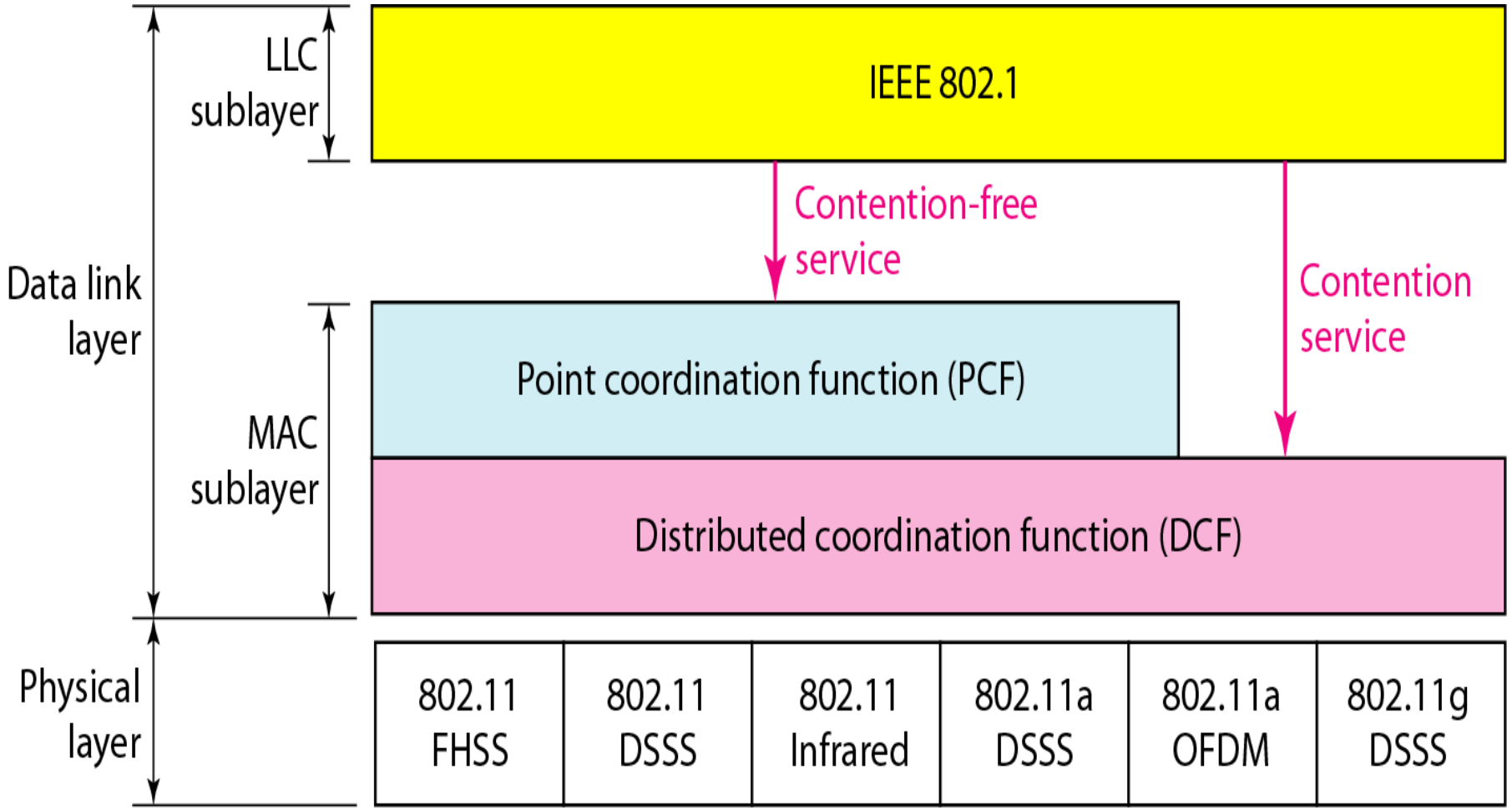


# Extended Service Set (ESS)

- It made up of two or more BSSs with ***Access Points (AP)***.
- BSSs are connected through a *distribution system* (usually Wired LAN)



# MAC layers in IEEE 802.11 standard



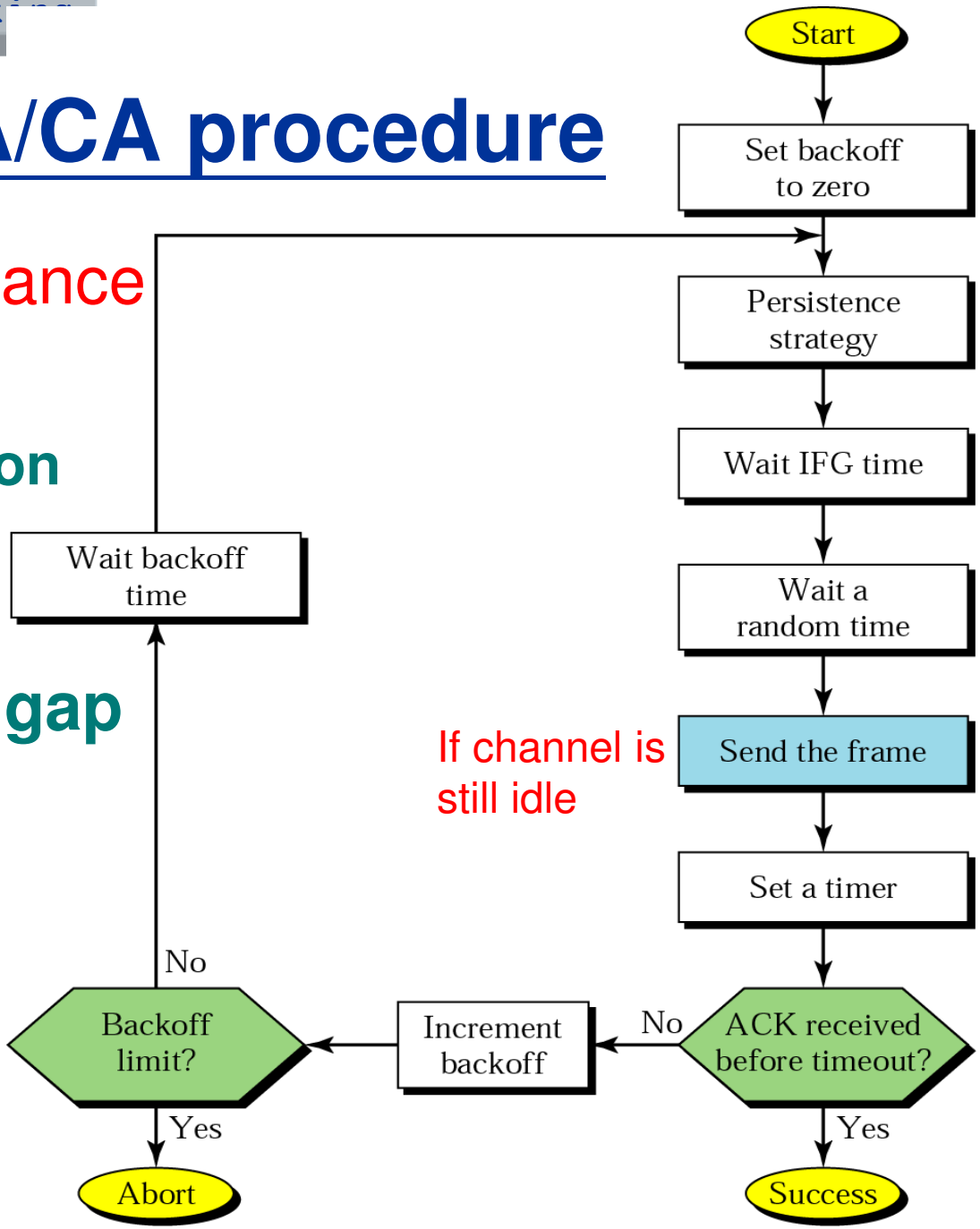

(Skip the details)



Figure 15.6

# CSMA/CA procedure

- CA: Collision Avoidance
- **Key difference:**
  - **There is no collision detection**
- **IFG is inter-frame gap**




(Skip the details)

# Wide Area Network (WAN)

- A network that links stations and LANs that are physically located in different geographic areas
- Include both public data networks and enterprise wide private data networks
- Three major concerns/functions in internetworking:
  - Routing
  - Congestion Control
  - Flow Control

# Three major concerns on WANs

- **Routing**
  - determine how packets are routed from source to destination (i.e. select the best path)
- **Congestion Control**
  - make sure the network is able to carry the offered traffic
  - a ***global issue*** involves all stations and routers
- **Flow Control**
  - make sure that a fast sender cannot continually transmit data faster than the receiver can accept
  - a ***local issue*** between a given sender and a given receiver

# Ch.8 Switching

- 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.

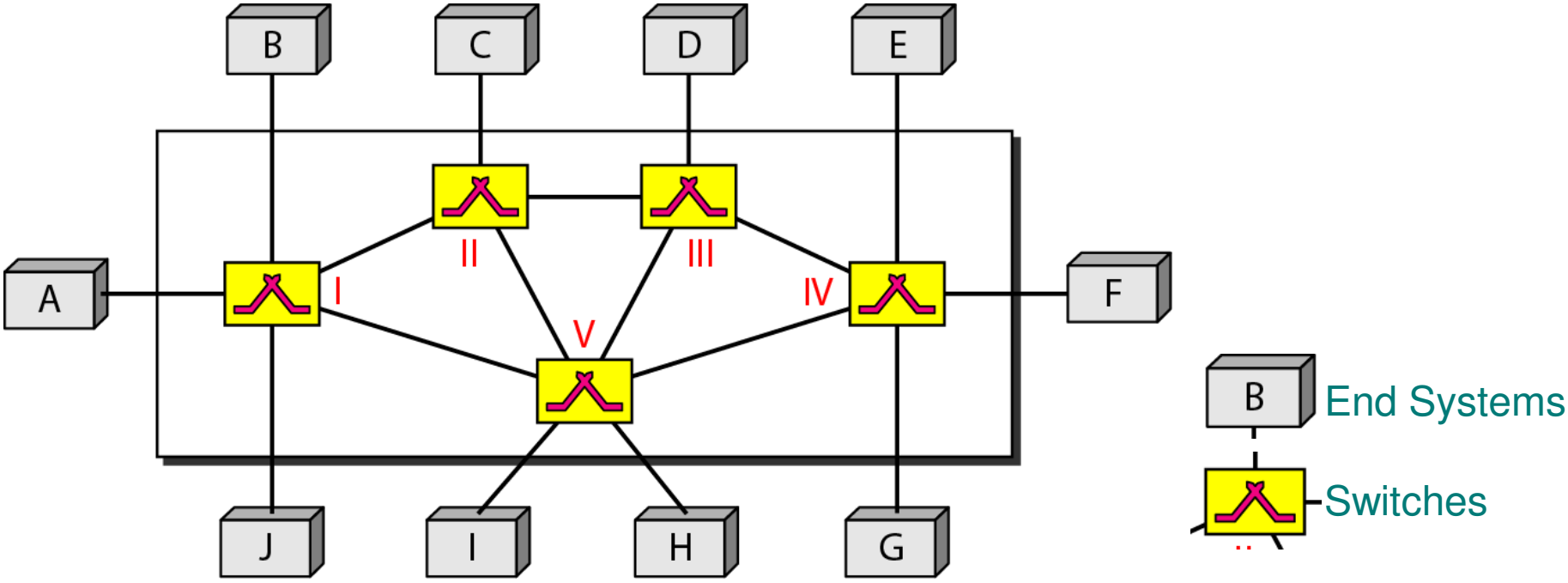


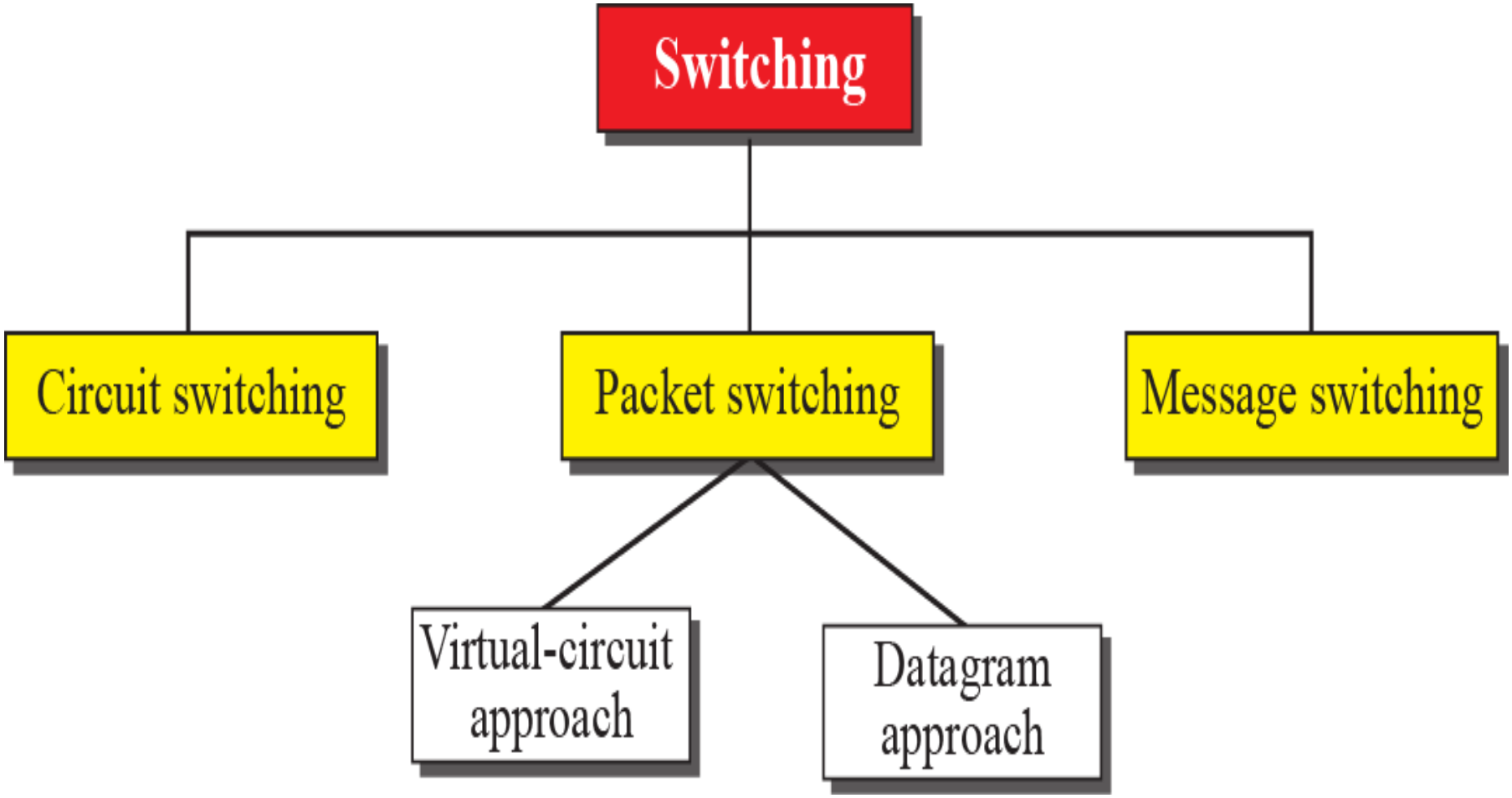



Figure 8.1 *Switched network*

# Three Methods of Switching

- Switching is a method in which communication devices are connected to one another efficiently.
- Traditionally three methods of switching: ***circuit switching, packet switching, and message switching.***
- The first two are commonly used today. The third has been phased out in general communications but still has applications.
- Packet switching can further be divided into two subcategories, **virtual-circuit** approach and **datagram** approach.

# Figure 8.2: Taxonomy of switched networks



# Circuit-switched Network

- It 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 (which is normally divided into n channels by using FDM or TDM).
- 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.

# Phases in Circuit-switched Network

- **Setup phase**
  - A channel is reserved on each link and the dedicated path is defined.
- **Data Transfer phase**
  - Two parties can transfer data.
- **Teardown Phase**
  - When one of the parties needs to disconnect, a signal is sent to each switch to release the resource.

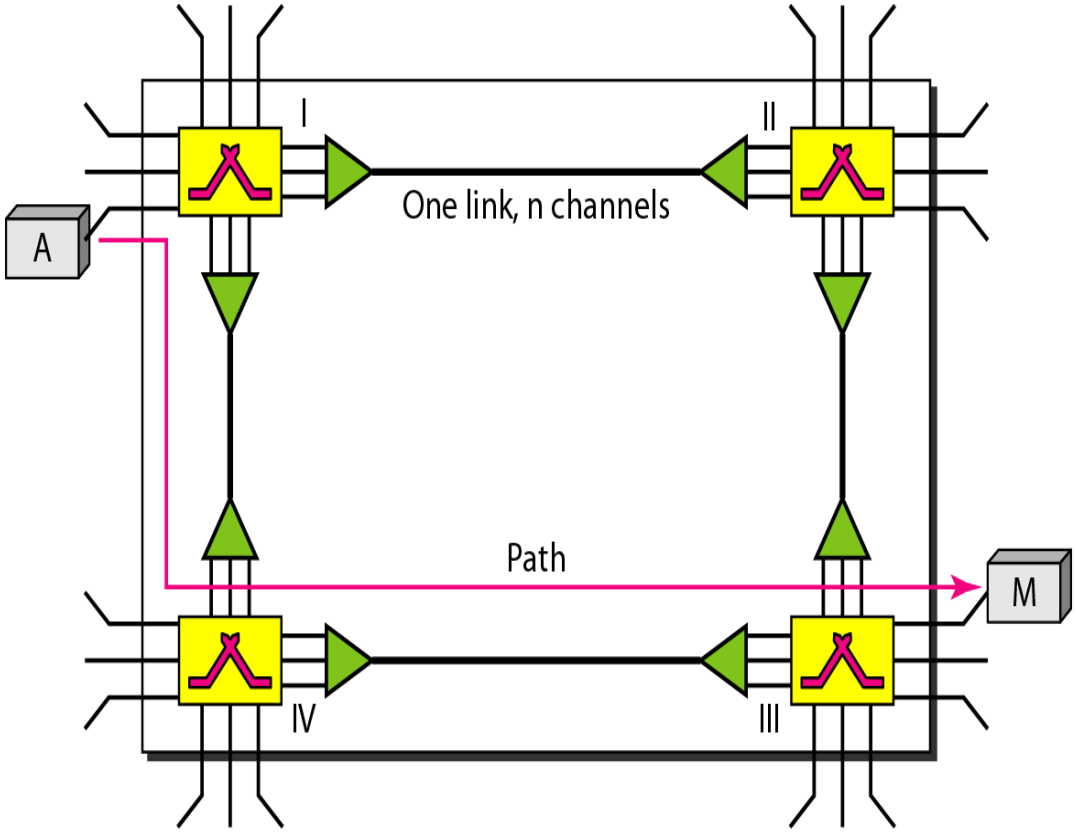



Figure 8.3 *A trivial circuit-switched network*

# Circuit Switching

- A (***temporary***) ***dedicated path*** (just like a point-to-point link) between the source and the destination is provided for the duration of data transmission (called ***session***). It is similar to a telephone call.
- Advantage
  - Throughput and delay characteristics are predictable
- Disadvantages:
  - Waste the capacity of the links (when no data within a session)
  - Connection establishment and disconnection are relatively time-consuming
  - Possibility of blocking (stop new data input) when traffic is heavy

# Delay in a circuit-switched network

- Note that during data transfer the data are not delayed at each switch, as no waiting time is required inside each switch

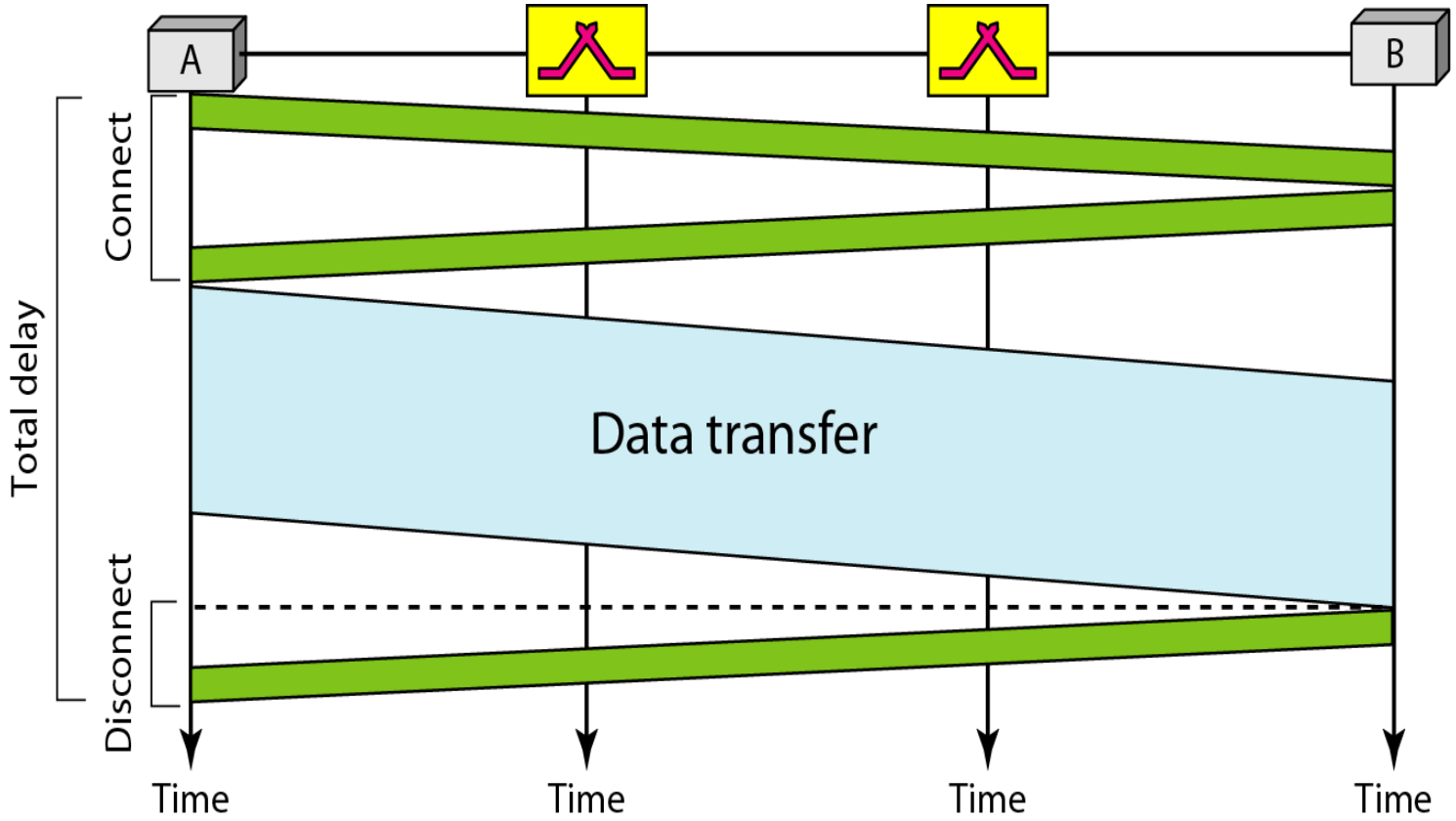



Figure 8.6

# Packet Switching

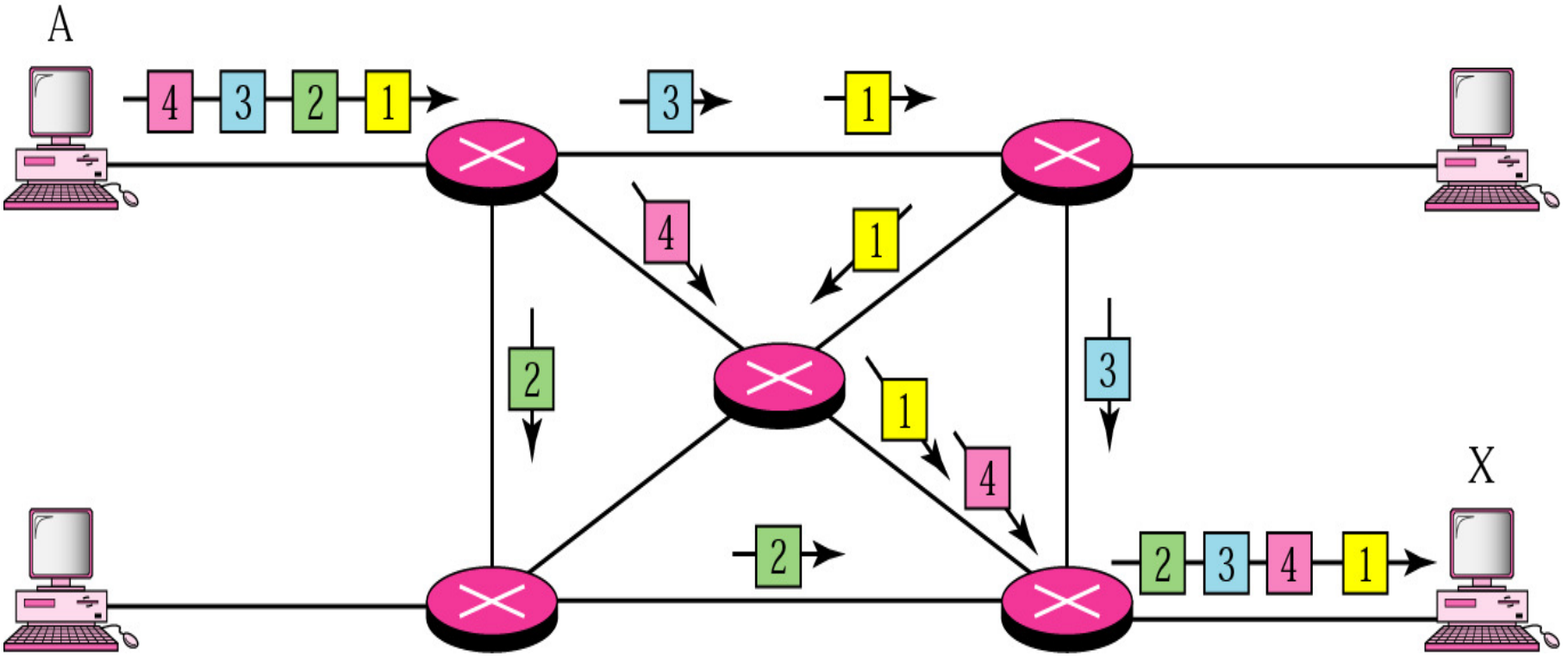
- **Packetizing**: the data message needs to be divided into packets of fixed or variable size
- The size of the packet is determined by the network and the governing protocol
- ***Encapsulating*** the payload in a network-layer packet *at the source*
- ***Decapsulating*** the payload from the network-layer packet *at the destination*
- Use ***Store-and Forward*** operation
- ***Virtual-circuit*** *approach and* ***Datagram*** *approach*

# Datagram Networks

- It is a **connectionless service** of packet switching
- Each packet (of the same message) is sent out **independently**
- **No connection set up** is required
- Does not guarantee delivery of error-free and sequenced data
- Packets of the same message may travel along different paths via different intermediate nodes (thus **re-sequencing** is needed at the destination node)
- Users must handle error & flow control themselves
- Packets in this approach are referred to as **datagrams**

# Main Features of Datagram Packet Switching

- Message is divided into **packets of fixed (maximum) size**
- There is **no resource reservation**
- Resources are allocated on demand
- Packets (of the same message) are only reassembled at the destination node



# Store-and-Forward Operation

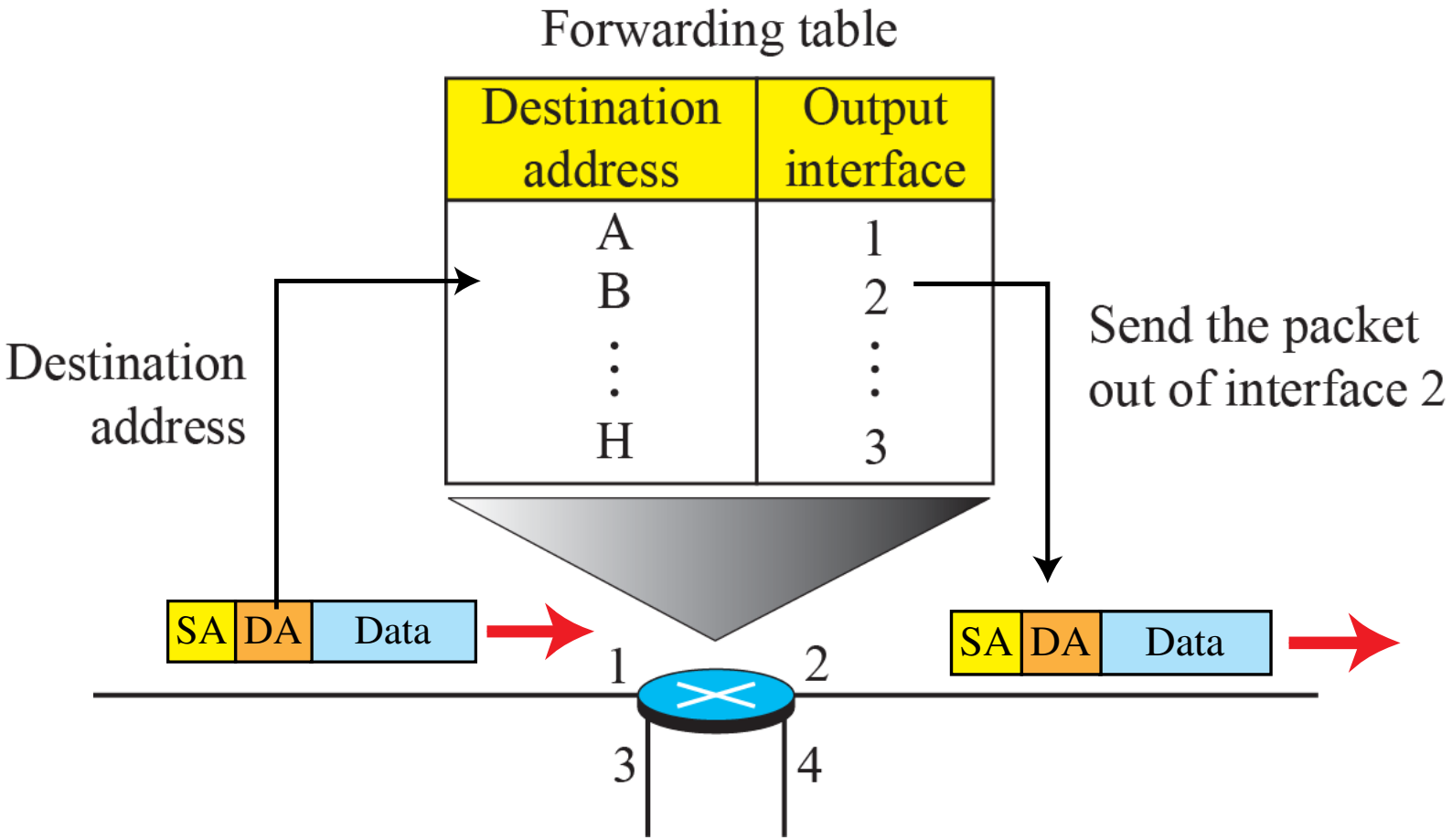
- Each cable (channel/link) connects a pair of nodes (Point-to-Point Channel)
- If no direct link between two nodes, they must communicate indirectly (via other nodes)
- The packet is received at each intermediate node, be stored there until the output link is free, and then be forwarded to another node
- A routing decision is made to select the next intermediate node before forwarding

# Forwarding Process & Routing Table

- A switch (router) uses a routing table (*forwarding table*) to determine the output port

- It is ***based on the destination address***, ***(for datagram approach)*** which *remains the same* during the entire journey of the packet.

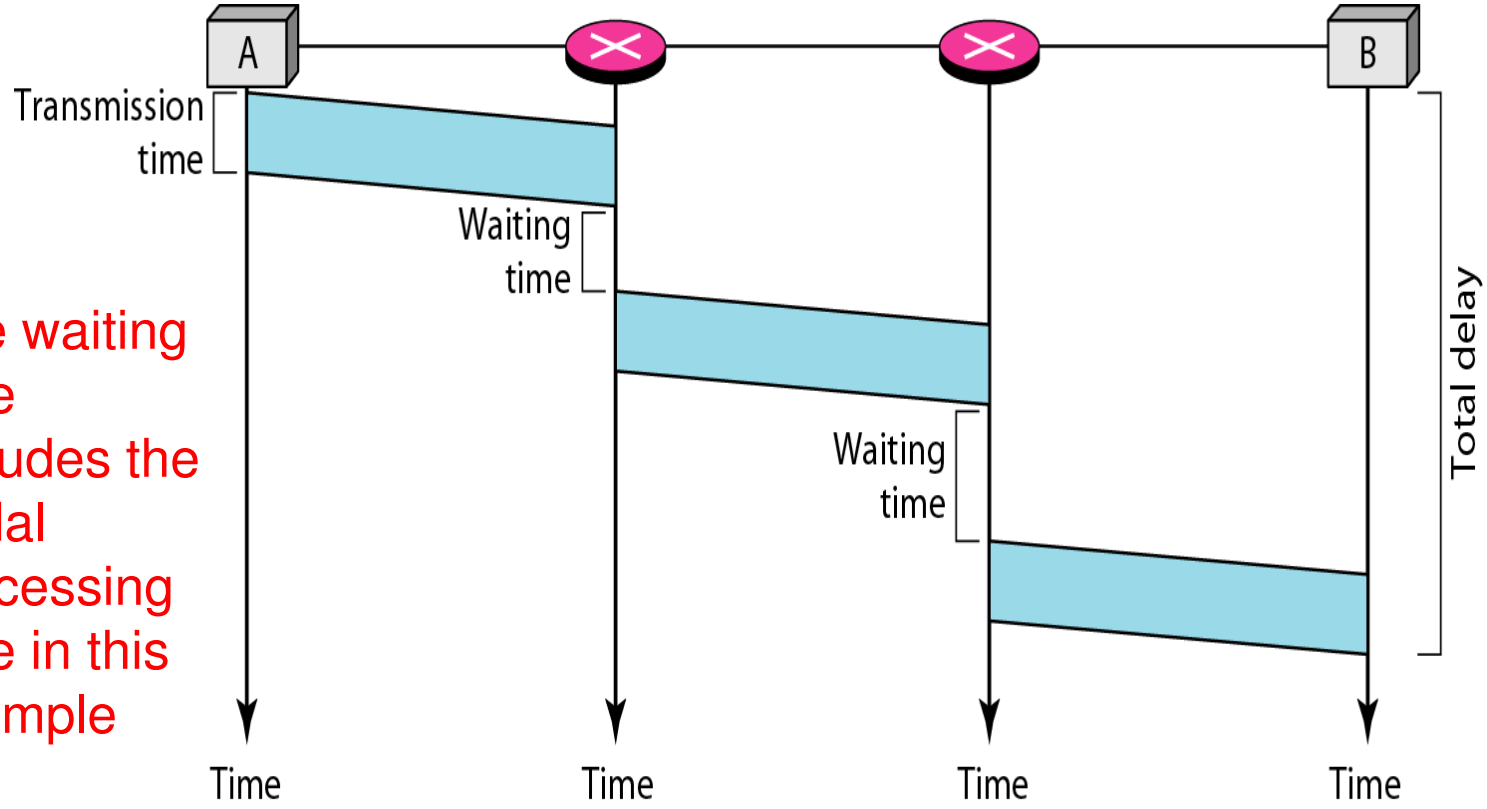
Figure 18.4: Forwarding process in a router when used in a connectionless datagram network



# Delay in a Datagram Network

- ***E.g. A packet travels two switches. There are***
  - ***3 transmission times (3 $T_x$)***
  - ***3 propagation delays (3 Tp)***
  - ***2 waiting times ($w_1$ and $w_2$)***
  - ***The total delay = $3T_x + 3T_p + w_1 + w_2$***

**Figure 8.9**




The waiting time includes the nodal processing time in this example

# Circuit Switching and Datagram

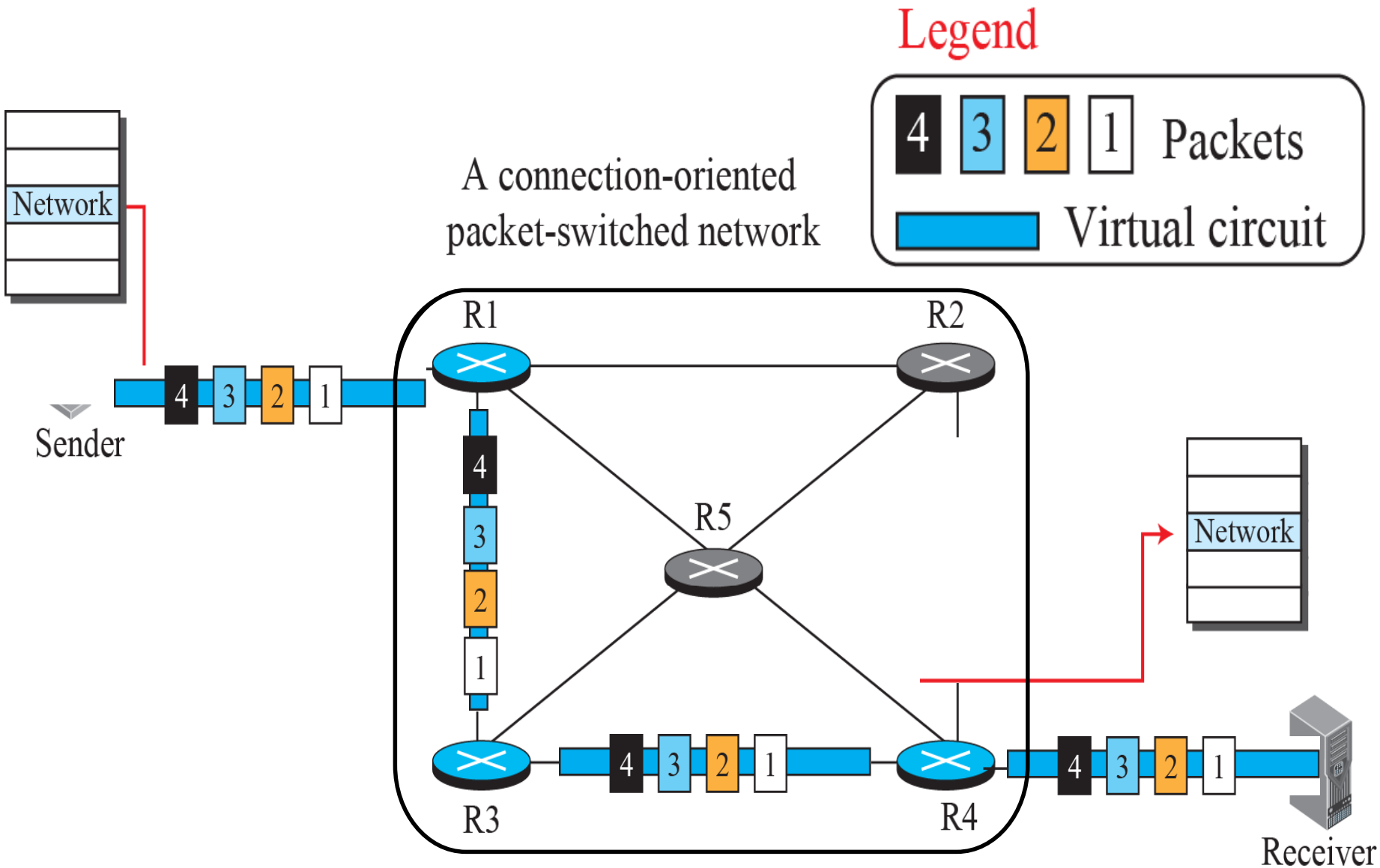
**Switching at the *physical layer* in the traditional telephone network uses the circuit-switching approach.**

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

# Virtual Circuit (VC) Approach

- In a **connection-oriented service** (also called virtual-circuit approach), there is a relationship between all packets belonging to a message.
- Before all datagrams in a message can be sent, a **virtual connection** should be set up to define the path for the datagrams.
- After connection setup, the datagrams can **all follow the same path** *using store-and-forward operation*.
- In this type of service, not only must the packet contain the source and destination addresses, it must also contain a flow label, a **virtual circuit identifier (VCI)** that defines the virtual path the packet should follow.

# Figure 18.5: A virtual-circuit packet-switched network



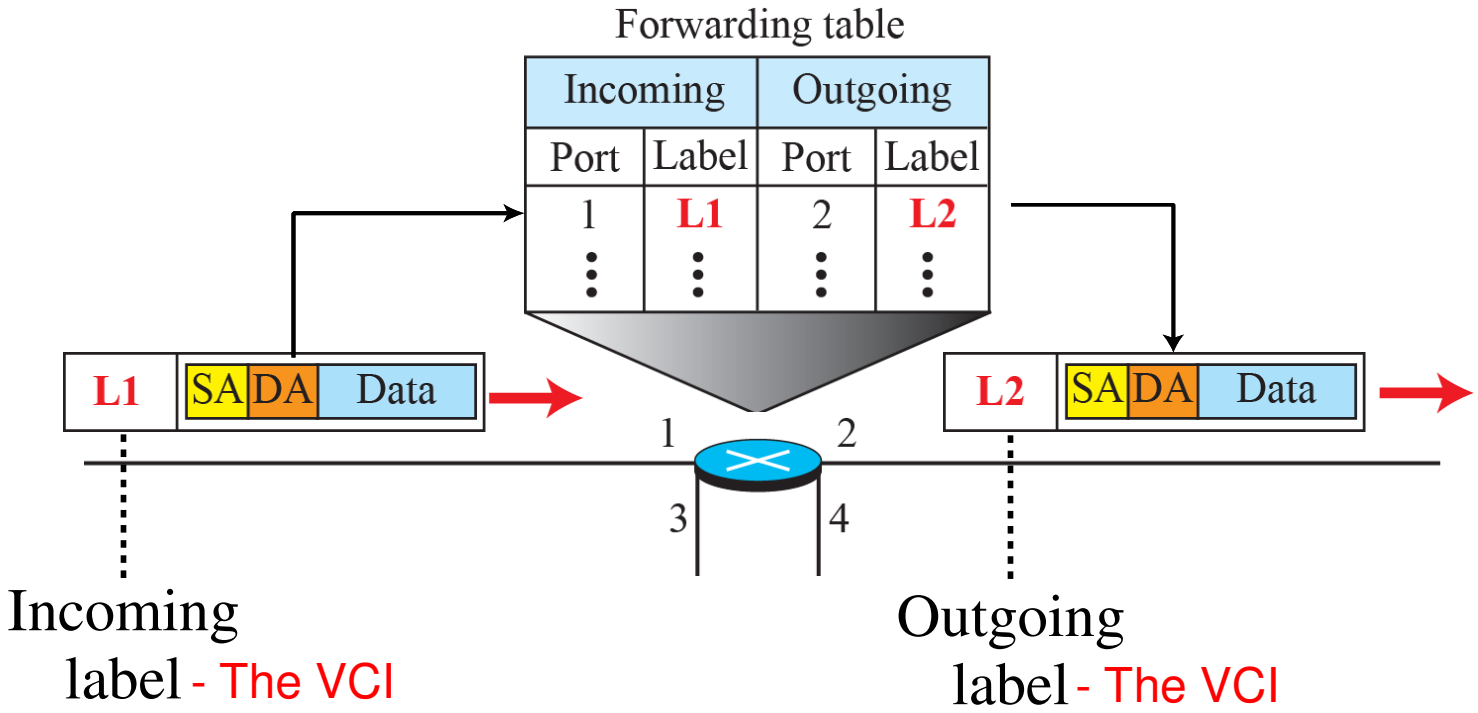
# Virtual Circuit Approach

- ***Virtual circuit*** approach (in packet switching) can be considered as a mix of *circuit switched* (CS) and *packet switched* (PS) networks.
  - Phase: Setup, data transfer, teardown (CS)
  - A "virtual" path is set up (***to book the resource***) before data transfer
  - Data are packetized. Each packet carries an address (and VCI) in the header (PS)
  - All packets of the same message **follow the exact (same) route** (indicated by the VCI) (CS)
  - But the physical path is ***not dedicated*** (and may be shared by other connections) (PS)

# Virtual Circuit Approach

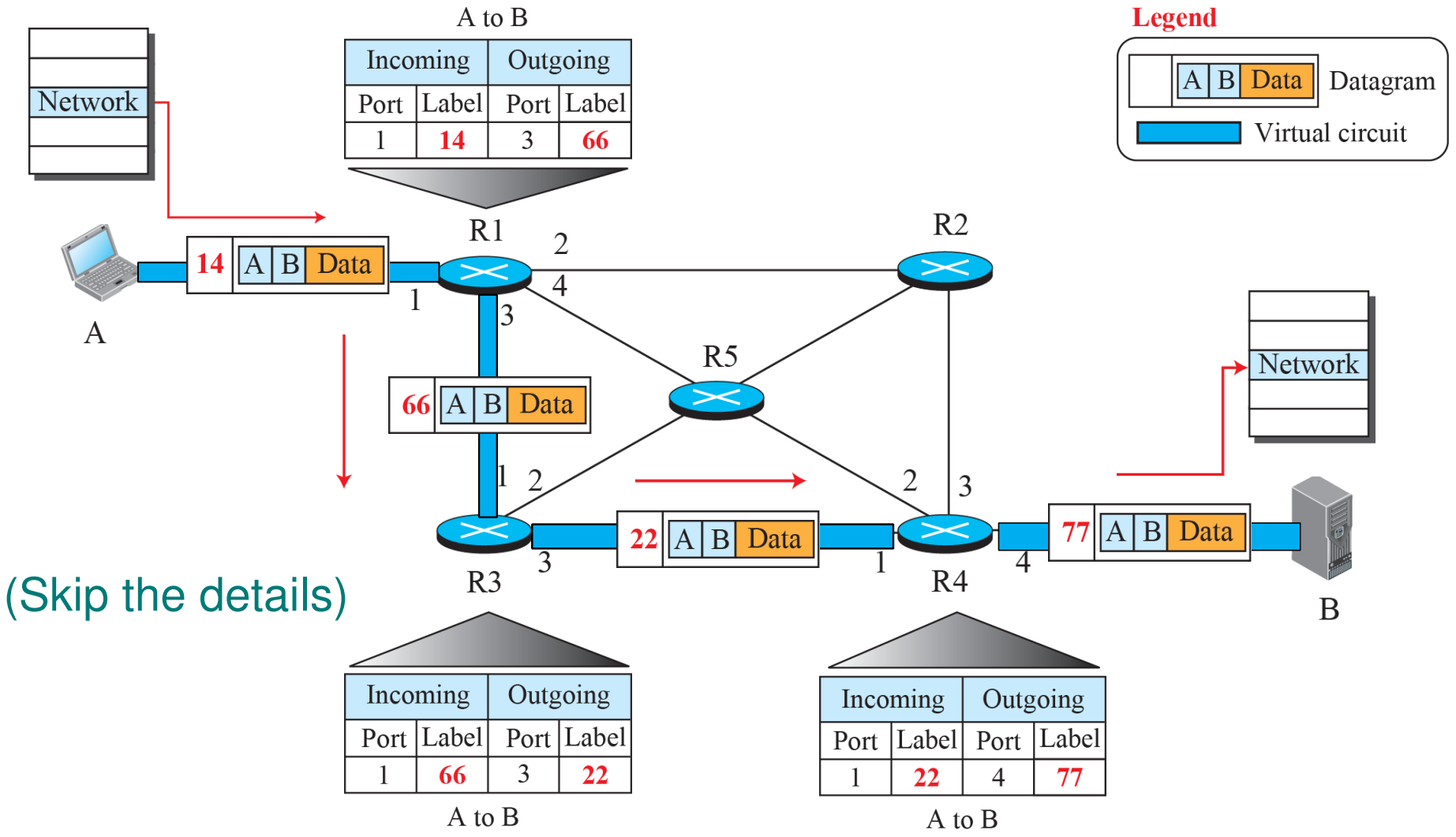
- This "***service***" provides with a **"perfect channel"** and **guarantees error-free and sequenced data**
- The packets may arrive at the destination with different delays
- The complicated communication issues (e.g. error and flow control, re-sequencing of data packets) are handled by the (VC) service provider

# Figure 18.6: Forwarding process in a router when used in a virtual circuit network




(Skip the details)

# Figure 18.9: Flow of one packet in an established virtual circuit




(Skip the details)

# Delay in a virtual-circuit network

- *E.g. A packet travels two switches.*
  - *The total delay = $3T_x$ +3 $T_p$ + Setup delay + teardown delay*
  - *(The nodal processing time usually can be neglected. Also assume no waiting time at each node in this example)*

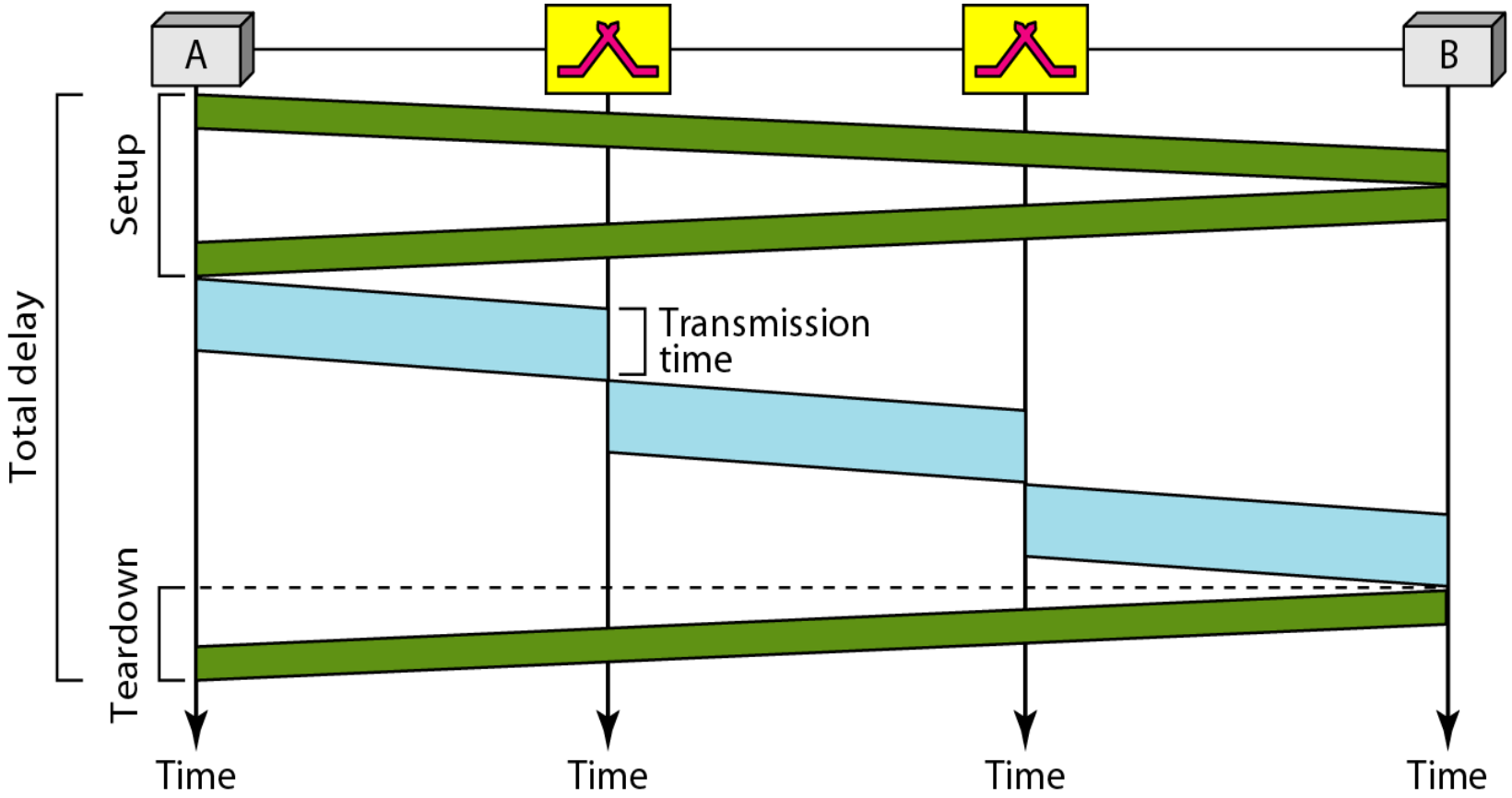



Figure 8.16

# Summary

- IEEE 802.3 Ethernet - 1-persistent CSMA/CD Bus
- IEEE 802.11 Wireless LAN – CSMA/CA
- Circuit Switching - A (temporary) dedicated path
- Packet Switching - Store-and-Forward operation
- Datagram Approach - Connectionless, Datagrams
- Virtual Circuit Approach - Connection-oriented
  - Packets travel along the same path
- Revision Quiz
  - http://highered.mheducation.com/sites/0073376221/student_view0/chapter8/quizzes.html