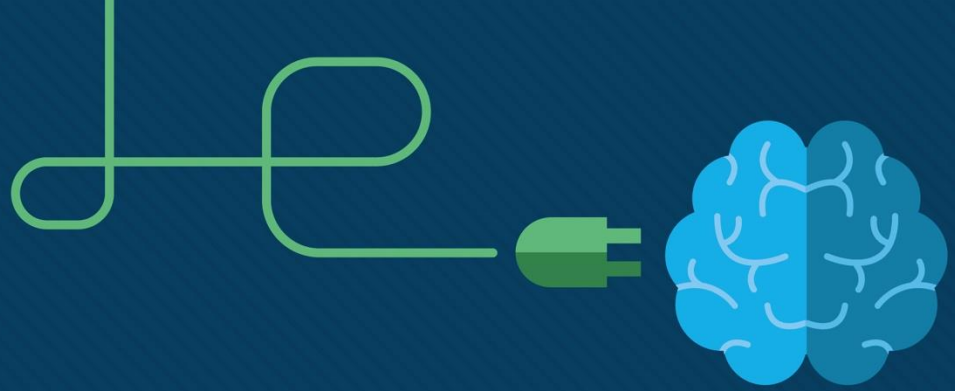
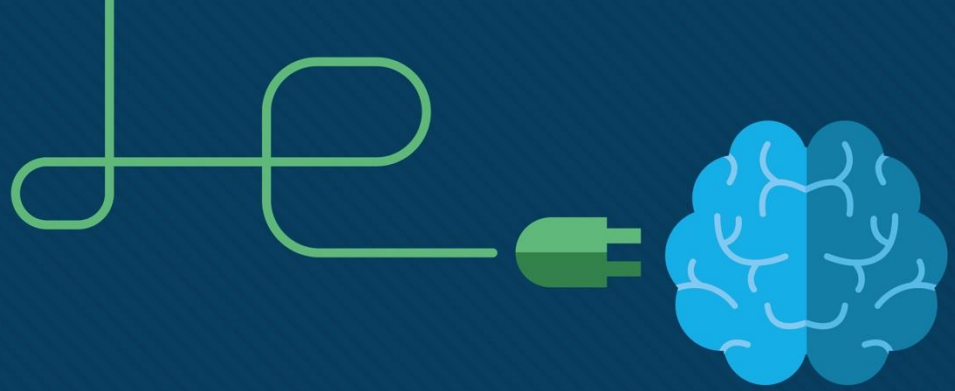


Module 6: Data Link Layer

Thomas Wyseur

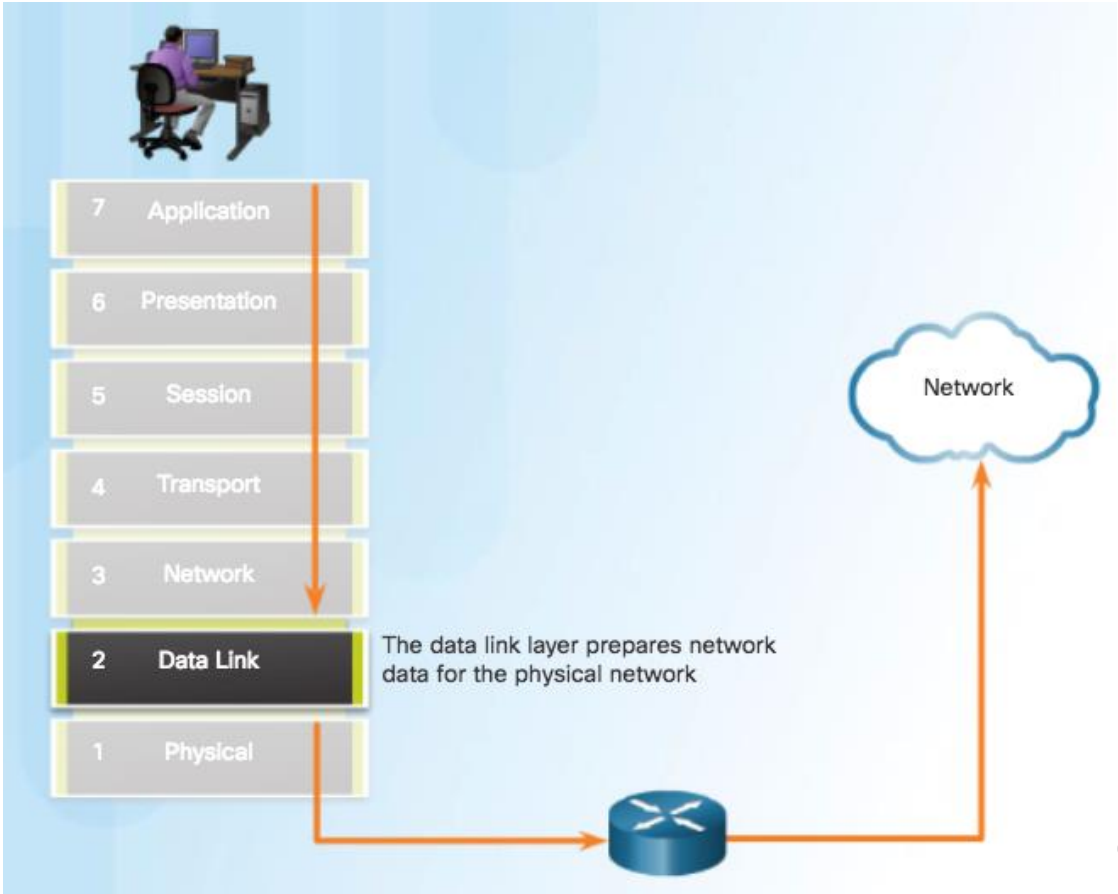
Introduction to Networks v7.0
(ITN)



Module 6: Data Link Layer

Introduction to Networks v7.0
(ITN)

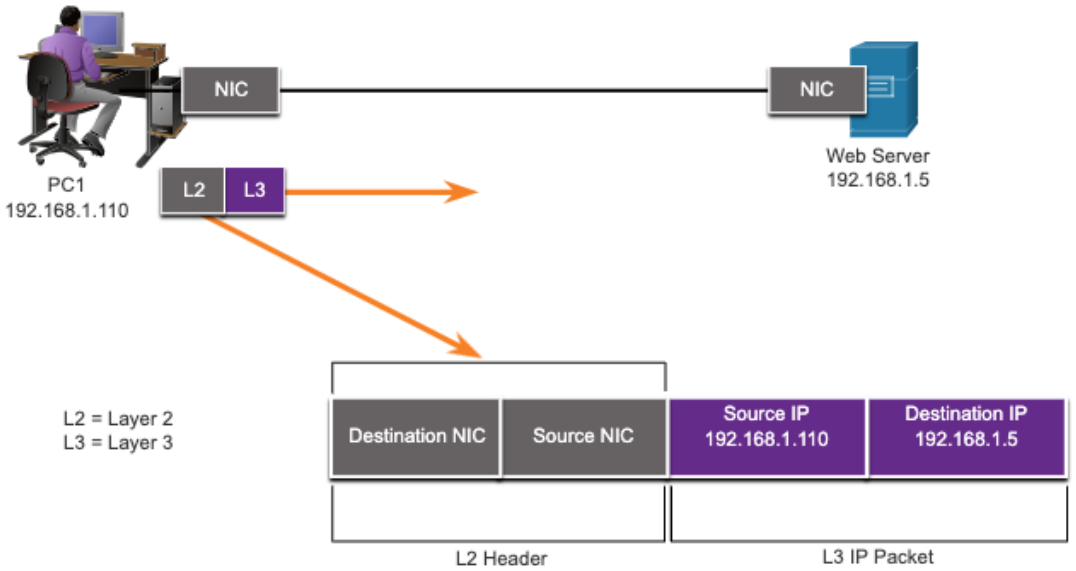
The Data Link Layer



6.1 Purpose of the Data Link Layer

The Data Link Layer

- The Data Link layer is responsible for communications between end-device network interface cards.
- It allows upper layer protocols to access the physical layer media and encapsulates Layer 3 packets (IPv4 and IPv6) into Layer 2 Frames.
- It also performs error detection and rejects corrupts frames.

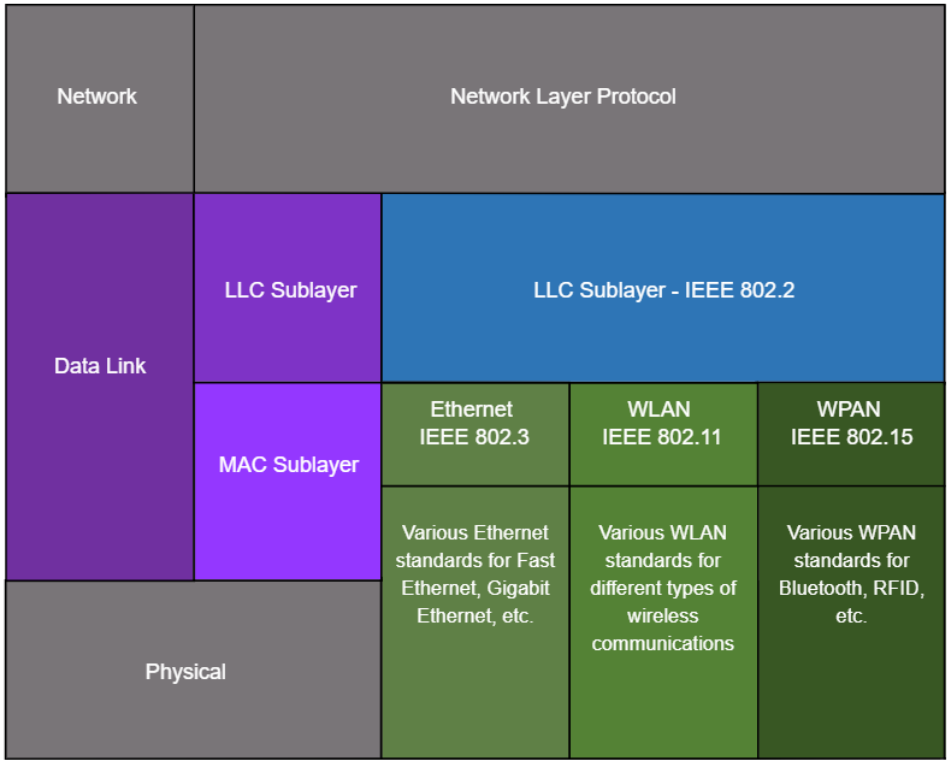


IEEE 802 LAN/MAN Data Link Sublayers

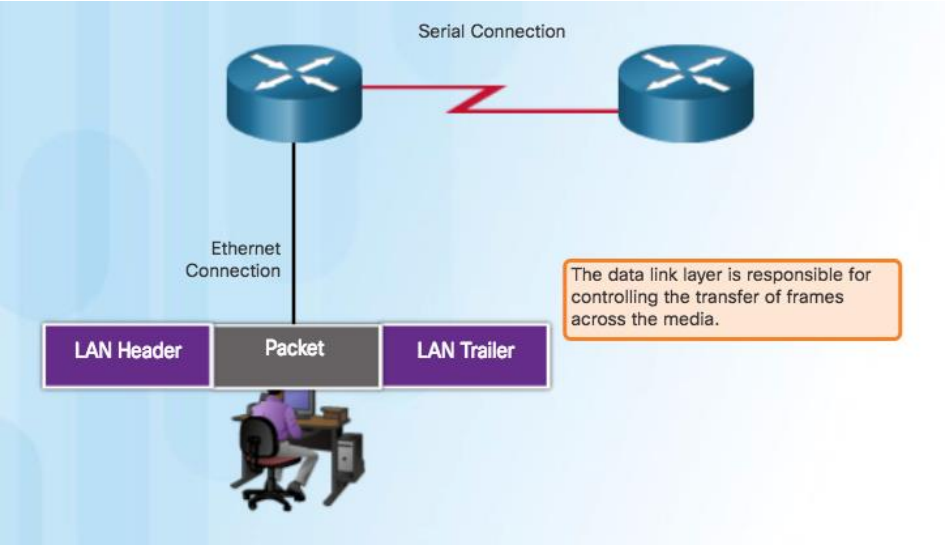
IEEE 802 LAN/MAN standards are specific to the type of network (Ethernet, WLAN, WPAN, etc).

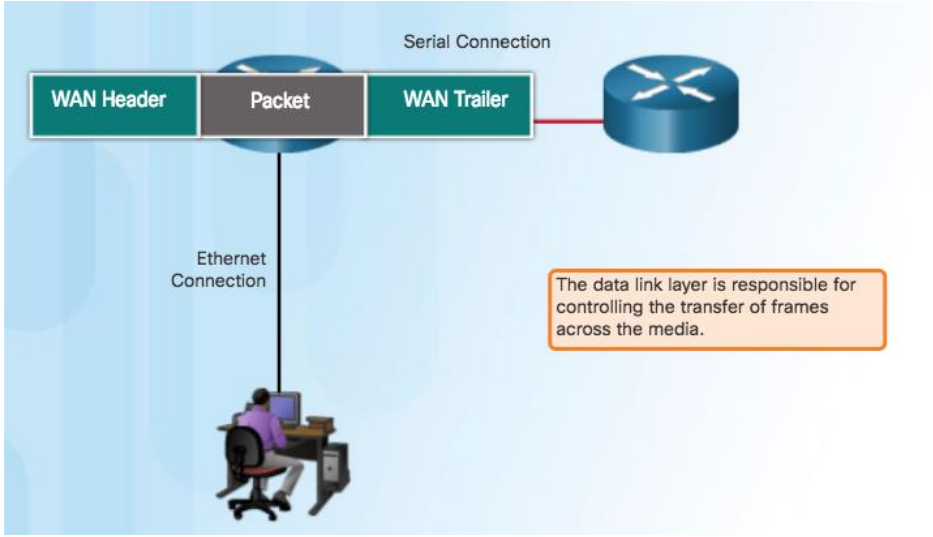
The Data Link Layer consists of two sublayers. **Logical Link Control (LLC)** and **Media Access Control (MAC).**

- The LLC sublayer communicates between the networking software at the upper layers and the device hardware at the lower layers.
- The MAC sublayer is responsible for data encapsulation and media access control.



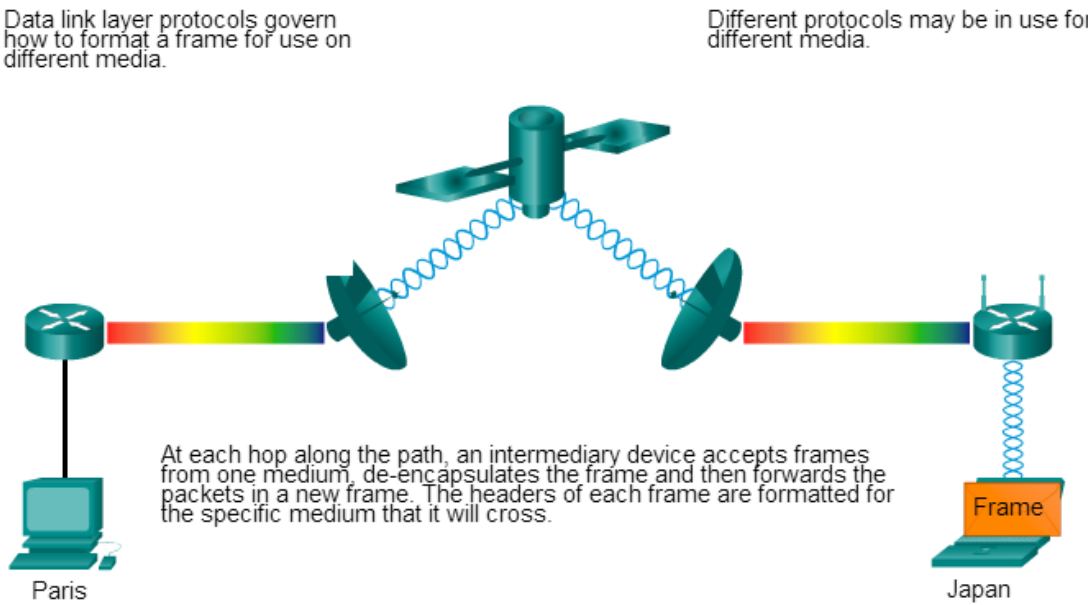
Providing Access to Media





- At each hop along the path, a router:
  - Accepts a frame from a medium
  - De-encapsulates the frame
  - Re-encapsulates the packet into a new frame
  - Forwards the new frame appropriate to the medium of that segment

Media Access Control



- As packets travel from the source host to the destination host, they travel over different physical networks.
- Physical networks can consist of different types of physical media such as copper wires, optical fibers, and wireless consisting of electromagnetic signals, radio and microwave frequencies, and satellite links.

Data Link Layer Standards

Data link layer protocols are defined by engineering organizations:

- Institute for Electrical and Electronic Engineers (IEEE).
- International Telecommunications Union (ITU).
- International Organizations for Standardization (ISO).
- American National Standards Institute (ANSI).

6.2 Topologies

Physical and Logical Topologies

The topology of a network is the arrangement and relationship of the network devices and the interconnections between them.

There are two types of topologies used when describing networks:

- **Physical topology** – shows physical connections and how devices are interconnected.
- **Logical topology** – identifies the virtual connections between devices using device interfaces and IP addressing schemes.

WAN Topologies

There are three common physical WAN topologies:

- **Point-to-point** – the simplest and most common WAN topology. Consists of a permanent link between two endpoints.
- **Hub and spoke** – similar to a star topology where a central site interconnects branch sites through point-to-point links.
- **Mesh** – provides high availability but requires every end system to be connected to every other end system.

Point-to-Point WAN Topology

- Physical point-to-point topologies directly connect two nodes.
- The nodes may not share the media with other hosts.
- Because all frames on the media can only travel to or from the two nodes, Point-to-Point WAN protocols can be very simple.

LAN Topologies

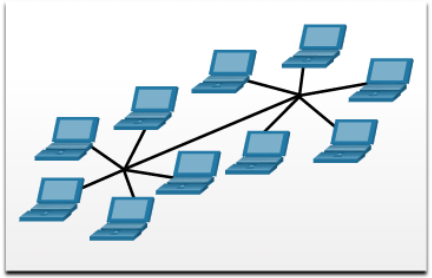
End devices on LANs are typically interconnected using a star or extended star topology. Star and extended star topologies are easy to install, very scalable and easy to troubleshoot.

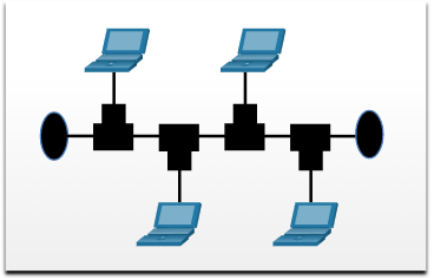
Early Ethernet and Legacy Token Ring technologies provide two additional topologies:

- **Bus** – All end systems chained together and terminated on each end.
- **Ring** – Each end system is connected to its respective neighbors to form a ring.

Physical Topologies


Star Topology


Extended Star Topology

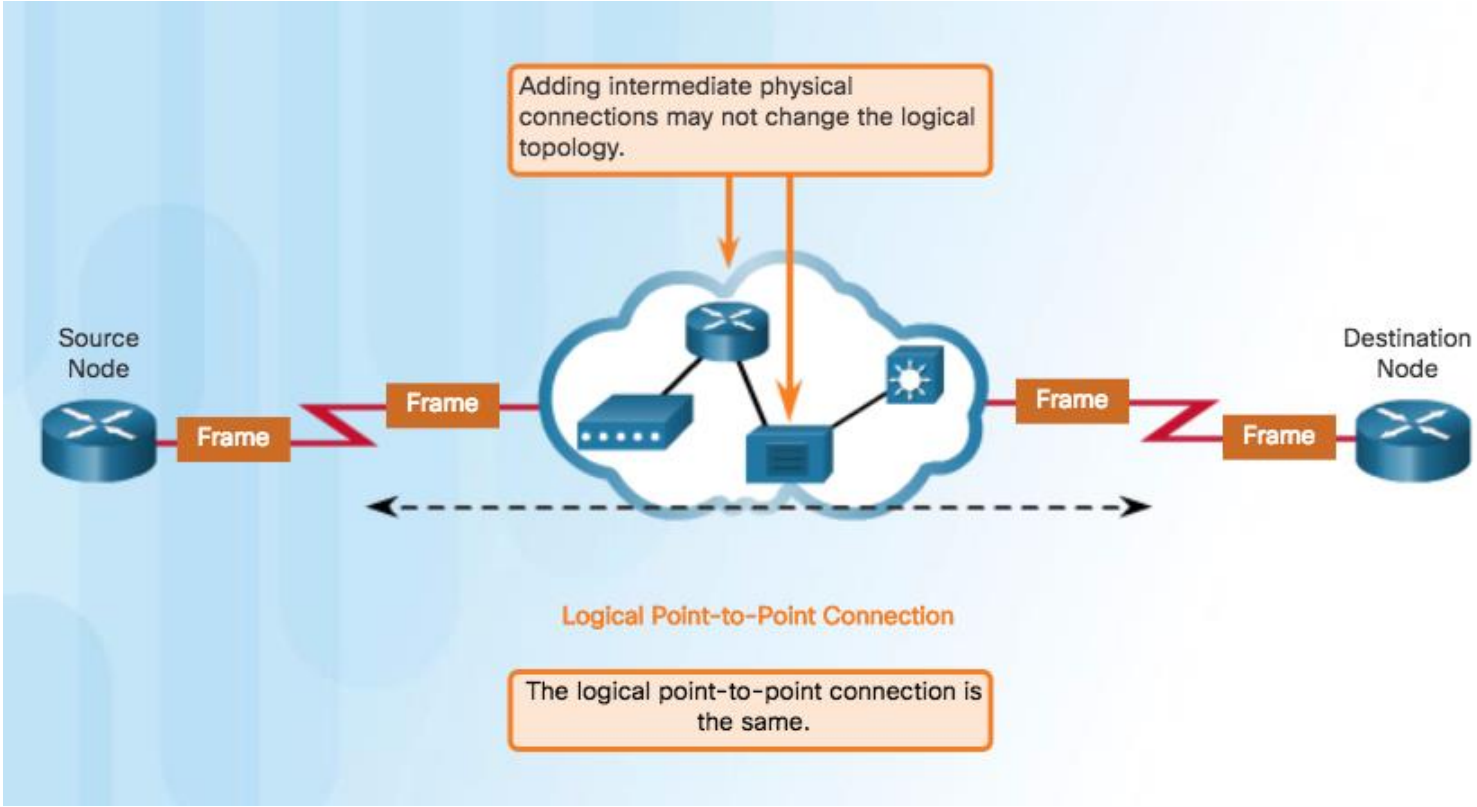

Bus Topology


Ring Topology

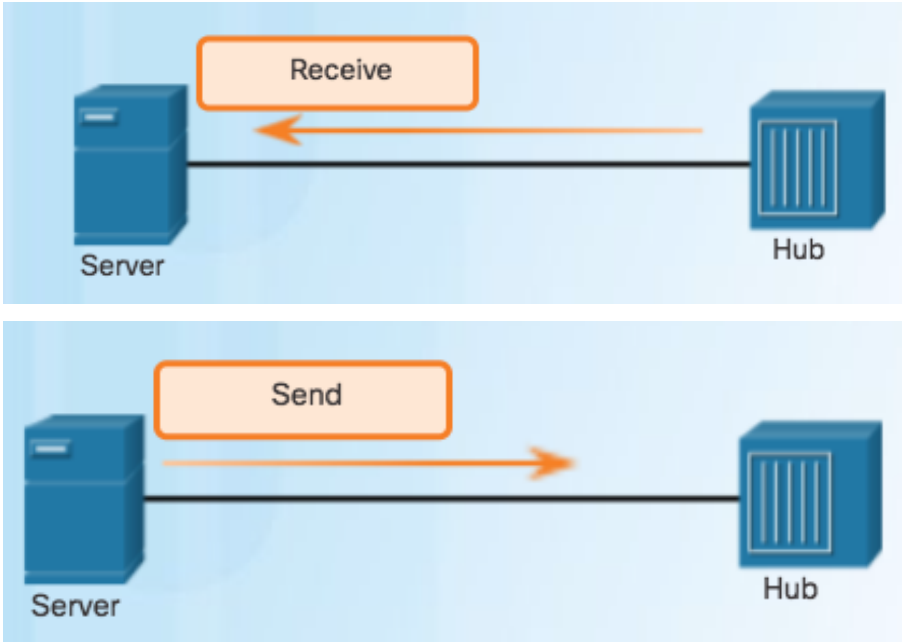
Logical Point-to-Point Topology

- End nodes communicating in a point-to-point network can be physically connected via a number of intermediate devices.
- However, the use of physical devices in the network does not affect the logical topology.
- The logical connection between nodes forms what is called a virtual circuit.

Logical Point-to-Point Topology (Cont.)

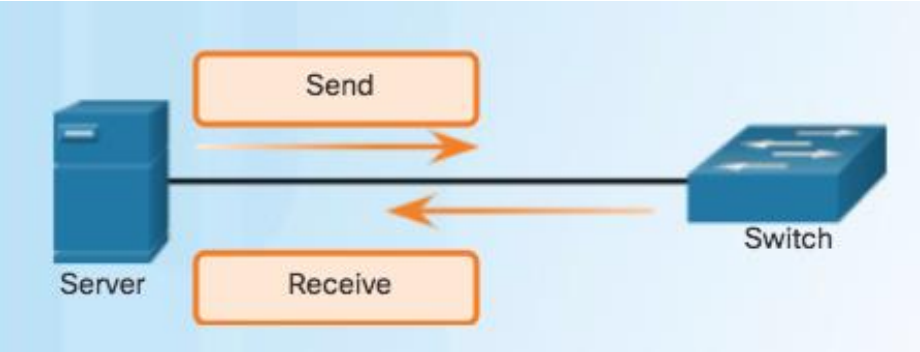


Half and Full Duplex



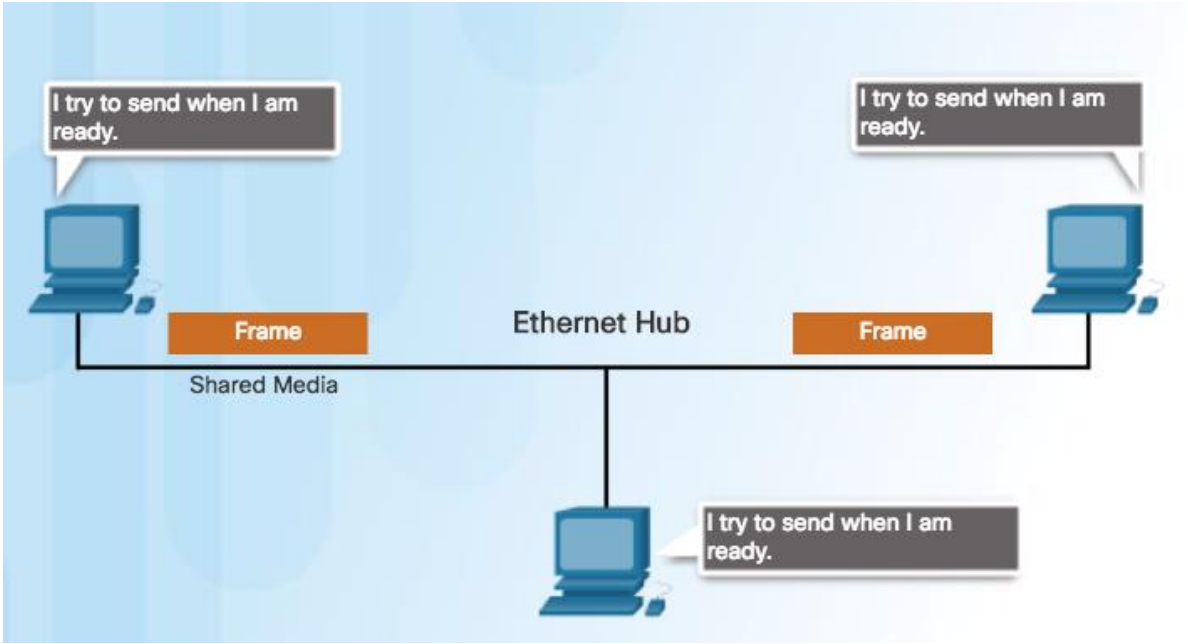
- **Half-Duplex Communication**
  - Both devices can transmit and receive on the media but cannot do so simultaneously.
  - Used in legacy bus topologies and with Ethernet hubs.
  - WLANs also operate in half-duplex.

Half and Full Duplex (Cont.)



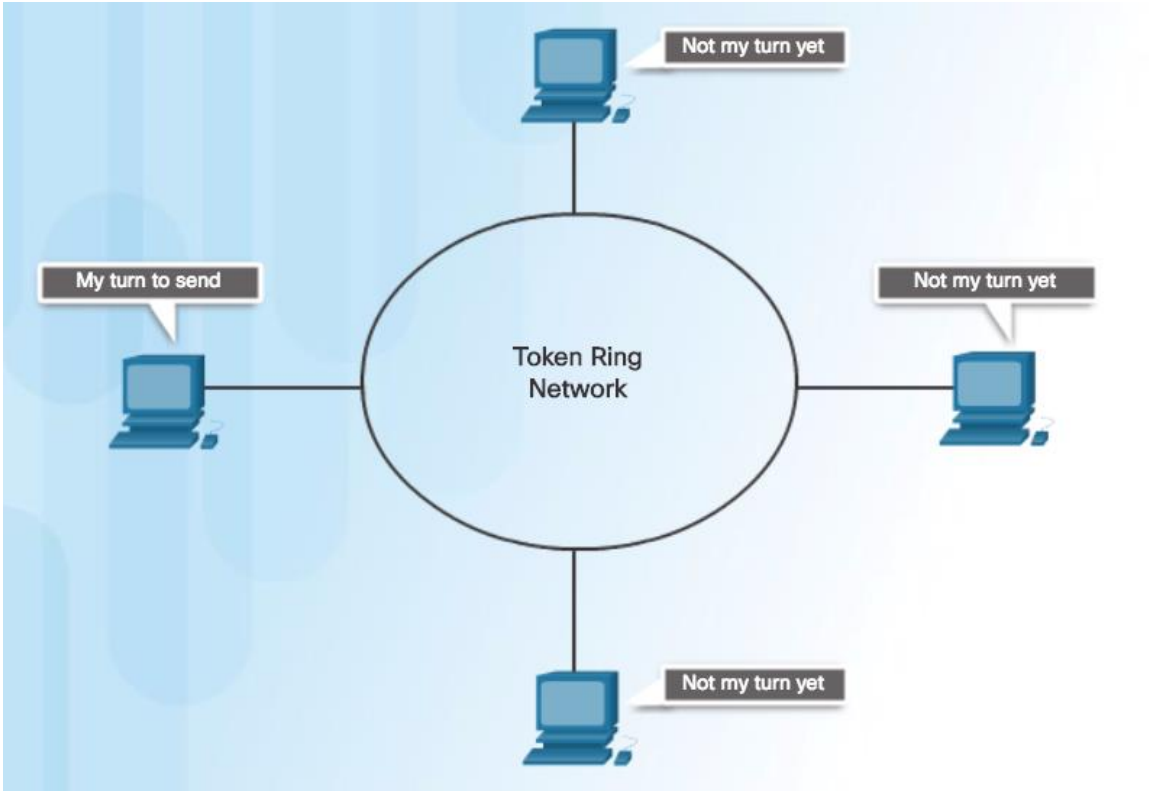
- **Full-Duplex Communication**
  - Both devices can transmit and receive on the media at the same time.
  - Data link layer assumes that the media is available for transmission for both nodes at any time.
  - Ethernet switches operate in full-duplex mode by default, but can operate in half-duplex if connecting to a device such as an Ethernet hub.

Media Access Control Methods



- Contention-Based Access
  - Nodes operate in half-duplex.
  - Compete for the use of the medium.
  - Only one device can send at a time.

Media Access Control Methods (Cont.)



- Controlled Access
  - Each node has its own time to use the medium.
  - Legacy Token Ring LANs are an example

Contention-Based Access – CSMA/CD

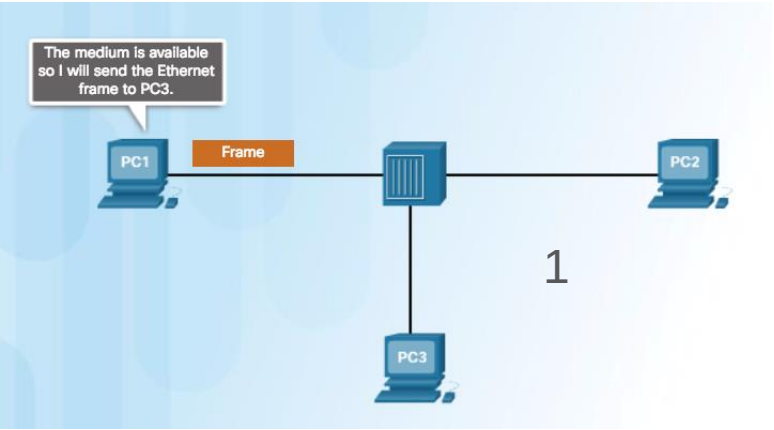
CSMA/CD

- Used by legacy Ethernet LANs.
- Operates in half-duplex mode where only one device sends or receives at a time.
- Uses a collision detection process to govern when a device can send and what happens if multiple devices send at the same time.

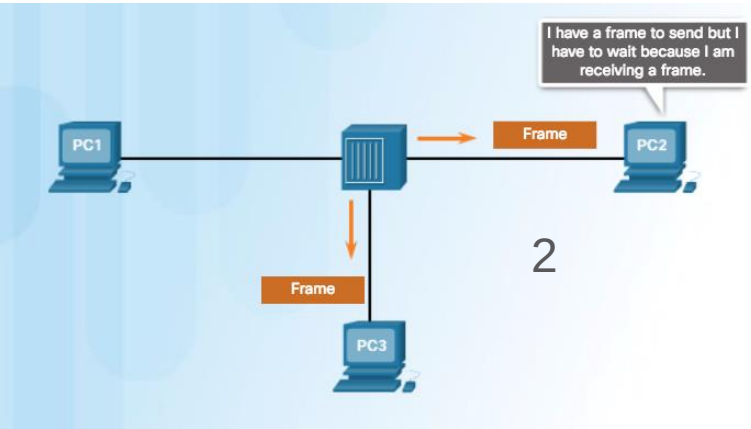
CSMA/CD collision detection process:

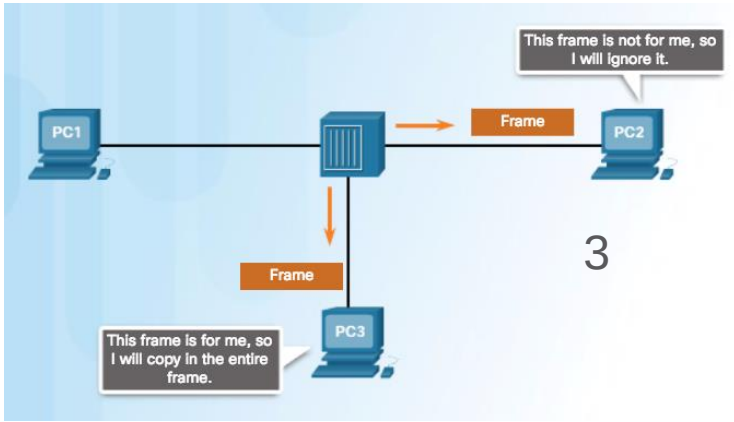
- Devices transmitting simultaneously will result in a signal collision on the shared media.
- Devices detect the collision.
- Devices wait a random period of time and retransmit data.

Contention-based Access - CSMA/CD



- Carrier Sense Multiple Access/Collision Detection (CSMA/CD) process is used in half-duplex Ethernet LANs.
  - If two devices transmit at the same time, a collision will occur.
  - Both devices will detect the collision on the network.
  - Data sent by both devices will be corrupted and will need to be resent.





Contention-Based Access – CSMA/CA

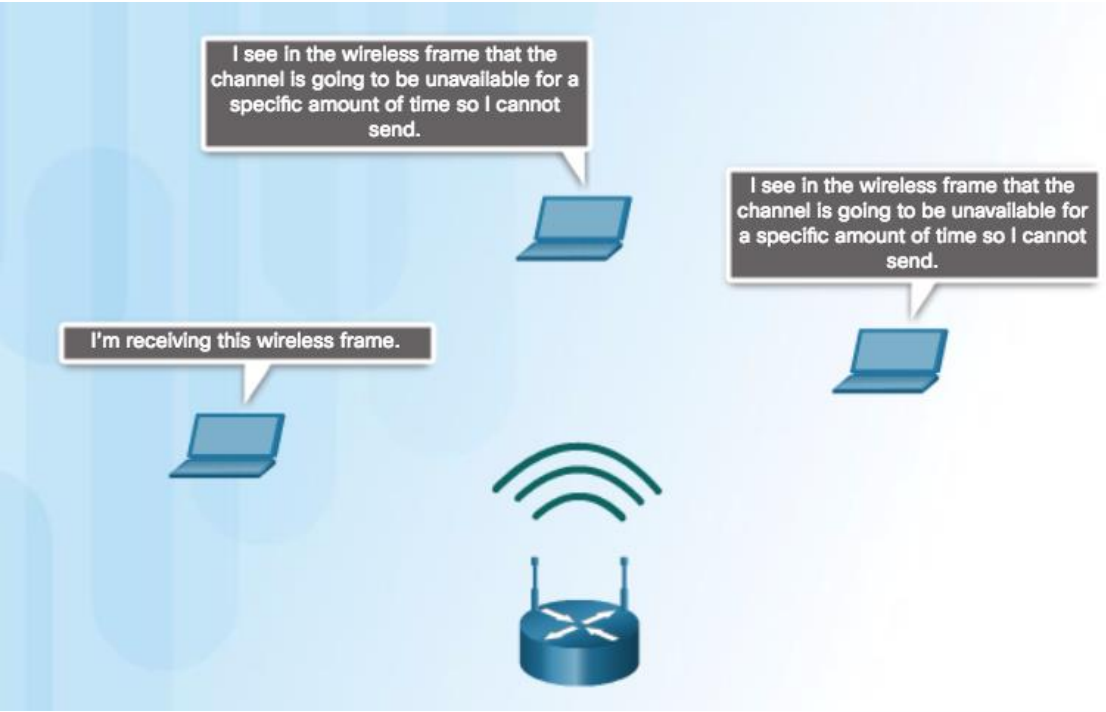
CSMA/CA

- Used by IEEE 802.11 WLANs.
- Operates in half-duplex mode where only one device sends or receives at a time.
- Uses a collision avoidance process to govern when a device can send and what happens if multiple devices send at the same time.

CSMA/CA collision avoidance process:

- When transmitting, devices also include the time duration needed for the transmission.
- Other devices on the shared medium receive the time duration information and know how long the medium will be unavailable.

Contention-based Access - CSMA/CA



- **CSMA/CA**
  - Uses a method to detect if the media is clear.
  - Does not detect collisions but attempts to avoid them by waiting before transmitting.
- **Note**: Ethernet LANs using switches do not use a contention-based system because the switch and the host NIC operate in full-duplex mode.

6.3 Data Link Frame

The Frame

Data is encapsulated by the data link layer with a header and a trailer to form a frame.

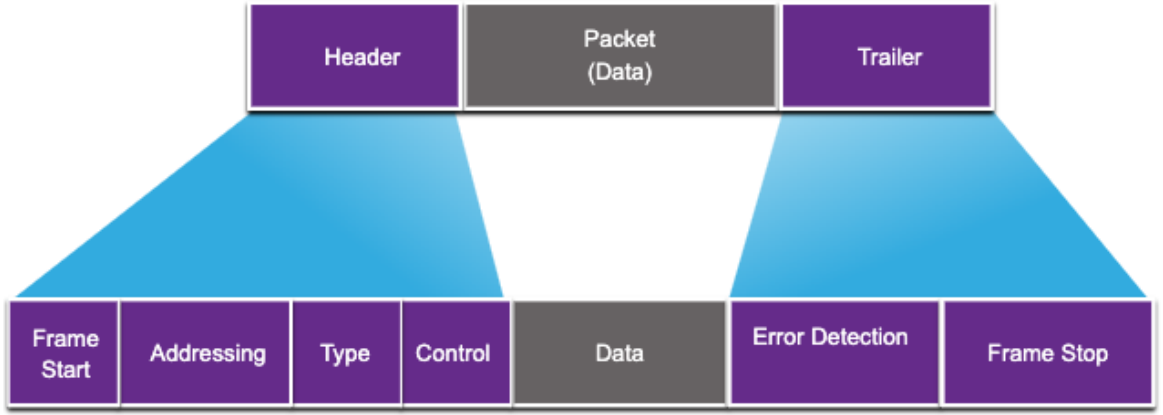
A data link frame has three parts:

- Header
- Data
- Trailer

The fields of the header and trailer vary according to data link layer protocol.

The amount of control information carried with in the frame varies according to access control information and logical topology.

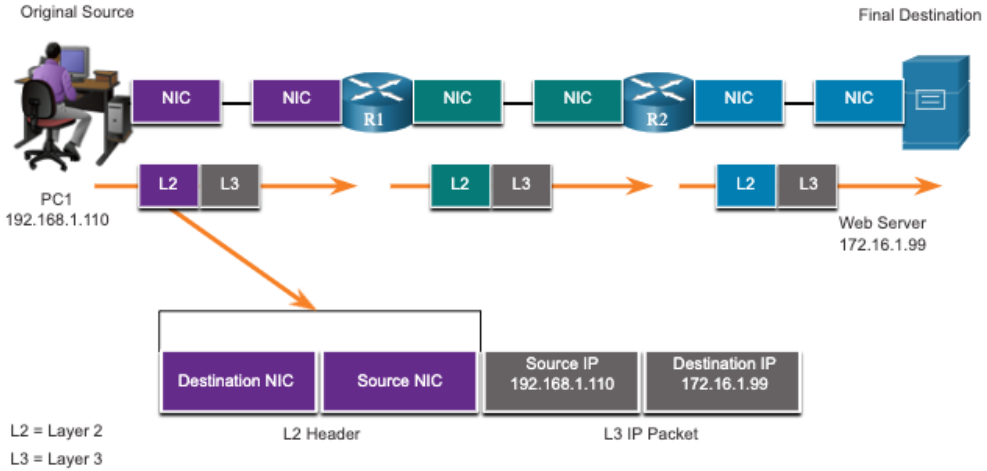
Frame Fields



Field	Description
Frame Start and Stop	Identifies beginning and end of frame
Addressing	Indicates source and destination nodes
Type	Identifies encapsulated Layer 3 protocol
Control	Identifies flow control services
Data	Contains the frame payload
Error Detection	Used for determine transmission errors

Layer 2 Addresses

- Also referred to as a physical address.
- Contained in the frame header.
- Used only for local delivery of a frame on the link.
- Updated by each device that forwards the frame.



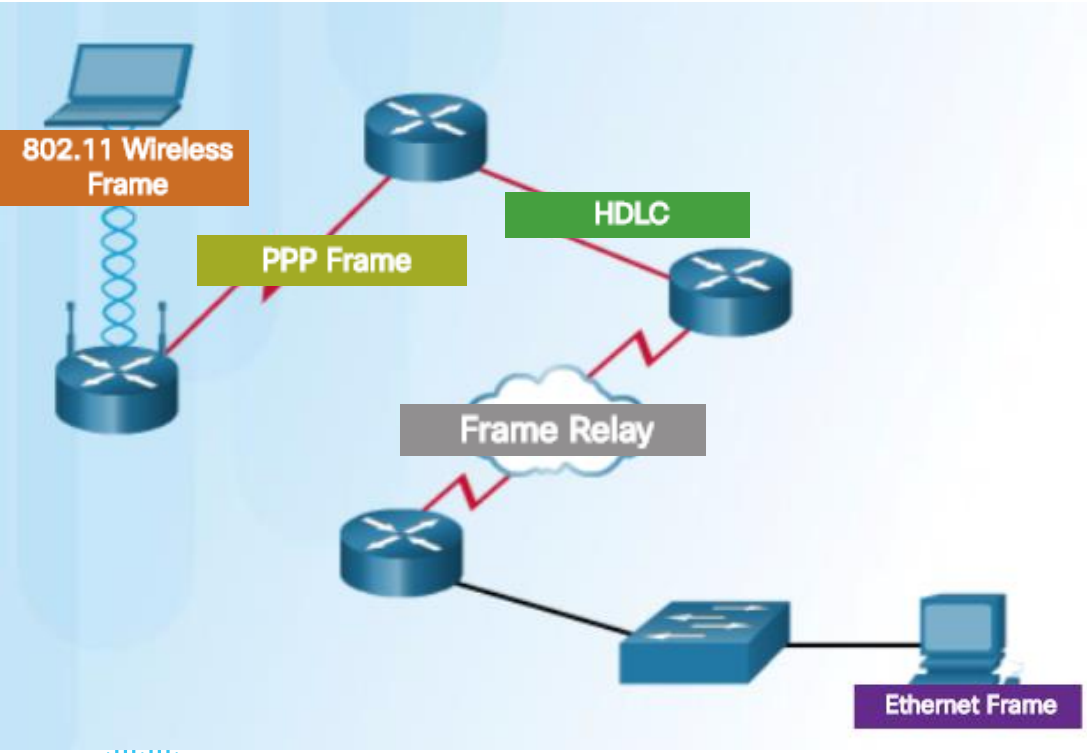
LAN and WAN Frames

The logical topology and physical media determine the data link protocol used:

- Ethernet
- 802.11 Wireless
- Point-to-Point (PPP)
- High-Level Data Link Control (HDLC)
- Frame-Relay

Each protocol performs media access control for specified logical topologies.

LAN and WAN Frames



- Layer 2 protocol used for a topology is determined by the technology.
- Data link layer protocols include:
  - Ethernet
  - 802.11 Wireless
  - Point-to-Point Protocol (PPP)
  - HDLC
  - Frame Relay


CISCO