Chapter 4B: Data Link Layer Protocols
OSI Data Link Layer
The OSI has 7 layers.
The Data Link Layer is the second layer, just above the Physical Layer.
OSI Data Link Layer

- This layer is the protocol layer.
- It **transfers data** between adjacent network nodes.
- It is concerned with local **delivery of frames** between devices.
- A frame is a digital data transmission unit.
OSI Data Link Layer - Media Access Control

The Data Link Layer

Data link layer protocols govern how to format a frame for use on different media.

At each hop along the path, an intermediary device accepts frames from one medium, decapsulates the frame and then forwards the packets in a new frame. The headers of each frame are formatted for the specific medium that it will cross.
OSI Data Link Layer

Framing

• Data are streamed from the network layer to the Data Link Layer.

• These Data are first framed, then delivered.
• **Framing** is a technique performed by the Data Link layer.
• It breaks the bit stream into discrete frames.
OSI Data Link Layer
A Frame

A frame comprises,
- A header
- A packet
- A trailer
A frame consists of a header, data, and a trailer. A header consists of a start frame, address type and control. A trailer consists of a FCS (Frame Check Sequence) and stop frame.
The packet contains the actual data to be sent.
**OSI Data Link Layer**

**The Trailer**

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**Frame Check Sequence (FCS)**

This field is used for error checking. The source calculates a number based on the frame's data and places that number in the FCS field. The destination then recalculates the data to see if the FCS matches. If they don't match, the destination deletes the frame.

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**Stop Frame**

This field, also called the Frame Trailer, is an optional field that is used when the length of the frame is not specified in the Type/Length field. It indicates the end of the frame when transmitted.
OSI Data Link Layer – Formatting Data for Transmission

- The frame header and trailer must be of a fixed format.
- The header signals start of a packet.
- The trailers signals the end of a packet.
OSI Data Link Layer
Formatting Data for Transmission

• Error Detection is done. If error is detected, the frame will not be transmitted.
**OSI Data Link Layer**

Ethernet Frame, used for LANs

### PARTS OF AN ETHERNET FRAME

<table>
<thead>
<tr>
<th>Field name</th>
<th>Preamble</th>
<th>Destination Address</th>
<th>Source Address</th>
<th>Type</th>
<th>Data or Payload (PDU)</th>
<th>Frame Check Sequence (FCS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>8 bytes</td>
<td>6 bytes</td>
<td>6 bytes</td>
<td>2 bytes</td>
<td>46 - 1500 bytes</td>
<td>4 bytes</td>
</tr>
</tbody>
</table>

**Type** - Value to indicate which upper layer protocol will receive the data after the Ethernet process is complete.

**Data or payload** - This is the PDU, typically an IPv4 packet, that is to be transported over the media.

**Frame Check Sequence (FCS)** - A value used to check for damaged frames.
The PPP frame has 6 fields. Each field contains bytes of information.

- **Flag** - indicates the start or end of a frame (0111 1110)
- **Address** - standard PPP broadcast address; does not assign individual station addresses
- **Control** - contains 0000 0011; calls for transmission of user data
- **Protocol** - identify protocol encapsulated in frame
- **Data** - contains datagram for protocol
- **Frame Check Sequence (FCS)** - error detection
OSI Data Link Layer – 802.11 Wireless Frame

The frame for wireless transmission is more complex, with many fields.
OSI Data Link Layer – Layer 2 Address

Logical Multi-Access Topology

A multi-access frame has many possible destinations.

Logical Point-to-Point Topology

A point-to-point frame has only 1 possible destination.
OSI Data Link Layer - LAN and WAN Frames

Examples of Layer 2 Protocols

- PPP Frame
- HDLC
- Frame Relay
- 802.11 Wireless Frame
- Ethernet Frame
Transmission of data must follow some standards so that all hardware can communicate.

<table>
<thead>
<tr>
<th>Standard organization</th>
<th>Networking Standards</th>
</tr>
</thead>
</table>
| **IEEE**              | 802.2: Logical Link Control (LLC)  
|                       | 802.3: Ethernet  
|                       | 802.4: Token bus  
|                       | 802.5: Token passing  
|                       | 802.11: Wireless LAN (WLAN) & Mesh (Wi-Fi certification)  
|                       | 802.15: Bluetooth  
|                       | 802.16: WiMax |
| **ITU-T**             | G.992: ADSL  
|                       | G.8100 - G.8199: MPLS over Transport aspects  
|                       | Q.921: ISDN  
|                       | Q.922: Frame Relay |
| **ISO**               | HDLC (High Level Data Link Control)  
|                       | ISO 9314: FDDI Media Access Control (MAC) |
| **ANSI**              | X3T9.5 and X3T12: Fiber Distributed Data Interface (FDDI) |
OSI Data Link Layer
Data Link Sublayers

This layer has 2 sub-layers:

- LLC (Logical Link Control) Layer interacts with Network Layer
- MAC (Media Access Control) Layer interacts with Physical Layer
OSI Data Link Layer – Media Access Control (MAC) Sublayer

Data Link Layer controls the transfer of frames.
Summary of data transfer
Data from a source go through the 7 layers (7 to 1) during encapsulation.
Bits sent from one source goes through the 7 layers (1 to 7) during de-encapsulation.
Device at destination receives data sent.
OSI Data Link Layer
Topology
OSI Data Link Layer

Topology

Topology is the way in which constituent parts are interrelated or arranged.

There are two types of network topology:

- Physical
- Logical
OSI Data Link Layer - Physical Topology

Physical topology is the placement of the various components of a network, including device location and cable installation.
OSI Data Link Layer - Logical Topology

Logical topology illustrates how data flows within a network, regardless of its physical design.

Logical Topology - shows the IP addresses of devices in the network.

Mail server 192.168.2.1
Web server 192.168.2.2
File server 192.168.2.3

Department Server

Admin Group

Classroom 1

192.168.2.4
192.168.2.5
192.168.2.6
192.168.1.1
192.168.1.2
192.168.1.3
192.168.1.4
192.168.1.5
192.168.1.6
192.168.1.7
192.168.1.8
192.168.1.9

Classroom 2

Classroom 3

Router-Firewall

Ethernet 192.168.2.0

Ethernet 192.168.1.0

Internet
OSI Data Link Layer –
Common Physical WAN Topologies

Common Physical **WAN Topologies** include:
- Point-to-Point
- Hub and Spoke
- Full Mesh
OSI Data Link Layer – WAN Physical Point-to-Point Topology

Point-to-Point Topology is limited to having 2 nodes.
OSI Data Link Layer -
WAN Logical Point-to-Point Topology

Adding more devices or changing locations do not affect the logical topology of a network.
OSI Data Link Layer –
WAN Half- and Full-Duplex

Half-Duplex – Data can be sent in one direction at any one time.

Full-Duplex – Data can be sent/received in both directions at the same time. Faster data transfer can be achieved.
OSI Data Link Layer –
Physical LAN Topologies

WAN Topologies – some are same as
LAN Topologies, some are not
OSI Data Link Layer – Physical LAN Topologies

Physical Topologies

- Star topology
- Extended star topology
- Bus topology
- Ring topology
OSI Data Link Layer –
LAN Logical Topology for Shared Media

There are two methods of sharing media (data) in a LAN:
• Contention-based Access Method
• Controlled Access Method
**OSI Data Link Layer – LAN Logical Topology for Shared Media**

**Contention-Based Access Method**

This method is based on devices contending to send data whenever there is room for traffic in the network.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Contention-Based Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Stations can transmit at any time</td>
<td>• CSMA/CD for 802.3 Ethernet networks</td>
</tr>
<tr>
<td>• Collision of frames can take place as there is no control of transmission</td>
<td>• CSMA/CA for 802.11 wireless networks</td>
</tr>
<tr>
<td>• There are mechanisms to resolve contention for the media</td>
<td></td>
</tr>
</tbody>
</table>

**Contention-Based Access**

![Contention-Based Access Diagram](image)
OSI Data Link Layer – LAN Logical Topology for Shared Media

**Controlled Access Method**
This method allows a device to send data only when it is given the right.

**Characteristics**
- Only one station can transmit at a time
- Devices wanting to transmit must wait their turn
- No collisions of frames at all
- May use a token passing method
  - **Token passing** - a signal called a token is passed between nodes; it authorizes the node to communicate

**Controlled Access Technologies**
- Token Ring (IEEE 802.5)
- FDDI
OSI Data Link Layer –
LAN Multi-Access Topology

Only one device is allowed to transmit
data at any one time.

Logical Multi-Access Topology

Computer A:

I need to transmit to E.

I check for other transmissions.

No other transmissions are detected.

Transmitting…
OSI Data Link Layer – LAN Ring Topology

In a LAN Ring Topology, a frame sent out stops at every device. If it is not meant for the device, the frame is sent to the next, until one device accept the frame. This is time consuming.
There are two network environments:

- **Fragile** environment
  Open air, weather interference, uncontrolled factors, etc.

- **Protected** environment
  In a building, all factors controllable
In a fragile environment, more controls are needed to ensure delivery. The header and trailer fields are larger as more control information is needed.

Greater effort needed to ensure delivery = higher overhead = slower transmission rates.
In a protected environment, we can count on the frame arriving at its destination. Fewer controls are needed, resulting in smaller fields and smaller frames.

Less effort needed to ensure delivery = lower overhead = faster transmission rates
Review

1. The OSI has ___ layers.

   The Data Link Layer is the _________ layer, just above the Physical Layer.
Review

1. The OSI has 7 layers.

The Data Link Layer is the second layer, just above the Physical Layer.
2. This data link layer is the ________ layer. It ________ data between adjacent network nodes.

It is concerned with local delivery of frames between devices. A_______ is a digital data transmission unit.
Review

3. The Data Link Layer protocols govern how to format a ________. 
Review

3. The Data Link Layer protocols govern how to format a frame.
Review

4. _________ is a technique performed by the Data Link layer.

It _________ the bit stream into discrete frames.
Review

4. **Framing** is a technique performed by the Data Link layer. It **breaks** the bit stream into discrete frames.
Review

5. A frame comprises,
   • A ______
   • A ______
   • A ______
   • A trailer
5. A frame comprises,
   • A header
   • A packet
   • A trailer
OSI Data Link Layer - The Data Link Header

6. A frame consists of a header, data, and a trailer. A header consists of a ______ frame, address type and control. A trailer consists of a _____ (Frame Check Sequence) and stop frame.
6. A frame consists of a header, data, and a trailer. A header consists of a start frame, address type and control. A trailer consists of a FCS (Frame Check Sequence) and stop frame.
Review

7. _____ Detection for the frame is done. If error is detected, the frame will ________ be transmitted.
7. Error Detection for the frame is done. If error is detected, the frame will not be transmitted.
Review

8. PPP stands for __________

The PPP frame has ___ fields.

Each field contains bytes of information.
Review

8. PPP stands for **Point-to-Point Protocol**.

The PPP frame has **6** fields.

Each field contains bytes of information.
Review

9. A multi-access frame has ______ destinations, while

A point-to-point access frame has ____ destination.
9. A multi-access frame has **many** destinations, while a point-to-point access frame has **only one** destination.
Review

10. The Data Link layer has 2 _________:

• LLC (Logical Link Control) Layer interacts with Network Layer
• MAC (Media Access Control) Layer interacts with Physical Layer
10. The Data Link layer has 2 _________:

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<tr>
<th>Network</th>
<th>Data Link</th>
<th>Physical</th>
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<tbody>
<tr>
<td>LLC Sublayer</td>
<td>802.3 Ethernet</td>
<td>802.11 Wi-Fi</td>
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Review

11. The Data Link Layer controls the transfer of ______.
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There are two types of network topology:

- Physical
- Logical
Review

13. _______ _____ is the placement of the various components of a network, including device location and cable installation.
Review

13. Physical topology is the placement of the various components of a network, including device location and cable installation.
14. __________ __________ illustrates how data flows within a network, regardless of its physical design.
Review

14. **Logical topology** illustrates how data flows within a network, regardless of its physical design.

Logical Topology - shows the IP addresses of devices in the network.

- Mail server: 192.168.2.1
- Web server: 192.168.2.2
- File server: 192.168.2.3
- Department Server: 192.168.2.4, 192.168.2.5, 192.168.2.6
- Classroom 1: 192.168.1.4, 192.168.1.5, 192.168.1.6
- Classroom 2: 192.168.1.7, 192.168.1.8, Printer 192.168.1.9
- Classroom 3: Ethernet 192.168.2.0, Ethernet 192.168.1.0
- Router-Firewall
- Internet
15. Common Physical WAN Topologies include:
   • Point-to-Point
   • ___________
   • Full Mesh
Review

15. Common Physical **WAN Topologies** include:
   - Point-to-Point
   - Hub and Spoke
   - Full Mesh
Review

16. Point-to-Point Topology is limited to having ____ nodes.
Review

16. Point-to-Point Topology is limited to having 2 nodes.
17. Adding more devices or changing locations do not affect the ________ topology of a network.
Review

17. Adding more devices or changing locations do not affect the logical topology of a network.
Review

18. Half-Duplex – Data can be sent in ____ direction at any one time.

Full-Duplex – Data can be sent/received in ____ directions at the same time.
Faster data transfer can be achieved.
Review

18. Half-Duplex – Data can be sent in one direction at any one time.

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Review

19. The 4 physical WAN topologies are Star, ______, ______ and Ring.
Review

19. The 4 physical WAN topologies are Star, Extended, Bus and Ring.
20. There are two methods of sharing media (data) in a LAN:
• ___________ Access Method
• ___________ Access Method
Review

20. There are two methods of sharing media (data) in a LAN:
• Contention-based Access Method
• Controlled Access Method
21. In a LAN Ring Topology, a frame sent out stops at ________ device.
Review

21. In a LAN Ring Topology, a frame sent out stops at every device.
22. There are two network environments:
   • ________ environment
   • _________ environment
Review

22. There are two network environments:
   • **Fragile** environment
     Open air, weather interference, uncontrolled factors, etc.
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     In a building, all factors controllable
End of Review