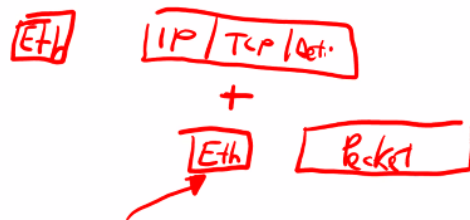
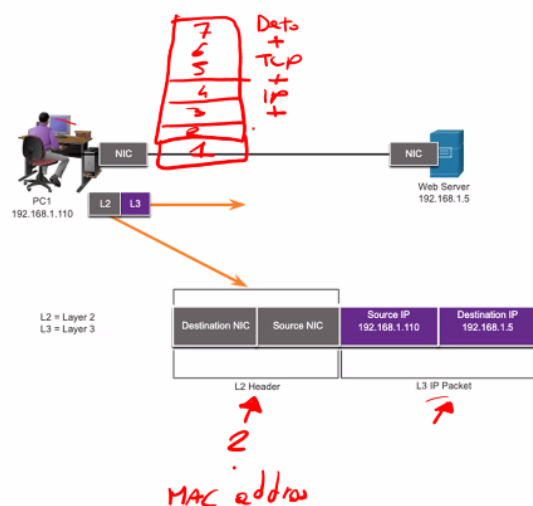


# Module 6: Data Link Layer

Introduction to Networks v7.0  
(ITN)

## 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.



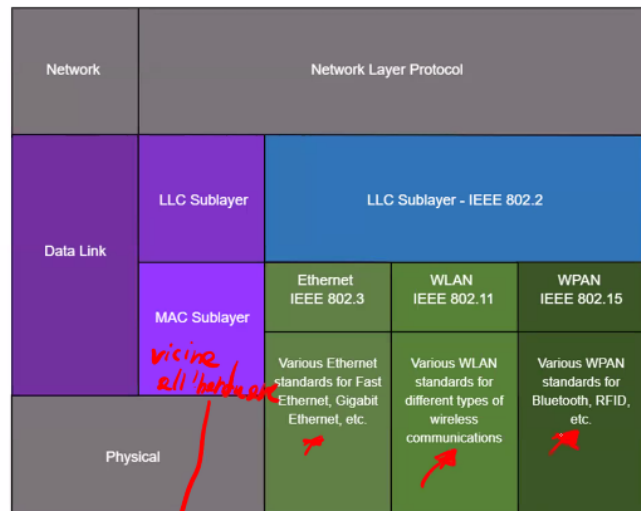
## Purpose of the Data Link Layer

### 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.



varia con il variaz del mezzo di trasmissione



Il Layer 3 incapsula il dato inserendo source/destination ip address e lo passa al Layer 2 che adatta il pacchetto al medium fisico usato dal Layer 1.

## Purpose of the Data Link Layer

### Providing Access to Media

Packets exchanged between nodes may experience numerous data link layers and media transitions.

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.



## Purpose of the Data Link Layer

### 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

## 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.



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## Topologies

# 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.



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## Topologies 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.



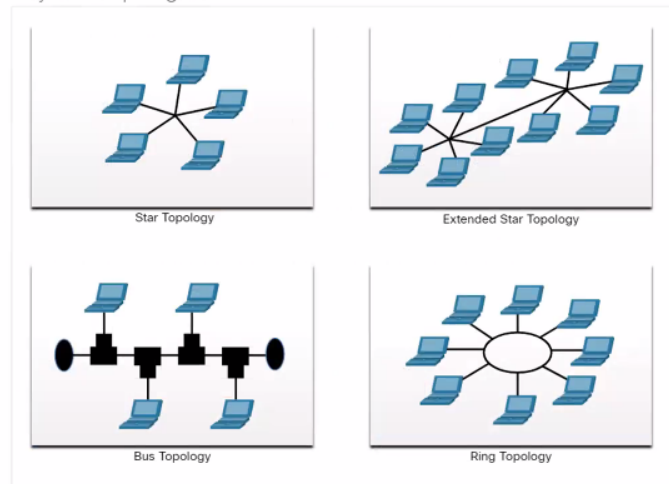
## Topologies LAN Topologies

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



Nella topologia RING esiste un pacchetto chiamato TOKEN che viene passato da un host all'altro. Chi ha il TOKEN può comunicare, quando finisce la comunicazione, passa il TOKEN al prossimo host:

- Se non devo comunicare, passo direttamente il TOKEN

## Topologies Half and Full Duplex Communication

### 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.  
*wireless*

### Full-duplex communication

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



## HALF DUPLEX:

## Topologies Access Control Methods

### Contention-based access

*chance to communicate, communicate*

All nodes operating 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. *bus topology hub*
- Carrier sense multiple access with collision avoidance (CSMA/CA) as used on Wireless LANs. *WLAN*

### Controlled access = *ring (red ethernet)*

- 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 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.



schiede di rete (nic)  
montano il **CD**

### CSMA/CD collision detection process:

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

Nel CSMA/CA quando succede una collisione, sul link viene mandato un segnale di JAM che notifica a tutti che è avvenuta una collisione:

- Successivamente il SENDER aspetta un tempo random prima di rinviare il messaggio
- Ripara il danno, non riesce ad evitarlo.

## Contention-Based Access – CSMA/CA

### CSMA/CA

*evitare di collisioni → si usa su reti wireless*

- 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.

*LAN → Livello 2 → Ethernet o VLAN  
WAN → Livello 2 → HDLC, Frame relay e Ethernet*

### Differenza del 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.
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### CSMA/CA collision avoidance process:

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## 6.3 Data Link Frame

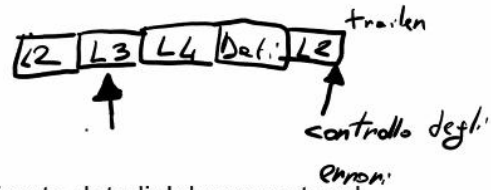


## Data Link Frame The Frame

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 *1 header = intestazione*
- Data
- **Trailer**

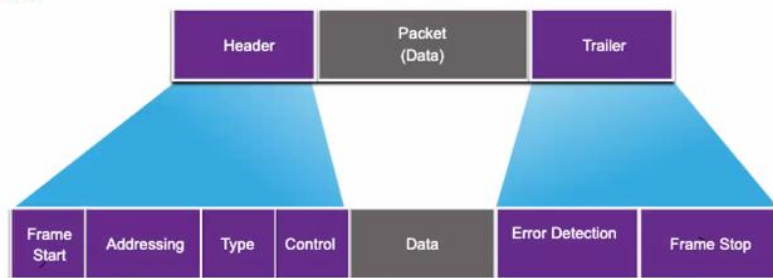


The fields of the header and trailer vary according to data link layer protocol.

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

## Data Link Frame Frame Fields

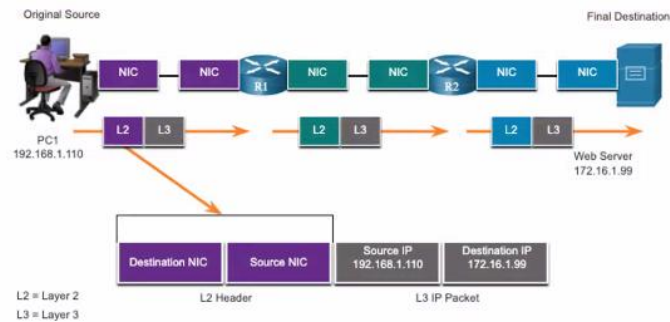
*header  
e  
trailer  
generici*



Field	Description
Frame Start and Stop	Identifies beginning and end of frame ←
Addressing	Indicates source and destination nodes
<b>Type</b> → <i>ind. il protocollo di L3</i>	Identifies encapsulated Layer 3 protocol
Control	Identifies flow control services
Data	Contains the frame payload
Error Detection	Used for determine transmission errors





## Data Link Frame 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.



## Data Link 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.