Chapter 4: Network Access

Introduction to Networks
Chapter 4

4.1 Physical Layer Protocols
4.2 Network Media
4.3 Data Link Layer Protocols
4.4 Media Access Control
4.5 Summary
Chapter 4: Objectives

Students will be able to:

- Explain how physical layer protocols and services support communications across data networks.
- Build a simple network using the appropriate.
- Explain the role of the data link layer in supporting communications across data networks.
- Compare media access control techniques and logical topologies used in networks.
Getting it Connected

Connecting to the Network

Home Router

Do buttons on 4.1.1.1

Embedded Wireless Antenna

Ethernet Switch

Internet Connection

4.1.1.1
Connecting to the Network

Connecting to the Wired LAN

Connect your computer to the Ethernet port (1, 2, 3, or 4).
Connecting to the Wireless LAN with a Range Extender
Purpose of the Physical Layer

The Physical Layer

In diagrams, signals on the physical media are depicted by this line symbol.

4.1.2.1
Purpose of the Physical Layer

Physical Layer Media

Outbound (Tx) signal

Sample electrical signals transmitted on copper cable

Representative light pulse fiber signals

Microwave (wireless) signals
### Purpose of the Physical Layer

#### Physical Layer Standards

<table>
<thead>
<tr>
<th>Standard organization</th>
<th>Networking Standards</th>
</tr>
</thead>
</table>
| **ISO**               | • ISO 8877: Officially adopted the RJ connectors (e.g., RJ-11, RJ-45)  
                         • ISO 11801: Network cabling standard similar to EIA/TIA 568. |
| **EIA/TIA**           | • TIA-568-C: Telecommunications cabling standards, used by nearly all voice, video and data networks.  
                         • TIA-569-B: Commercial Building Standards for Telecommunications Pathways and Spaces  
                         • TIA-598-C: Fiber optic color coding  
                         • TIA-942: Telecommunications Infrastructure Standard for Data Centers |
| **ANSI**              | • 568-C: RJ-45 pinouts. Co-developed with EIA/TIA |
| **ITU-T**             | • G.992: ADSL |
| **IEEE**              | • 802.3: Ethernet  
                         • 802.11: Wireless LAN (WLAN) & Mesh (Wi-Fi certification)  
                         • 802.15: Bluetooth |

*Do buttons on 4.1.2.3*
## Fundamental Principles of Layer 1
### Physical Layer Fundamental Principles

<table>
<thead>
<tr>
<th>Media</th>
<th>Physical Components</th>
<th>Frame Encoding Technique</th>
<th>Signalling Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper cable</td>
<td>• UTP • Coaxial • Connectors • NICs • Ports • Interfaces</td>
<td>• Manchester Encoding • Non-Return to Zero (NRZ) techniques • 4B/5B codes are used with Multi-Level Transition Level 3 (MLT-3) signaling • 8B/10B • PAM5</td>
<td>• Changes in the electromagnetic field • Intensity of the electromagnetic field • Phase of the electromagnetic wave</td>
</tr>
<tr>
<td>Fiber Optic cable</td>
<td>• Single-mode Fiber • Multimode Fiber • Connectors • NICs • Interfaces • Lasers and LEDs • Photoreceptors</td>
<td>• Pulses of light • Wavelength multiplexing using different colors</td>
<td>• A pulse equals 1. • No pulse is 0.</td>
</tr>
<tr>
<td>Wireless media</td>
<td>• Access Points • NICs • Radio • Antennae</td>
<td>• DSSS (direct-sequence spread-spectrum) • OFDM (orthogonal frequency division multiplexing)</td>
<td>• Radio waves</td>
</tr>
</tbody>
</table>

4.1.3.1
# Fundamental Principles of Layer 1

## Bandwidth

<table>
<thead>
<tr>
<th>Unit of Bandwidth</th>
<th>Abbreviation</th>
<th>Equivalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bits per second</td>
<td>bps</td>
<td>$1 \text{ bps} = \text{fundamental unit of bandwidth}$</td>
</tr>
<tr>
<td>Kilobits per second</td>
<td>kbps</td>
<td>$1 \text{ kbps} = 1,000 \text{ bps} = 10^3 \text{ bps}$</td>
</tr>
<tr>
<td>Megabits per second</td>
<td>Mbps</td>
<td>$1 \text{ Mbps} = 1,000,000 \text{ bps} = 10^6 \text{ bps}$</td>
</tr>
<tr>
<td>Gigabits per second</td>
<td>Gbps</td>
<td>$1 \text{ Gbps} = 1,000,000,000 \text{ bps} = 10^9 \text{ bps}$</td>
</tr>
<tr>
<td>Terabits per second</td>
<td>Tbps</td>
<td>$1 \text{ Tbps} = 1,000,000,000,000 \text{ bps} = 10^{12} \text{ bps}$</td>
</tr>
</tbody>
</table>
 Fundamental Principles of Layer 1
Throughput

Know the Difference:
- Bandwidth
- Throughput
- Goodput

Try:
www.speedtest.net
One student
Then all at once!
Fundamental Principles of Layer 1

Types of Physical Media
Fundamental Principles of Layer 1
4.1.3.5 Activity - Physical Layer Terminology

Do in Activities on both buttons in class
Network Media

Copper Cabling
Copper Cabling

Characteristics of Copper Media

Do the animation on 4.2.1.1
Copper Cabling

Copper Media

Unshielded Twisted Pair (UTP) cable

Shielded Twisted Pair (STP) cable

Coaxial cable

Know:
UTP
STP
Copper Cabling
Unshielded Twisted-Pair (UTP) Cable

4.2.1.3
Copper Cabling

Shielded Twisted-Pair (STP) Cable

4.2.1.4
Copper Cabling

Coaxial Cable

- Outer Jacket
- Braided Copper Shielding
- Copper Conductor
- Plastic Insulation

Coaxial Connectors

- BNC
- N type
- F type
Copper Cabling
Cooper Media Safety

The separation of data and electrical power cabling must comply with safety codes.

Cables must be connected correctly.

Installations must be inspected for damage.

Equipment must be grounded correctly.
UTP Cabling

4.2.1.7 Activity - Copper Media Characteristics

Do activity 4.2.1.7 in class
UTP Cabling

Properties of UTP Cabling
Understanding How Cancellation Works to limit signal degradation.

Each pair has a varying number of twists.
UTP Cabling

UTP Cabling Standards

Category 3 Cable (UTP)

Category 7 Cable (ScTP)

Category 6 Cable (UTP)

Category 5 and 5e Cable (UTP)

Category 5 and 5e Cable
(UTP)

- Used for Data transmission
- Cat 5 supports 100 Mbps and can support 1000 Mbps but it is not recommended
- Cat 5e supports 1000 Mbps

Click on each cable on 4.2.2.2
**UTP Cabling**

**UTP Connectors**

- **Bad connector** - Wires are exposed, untwisted, and not entirely covered by the sheath.

- **Good connector** - Wires are untwisted to the extent necessary to attach the connector.

Do buttons and watch video on 4.2.2.3

Note poorly made cable on button 3
UTP Cabling
Types of UTP Cable

Memorize!

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Standard</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet Straight-through</td>
<td>Both ends T568A or both ends T568B</td>
<td>Connecting a network host to a network device such as a switch or hub.</td>
</tr>
<tr>
<td>Ethernet Crossover</td>
<td>One end T568A, other end T568B</td>
<td>Connecting two network hosts. Connecting two network intermediary devices (switch to switch, or router to router).</td>
</tr>
<tr>
<td>Rollover</td>
<td>Cisco proprietary</td>
<td>Connect a workstation serial port to a router console port, using an adapter.</td>
</tr>
</tbody>
</table>

Know straight-through and crossover
Roll over is use to console to cisco routers.
UTP Cabling

Testing UTP Cables

Test newly made cables for:
- Wire map
- Cable length
- Signal loss due to attenuation
- Crosstalk
**UTP Cabling**

**4.2.2.6 Activity - Cable Pinouts**

*Activity - Cable Pinouts*
Correctly align the wire colors to build a UTP 568B, straight-through cable pinout.

Drag each wire color to its correct placement on the RJ-45 image in the graphic.

*Bottom view of an RJ-45 connector*

**Do 4.2.2.6 in class**
Fiber-optic cabling is now being used in four types of industry:

- Enterprise Networks
- FTTH and Access Networks
- Long-Haul Networks
- Submarine Networks
Fiber Optic Cabling

Fiber Media Cable Design

Jacket

- Added to protect the fiber against abrasion, solvents, and other contaminants. This outer jacket composition can vary depending on the cable usage.

Click on the parts of the diagram on 4.2.3.2
Fiber Optic Cabling
Types of Fiber Media

Single Mode
- Produces single straight path for light
- Glass Core=9 microns
- Glass Cladding 125 microns diameter
- Polymeric coating

Multimode
- Allows multiple paths for light
- Glass Core=50/62.5 microns
- Glass Cladding 125 microns diameter
- Coating

- Larger core than single mode cable
- Allows greater dispersion and therefore, loss of signal
- Suited for long distance applications, but shorter than single mode
- Uses LEDs as the light source
- Commonly used with LANs or distances of a couple hundred meters within a campus network

4.2.3.3

Click on buttons on 4.2.3.3
Fiber Optic Cabling
Network Fiber Connectors

- ST Connectors
- SC Connectors
- LC Connector
- Duplex Multimode LC Connectors

Click on buttons on 4.2.3.4
Fiber Optic Cabling

Network Fiber Connectors

- TIA-598 standard which recommends the use of a
  - Yellow jacket for single-mode fiber cables
  - Orange (or aqua) for multimode fiber cables
Fiber Optic Cabling

Testing Fiber Cables

Optical Time Domain Reflectometer (OTDR)
## Fiber Optic Cabling

### Fiber versus Copper

<table>
<thead>
<tr>
<th>Implementation issues</th>
<th>Copper media</th>
<th>Fibre-optic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth supported</td>
<td>10 Mbps – 10 Gbps</td>
<td>10 Mbps – 100 Gbps</td>
</tr>
<tr>
<td>Distance</td>
<td>Relatively short (1 – 100 meters)</td>
<td>Relatively High (1 – 100,000 meters)</td>
</tr>
<tr>
<td>Immunity to EMI and RFI</td>
<td>Low</td>
<td>High (Completely immune)</td>
</tr>
<tr>
<td>Immunity to electrical hazards</td>
<td>Low</td>
<td>High (Completely immune)</td>
</tr>
<tr>
<td>Media and connector costs</td>
<td>Lowest</td>
<td>Highest</td>
</tr>
<tr>
<td>Installation skills required</td>
<td>Lowest</td>
<td>Highest</td>
</tr>
<tr>
<td>Safety precautions</td>
<td>Lowest</td>
<td>Highest</td>
</tr>
</tbody>
</table>
Fiber Optic Cabling

4.2.3.7 Activity - Fiber Optics Terminology

### Activity – Fiber-optics Terminology

Descriptions of fiber-optic media are provided in the table. Click the appropriate field to match the description to the fiber-optic cable type.

<table>
<thead>
<tr>
<th>Description</th>
<th>Multimode</th>
<th>Single-mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Can help data travel approximately 1.24 miles or 2 km/2000 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Uses light emitting diodes (LEDs) as a data light source transmitter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Uses lasers in a single stream as a data light source transmitter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Used to connect long-distance telephony and cable TV applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Can travel approximately 62.5 miles or 100 km/100000 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Used within a campus network</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do Activity 4.2.3.7 in class
Wireless Media
Properties of Wireless Media

Wireless does have some areas of concern including:
• Coverage area
• Interference
• Security
### Types of Wireless Media

<table>
<thead>
<tr>
<th></th>
<th>IEEE 802.11 standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Commonly referred to as Wi-Fi.</td>
</tr>
<tr>
<td></td>
<td>Uses CSMA/CA</td>
</tr>
<tr>
<td></td>
<td>Variations include:</td>
</tr>
<tr>
<td></td>
<td>802.11a: 54 Mbps, 5 GHz</td>
</tr>
<tr>
<td></td>
<td>802.11b: 11 Mbps, 2.4 GHz</td>
</tr>
<tr>
<td></td>
<td>802.11g: 54 Mbps, 2.4 GHz</td>
</tr>
<tr>
<td></td>
<td>802.11n: 600 Mbps, 2.4 and 5 GHz</td>
</tr>
<tr>
<td></td>
<td>802.11ac: 1 Gbps, 5 GHz</td>
</tr>
<tr>
<td></td>
<td>802.11ad: 7 Gbps, 2.4 GHz, 5 GHz, and 60 GHz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>IEEE 802.15 standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Supports speeds up to 3 Mbps</td>
</tr>
<tr>
<td></td>
<td>Provides device pairing over distances from 1 to 100 meters.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>IEEE 802.16 standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Provides speeds up to 1 Gbps</td>
</tr>
<tr>
<td></td>
<td>Uses a point-to-multipoint topology to provide wireless broadband access.</td>
</tr>
</tbody>
</table>
Wireless Media

Wireless LAN

Cisco Linksys EA6500 802.11ac wireless router
## 802.11 Wi-Fi Standards

### Table: Wireless Media

<table>
<thead>
<tr>
<th>Standard</th>
<th>Maximum Speed</th>
<th>Frequency</th>
<th>Backwards compatible</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11a</td>
<td>54 Mbps</td>
<td>5 GHz</td>
<td>No</td>
</tr>
<tr>
<td>802.11b</td>
<td>11 Mbps</td>
<td>2.4 GHz</td>
<td>No</td>
</tr>
<tr>
<td>802.11g</td>
<td>54 Mbps</td>
<td>2.4 GHz</td>
<td>802.11b</td>
</tr>
<tr>
<td>802.11n</td>
<td>600 Mbps</td>
<td>2.4 GHz or 5 GHz</td>
<td>802.11b/g</td>
</tr>
<tr>
<td>802.11ac</td>
<td>1.3 Gbps (1300 Mbps)</td>
<td>2.4 GHz and 5.5 GHz</td>
<td>802.11b/g/n</td>
</tr>
<tr>
<td>802.11ad</td>
<td>7 Gbps (7000 Mbps)</td>
<td>2.4 GHz, 5 GHz and 60 GHz</td>
<td>802.11b/g/n/ac</td>
</tr>
</tbody>
</table>
Wireless Media
4.2.4.5 Packet Tracer - Connecting a Wired and Wireless LAN
4.2.4.6 Lab - Viewing Wired and Wireless NIC Information

Homework:
Do Packet Tracer
4.2.4.5
Purpose of the Data Link Layer

The Data Link Layer

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical

Network
### Purpose of the Data Link Layer

**Data Link Sublayers**

<table>
<thead>
<tr>
<th>Network</th>
<th>Data Link</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LLC Sublayer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAC Sublayer</td>
<td>802.3 Ethernet</td>
</tr>
</tbody>
</table>

The data link layer is actually divided into two sublayers:

- Logical Link Control (LLC)
- Media Access Control (MAC)
Purpose of the Data Link Layer

Media Access Control

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

Different protocols may be in use for 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.

Do Animation on 4.3.1.3
Purpose of the Data Link Layer

Providing Access to Media

The Data Link layer is responsible for controlling the transfer of frames across the media.

Do Animation on 4.3.1.4
Data Link Layer
Layer 2 Frame Structure

Formatting Data for Transmission

HEADER | Packet (Data) | TRAILER
---|---|---
Frame Start | Addressing | Type | Quality Control | DATA | Error Detection | Frame Stop
1010 | 01110 | 01110 | 01110 | 01001

A specific bit pattern denotes the start of the frame.

Another specific bit pattern denotes the end of the frame.
Layer 2 Frame Structure

Creating a Frame

Diagram showing the structure of a Layer 2 frame, with sections for HEADER, Packet (Data), TRAILER, Frame Start, Addressing, Type, Control, DATA, Error Detection, and Frame Stop.
Layer 2 Frame Structure

4.3.2.3 Activity - Generic Frame Fields

Activity - Part 1: Generic Frame Fields
Drag the generic frame field to its correct location on the diagram.

Do the Activities 4.3.2.3 on both buttons in class
## Data Link Layer

### Layer 2 Standards

<table>
<thead>
<tr>
<th>OSI Layers</th>
<th>LAN Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Layer</td>
<td>Ethernet</td>
</tr>
<tr>
<td>MAC Sublayer</td>
<td>IEEE 802.3 (Ethernet)</td>
</tr>
<tr>
<td>LLC Sublayer</td>
<td>IEEE 802.3u (FastEthernet)</td>
</tr>
<tr>
<td></td>
<td>IEEE 802.3z (GigabitEthernet)</td>
</tr>
<tr>
<td></td>
<td>IEEE 802.3ab (GigabitEthernet over Copper)</td>
</tr>
<tr>
<td></td>
<td>Token Ring/IEEE 802.6</td>
</tr>
<tr>
<td></td>
<td>FDDI</td>
</tr>
</tbody>
</table>
## Layer 2 Standards

### Data Link Layer Standards

<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) |
Topologies

4.3.3.2 Activity - Data Link Layer Standards Organizations

Do the Activity 4.3.3.2 in class
Topologies

Controlling Access to the Media

We need rules for how to share the media.

Frame

Shared Media

We need rules for how to share the media.

Frame

4.4.1.1
Topologies
Physical and Logical Topologies

Do the Buttons on 4.4.1.2 in class
WAN Topologies

Common Physical WAN Topologies

- Point-to-point topology
- Hub and spoke topology
- Full mesh topology
WAN Topologies
Physical Point-to-Point Topology

Node 1

Limited to two nodes

Node 2
WAN Topologies

Logical Point-to-Point Topology

Do the Buttons on 4.4.2.3 in class
WAN Topologies

Half and Full Duplex

Do the Buttons and animations on 4.4.2.5 in class
LAN Topologies

Physical LAN Topologies

- Star topology
- Extended star topology
- Bus topology
- Ring topology
LAN Topologies

Logical Topology for Shared Media

Contestion-Based Access

I try to send when I am ready.

I try to send when I am ready.

I try to send when I am ready.

Controlled Access

I have a packet to send, but it is not my turn. I'll wait.

I have nothing to send.

It is my turn to send. I will send now.

Do the Buttons on 4.4.3.2 in class
LAN Topologies

Contention-Based Access

Contestion-Based Access

<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 exist</td>
<td>• CSMA/CA for 802.11 wireless networks</td>
</tr>
<tr>
<td>• There are mechanisms to resolve</td>
<td></td>
</tr>
<tr>
<td>contention for the media</td>
<td></td>
</tr>
</tbody>
</table>

4.4.3.3
LAN Topologies

Multi-Access Topology

Do the Animation on 4.4.3.4 in class
LAN Topologies

Controlled Access

Characteristics

- Only one station can transmit at a time
- Devices wishing to transmit must wait their turn
- No collisions
- May use a token passing method

Controlled Access Technologies

- Token Ring (IEEE 802.5)
- Fiber Distributed Data Interface (FDDI)

Both are obsolete.
LAN Topologies

Ring Topology

Do the Animation on 4.4.3.6 in class
# LAN Topologies

## 4.4.3.7 Activity - Logical and Physical Topologies

### Activity – Logical and Physical Topology Characteristics

This activity provides you with characteristics of data link layer media access control methods.

Classify each media access control method as a Physical or Logical Topology characteristic by clicking in the appropriate column.

<table>
<thead>
<tr>
<th>Physical Topology</th>
<th>Logical Topology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CSMA/CD</td>
<td></td>
</tr>
<tr>
<td>2. Star</td>
<td></td>
</tr>
<tr>
<td>3. Contention-based access</td>
<td></td>
</tr>
<tr>
<td>4. Bus</td>
<td></td>
</tr>
<tr>
<td>5. CSMA/CA</td>
<td></td>
</tr>
<tr>
<td>6. Controlled access</td>
<td></td>
</tr>
<tr>
<td>7. Point-to-Point</td>
<td></td>
</tr>
<tr>
<td>8. Ring</td>
<td></td>
</tr>
<tr>
<td>9. Hub and Spoke</td>
<td></td>
</tr>
</tbody>
</table>

**Do the Activity on 4.4.3.7 in class**
In a fragile environment, more controls are needed to ensure delivery. The header and trailer fields are larger as more control information is needed.

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.
# Data Link Frame

## The Header

<table>
<thead>
<tr>
<th>Header</th>
<th>Data</th>
<th>FCS</th>
<th>STOP FRAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Frame</td>
<td>Address</td>
<td>Type/Length</td>
<td></td>
</tr>
</tbody>
</table>
Data Link Frame

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.
Data Link Frame

The Trailer

Click on parts of 4.4.4.4 in class
Data Link Frame

LAN and WAN Frames

Do animation on 4.4.4.4 in class
### Data Link Frame

#### Ethernet Frame

A Common Data Link Layer Protocol for LANs

<table>
<thead>
<tr>
<th>Field name</th>
<th>Preamble</th>
<th>Destination</th>
<th>Source</th>
<th>Type</th>
<th>Data</th>
<th>Frame Check Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</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>

Preamble - used for synchronization; also contains a delimiter to mark the end of the timing information.

Destination Address - 48 bit MAC address for the destination node.

Source Address - 48 bit MAC address for the source node.

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.

Minimum Frame length: 64 or 72? Depends on if you count the Preamble.
Data Link Frame

Point-to-Point Protocol Frame

A Common Data Link Protocol for WANs

<table>
<thead>
<tr>
<th>Field</th>
<th>Size (bytes)</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flag</td>
<td>1 byte</td>
<td>A single byte that indicates the beginning or end of a frame. The flag field consists of the binary sequence 01111110.</td>
</tr>
<tr>
<td>Address</td>
<td>1 byte</td>
<td>A single byte that contains the standard PPP broadcast address. PPP does not assign individual station addresses.</td>
</tr>
<tr>
<td>Control</td>
<td>1 byte</td>
<td>A single byte that contains the binary sequence 00000011, which calls for transmission of user data in an unsequenced frame.</td>
</tr>
<tr>
<td>Protocol</td>
<td>2 bytes</td>
<td>Two bytes that identify the protocol encapsulated in the data field of the frame. The most up-to-date values of the protocol field are specified in the most recent Assigned Numbers Request For Comments (RFC).</td>
</tr>
<tr>
<td>Data</td>
<td>variable</td>
<td>Zero or more bytes that contain the datagram for the protocol specified in the protocol field.</td>
</tr>
<tr>
<td>Frame Check Sequence (FCS)</td>
<td>2 or 4 bytes</td>
<td>Normally 16 bits (2 bytes). By prior agreement, consenting PPP implementations can use a 32-bit (4-byte) FCS for improved error detection.</td>
</tr>
</tbody>
</table>
Data Link Frame

802.11 Wireless Frame

4.4.4.8
Data Link Frame

4.4.4.9 Activity - Frame Fields

Do activities on all buttons on 4.4.4.9 In class
Network Access

Summary

• Physical Layer Protocols
• Network Media
• Data Link Layer Protocols
• Media Access Control