Module 6: Data Link Layer

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Purpose of the Data Link Layer

Describe the purpose and function of the data link layer in preparing communication for transmission on specific media.

The Data Link layer is responsible for communications between end-device network interface cards. It allows. 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 corrupted frames.
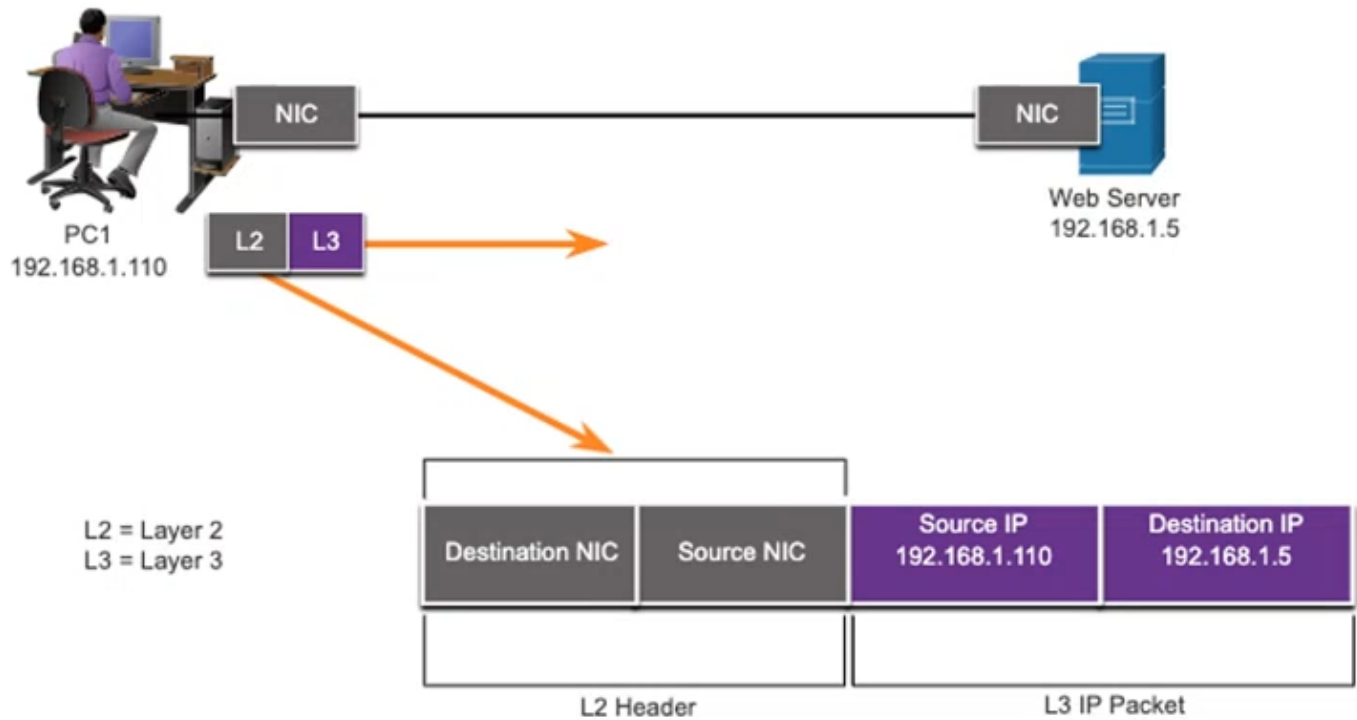
IEEE 802 LAN/MAN standards are specific to the type of network (Ethernet, WLAN, WPAN, etc.)

The Data Link Layer consists of two sublayers.

- **Logical Link Control (LLC):** Communicates between the networking software at the upper layers and the device hardware at the lower layers.
- **Media Access Control (MAC):** Is responsible for data encapsulation and media access control.
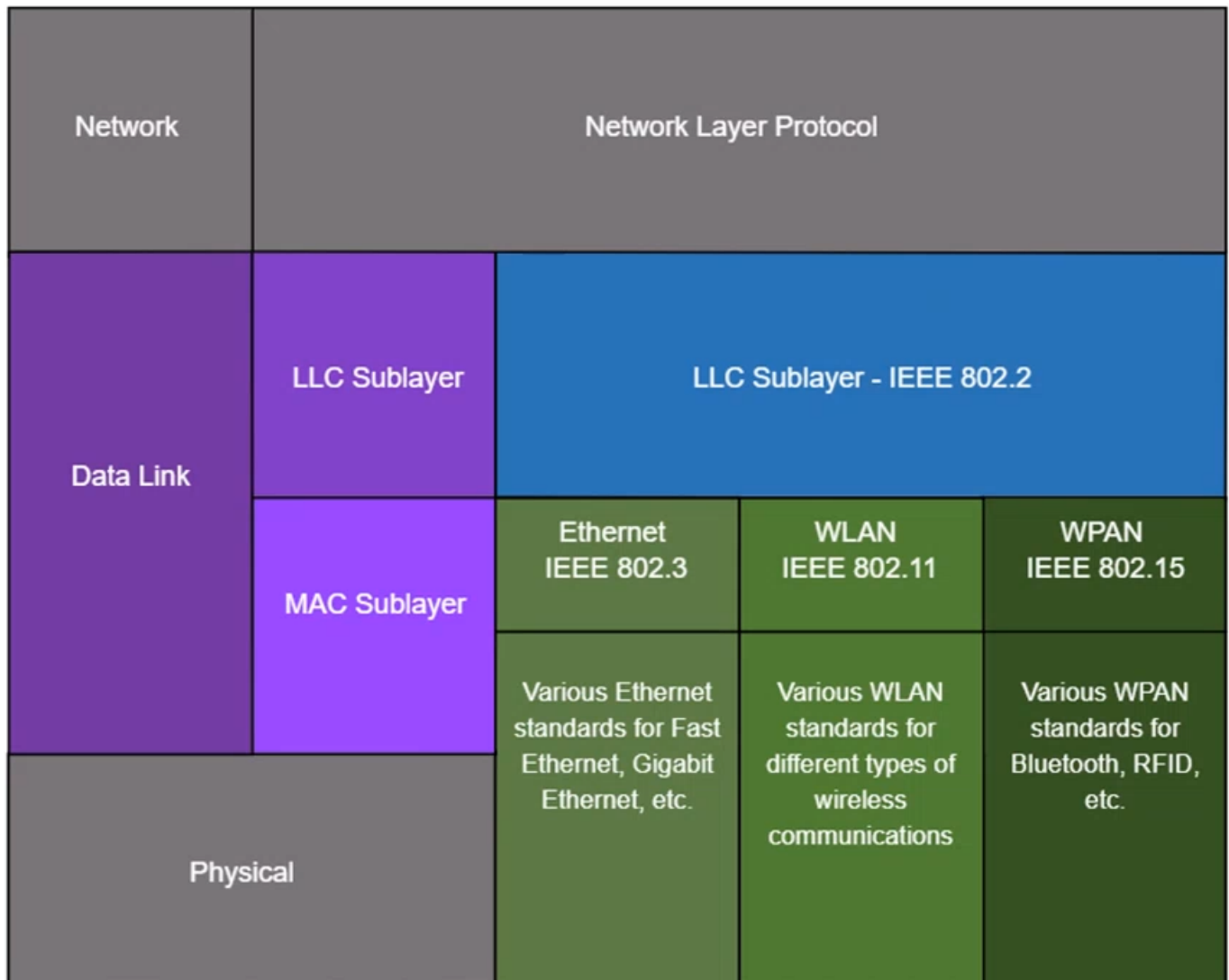
Providing Access to Media

At each hop along the path, a router performs four basic Layer 2 functions:

- **Accepts a frame** from the network medium
- **De-encapsulates** the frame to expose the encapsulated packet
- **Re-encapsulates** the packet into a new frame
- **Forwards** the new frame on the medium of the next network segment

Data Link Layer Standards

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

Topologies

Compare the characteristics of media control methods on WAN and LAN topologies.

Difference Physical and Logical Topologies

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 interface 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 (aka LAN 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.

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.

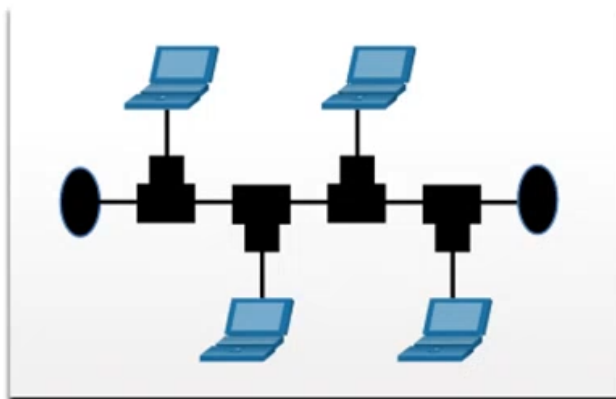Early Ethernet and Legacy Token Ring technologies provide two additional topologies:

- **Bus:** All end systems chained together and terminate on each end. (Vulnerable for interruption, one disconnect means topology offline)
- **Ring:** Each end system is connected to its respective neighbors to form a ring.

Star Topology
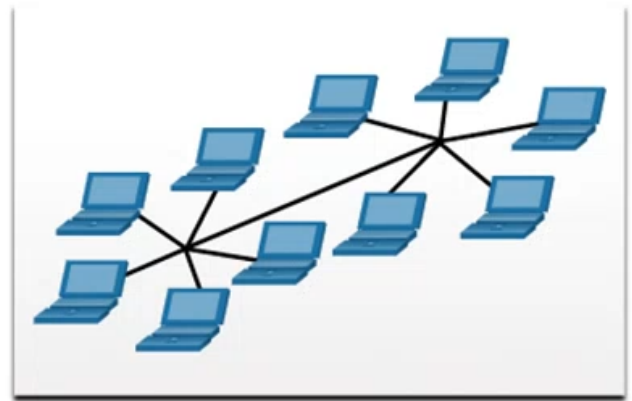
Extended Star Topology

Bus Topology

Ring Topology

Half and Full Duplex Communication IMPORANT

Mixing half- and full-duplex communications with each other will cause issues. This gives **duplex mismatch**. But modern switches, pcs and servers are full-duplex. Only WLANs can be half-duplex.

Half-duplex communication:

- Only allows one device to send or receive at a time on a shared medium.
- Used on WLANs and legacy bus topologies with Ethernet hubs.

Full-duplex communication:

- Allows both devices to simultaneously transmit and receive on a shared medium.
- Ethernet switches operate in full-duplex mode.

Access Control Methods

Contention-based access: All nodes operation in half-duplex, competing for use of the medium. Examples are:

- Carrier sense multiple access with collision detection (CSMA/CD) as used on legacy bus-topology Ethernet.
- Carrier sense multiple access with collision avoidance (CSMA/CA) as used on Wireless LANs.

Controlled access:

- Deterministic access where each node has its own time on the medium.

- Used on legacy networks such as Token Ring and ARCNET.

Contention-Based Access - CSMA/CD

CSMA/CD:

- Used by legacy Ethernet LANs
- Operates in half-duplex mode where only on 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/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.

Data Link Frame

<u>Describe the characteristics and functions of the data link frame.</u>

Data is encapsulated by the data link layer with a header and a trailer to form a frame. A data link frame has tree parts:

- Header
- Data
- Trailer
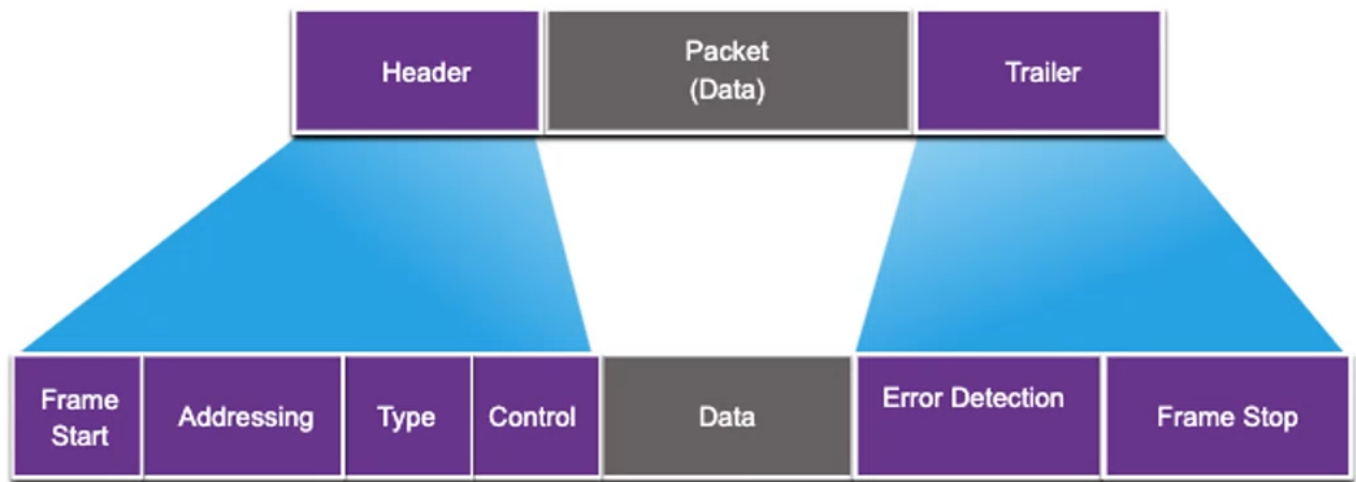
Layer 2 addresses

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