Module 4: Physical Layer

Introduction to Networks v7.0
(ITN)
4.1 Purpose of the Physical Layer
## The OSI Reference Model

<table>
<thead>
<tr>
<th>OSI Model Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 - Application</td>
<td>Contains protocols used for process-to-process communications.</td>
</tr>
<tr>
<td>6 - Presentation</td>
<td>Provides for common representation of the data transferred between application layer services.</td>
</tr>
<tr>
<td>5 - Session</td>
<td>Provides services to the presentation layer and to manage data exchange.</td>
</tr>
<tr>
<td>4 - Transport</td>
<td>Defines services to segment, transfer, and reassemble the data for individual communications.</td>
</tr>
<tr>
<td>3 - Network</td>
<td>Provides services to exchange the individual pieces of data over the network.</td>
</tr>
<tr>
<td>2 - Data Link</td>
<td>Describes methods for exchanging data frames over a common media.</td>
</tr>
<tr>
<td>1 - Physical</td>
<td>Describes the means to activate, maintain, and de-activate physical connections.</td>
</tr>
</tbody>
</table>
Before any network communications can occur, a physical connection to a local network must be established.

This connection could be wired or wireless, depending on the setup of the network.

This generally applies whether you are considering a corporate office or a home.

A Network Interface Card (NIC) connects a device to the network.

Some devices may have just one NIC, while others may have multiple NICs (Wired and/or Wireless, for example).

Not all physical connections offer the same level of performance.
4.2 Physical Layer Characteristics
Physical Layer Characteristics

Physical Layer Standards

The TCP/IP standards are implemented in software and governed by the IETF.

The physical layer standards are implemented in hardware and are governed by many organizations including:

- ISO
- EIA/TIA
- ITU-T
- ANSI
- IEEE
Physical Layer Characteristics

Physical Components

Physical Layer Standards address three functional areas:

- Physical Components
- Encoding
- Signaling

The Physical Components are the hardware devices, media, and other connectors that transmit the signals that represent the bits.

- Hardware components like NICs, interfaces and connectors, cable materials, and cable designs are all specified in standards associated with the physical layer.
Physical Layer Characteristics

Encoding

• Encoding converts the stream of bits into a format recognizable by the next device in the network path.
• This ‘coding’ provides predictable patterns that can be recognized by the next device.
• Examples of encoding methods include Manchester (shown in the figure), 4B/5B, and 8B/10B.
Physical Layer Characteristics

Signaling

- The signaling method is how the bit values, “1” and “0” are represented on the physical medium.
- The method of signaling will vary based on the type of medium being used.
Physical Layer Characteristics

Bandwidth

- Bandwidth is the capacity at which a medium can carry data.
- Digital bandwidth measures the amount of data that can flow from one place to another in a given amount of time; how many bits can be transmitted in a second.
- Physical media properties, current technologies, and the laws of physics play a role in determining available 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 bps = fundamental unit of bandwidth</td>
</tr>
<tr>
<td>Kilobits per second</td>
<td>Kbps</td>
<td>1 Kbps = 1,000 bps = $10^3$ bps</td>
</tr>
<tr>
<td>Megabits per second</td>
<td>Mbps</td>
<td>1 Mbps = 1,000,000 bps = $10^6$ bps</td>
</tr>
<tr>
<td>Gigabits per second</td>
<td>Gbps</td>
<td>1 Gbps = 1,000,000,000 bps = $10^9$ bps</td>
</tr>
<tr>
<td>Terabits per second</td>
<td>Tbps</td>
<td>1 Tbps = 1,000,000,000,000 bps = $10^{12}$ bps</td>
</tr>
</tbody>
</table>
Physical Layer Characteristics

Bandwidth Terminology

Latency

• Amount of time, including delays, for data to travel from one given point to another

Throughput

• The measure of the transfer of bits across the media over a given period of time

Goodput

• The measure of usable data transferred over a given period of time

• Goodput = Throughput - traffic overhead
4.3 Copper Cabling
Copper Cabling
Characteristics of Copper Cabling

Copper cabling is the most common type of cabling used in networks today. It is inexpensive, easy to install, and has low resistance to electrical current flow.

Limitations:

- Attenuation – the longer the electrical signals have to travel, the weaker they get.
- The electrical signal is susceptible to interference from two sources, which can distort and corrupt the data signals (Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) and Crosstalk).

Mitigation:

- Strict adherence to cable length limits will mitigate attenuation.
- Some kinds of copper cable mitigate EMI and RFI by using metallic shielding and grounding.
- Some kinds of copper cable mitigate crosstalk by twisting opposing circuit pair wires together.
Copper Cabling

Types of Copper Cabling

Unshielded Twisted-Pair (UTP) Cable

Shielded Twisted-Pair (STP) Cable

Coaxial Cable
Copper Cabling
Unshielded Twisted Pair (UTP)

• UTP is the most common networking media.
• Terminated with RJ-45 connectors
• Interconnects hosts with intermediary network devices.

Key Characteristics of UTP
1. The outer jacket protects the copper wires from physical damage.
2. Twisted pairs protect the signal from interference.
3. Color-coded plastic insulation electrically isolates the wires from each other and identifies each pair.
Copper Cabling
Shielded Twisted Pair (STP)

- Better noise protection than UTP
- More expensive than UTP
- Harder to install than UTP
- Terminated with RJ-45 connectors
- Interconnects hosts with intermediary network devices

Key Characteristics of STP
1. The outer jacket protects the copper wires from physical damage
2. Braided or foil shield provides EMI/RFI protection
3. Foil shield for each pair of wires provides EMI/RFI protection
4. Color-coded plastic insulation electrically isolates the wires from each other and identifies each pair
Copper Cabling
Coaxial Cable

Consists of the following:
1. Outer cable jacket to prevent minor physical damage
2. A woven copper braid, or metallic foil, acts as the second wire in the circuit and as a shield for the inner conductor.
3. A layer of flexible plastic insulation
4. A copper conductor is used to transmit the electronic signals.

There are different types of connectors used with coax cable.

Commonly used in the following situations:
- Wireless installations - attach antennas to wireless devices
- Cable internet installations - customer premises wiring
4.4 UTP Cabling
UTP Cabling
Properties of UTP Cabling

UTP has four pairs of color-coded copper wires twisted together and encased in a flexible plastic sheath. No shielding is used. UTP relies on the following properties to limit crosstalk:

- Cancellation - Each wire in a pair of wires uses opposite polarity. One wire is negative, the other wire is positive. They are twisted together and the magnetic fields effectively cancel each other and outside EMI/RFI.

- Variation in twists per foot in each wire - Each wire is twisted a different amount, which helps prevent crosstalk amongst the wires in the cable.
Standards for UTP are established by the TIA/EIA. TIA/EIA-568 standardizes elements like:

- Cable Types
- Cable Lengths
- Connectors
- Cable Termination
- Testing Methods

Electrical standards for copper cabling are established by the IEEE, which rates cable according to its performance. Examples include:

- Category 3
- Category 5 and 5e
- Category 6
UTP Cabling

UTP Cabling Standards and Connectors (Cont.)

RJ-45 Connector

Poorly terminated UTP cable

RJ-45 Socket

Properly terminated UTP cable
# UTP Cabling

## Straight-through and Crossover UTP Cables

<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 T568B</td>
<td>Host to Network Device</td>
</tr>
<tr>
<td>Ethernet Crossover *</td>
<td>One end T568A, other end T568B</td>
<td>Host-to-Host, Switch-to-Switch, Router-to-Router</td>
</tr>
<tr>
<td>* Considered Legacy due to most NICs using Auto-MDIX to sense cable type and complete connection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rollover</td>
<td>Cisco Proprietary</td>
<td>Host serial port to Router or Switch Console Port, using an adapter</td>
</tr>
</tbody>
</table>

---

* Considered Legacy due to most NICs using Auto-MDIX to sense cable type and complete connection
4.5 Fiber-Optic Cabling
Fiber-Optic Cabling
Properties of Fiber-Optic Cabling

• Not as common as UTP because of the expense involved
• Ideal for some networking scenarios
• Transmits data over longer distances at higher bandwidth than any other networking media
• Less susceptible to attenuation, and completely immune to EMI/RFI
• Made of flexible, extremely thin strands of very pure glass
• Uses a laser or LED to encode bits as pulses of light
• The fiber-optic cable acts as a wave guide to transmit light between the two ends with minimal signal loss
Fiber-Optic Cabling
Types of Fiber Media

Single-Mode Fiber

- Very small core
- Uses expensive lasers
- Long-distance applications

Multimode Fiber

- Larger core
- Uses less expensive LEDs
- LEDs transmit at different angles
- Up to 10 Gbps over 550 meters

Dispersion refers to the spreading out of a light pulse over time. Increased dispersion means increased loss of signal strength. MMF has greater dispersion than SMF, with a the maximum cable distance for MMF is 550 meters.
Fiber-optic cabling is now being used in four types of industry:

1. **Enterprise Networks** - Used for backbone cabling applications and interconnecting infrastructure devices
2. **Fiber-to-the-Home (FTTH)** - Used to provide always-on broadband services to homes and small businesses
3. **Long-Haul Networks** - Used by service providers to connect countries and cities
4. **Submarine Cable Networks** - Used to provide reliable high-speed, high-capacity solutions capable of surviving in harsh undersea environments at up to transoceanic distances.

Our focus in this course is the use of fiber within the enterprise.
Fiber-Optic Cabling
Fiber-Optic Connectors

- Straight-Tip (ST) Connectors
- Lucent Connector (LC) Simplex Connectors
- Subscriber Connector (SC) Connectors
- Duplex Multimode LC Connectors
Fiber-Optic Cabling

Fiber Patch Cords

- SC-SC MM Patch Cord
- LC-LC SM Patch Cord
- ST-LC MM Patch Cord
- ST-SC SM Patch Cord

A yellow jacket is for single-mode fiber cables and orange (or aqua) for multimode fiber cables.
Optical fiber is primarily used as backbone cabling for high-traffic, point-to-point connections between data distribution facilities and for the interconnection of buildings in multi-building campuses.

<table>
<thead>
<tr>
<th>Implementation Issues</th>
<th>UTP Cabling</th>
<th>Fiber-Optic Cabling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth supported</td>
<td>10 Mb/s - 10 Gb/s</td>
<td>10 Mb/s - 100 Gb/s</td>
</tr>
<tr>
<td>Distance</td>
<td>Relatively short (1 - 100 meters)</td>
<td>Relatively long (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>
4.6 Wireless Media
Wireless Media
Properties of Wireless Media

It carries electromagnetic signals representing binary digits using radio or microwave frequencies. This provides the greatest mobility option. Wireless connection numbers continue to increase.

Some of the limitations of wireless:

- **Coverage area** - Effective coverage can be significantly impacted by the physical characteristics of the deployment location.

- **Interference** - Wireless is susceptible to interference and can be disrupted by many common devices.

- **Security** - Wireless communication coverage requires no access to a physical strand of media, so anyone can gain access to the transmission.

- **Shared medium** - WLANs operate in half-duplex, which means only one device can send or receive at a time. Many users accessing the WLAN simultaneously results in reduced bandwidth for each user.
Types of Wireless Media

The IEEE and telecommunications industry standards for wireless data communications cover both the data link and physical layers. In each of these standards, physical layer specifications dictate:

- Data to radio signal encoding methods
- Frequency and power of transmission
- Signal reception and decoding requirements
- Antenna design and construction

Wireless Standards:

- **Wi-Fi (IEEE 802.11)** - Wireless LAN (WLAN) technology
- **Bluetooth (IEEE 802.15)** - Wireless Personal Area network (WPAN) standard
- **WiMAX (IEEE 802.16)** - Uses a point-to-multipoint topology to provide broadband wireless access
- **Zigbee (IEEE 802.15.4)** - Low data-rate, low power-consumption communications, primarily for Internet of Things (IoT) applications
Wireless Media
Wireless LAN

In general, a Wireless LAN (WLAN) requires the following devices:

• **Wireless Access Point (AP)** - Concentrate wireless signals from users and connect to the existing copper-based network infrastructure

• **Wireless NIC Adapters** - Provide wireless communications capability to network hosts

There are a number of WLAN standards. When purchasing WLAN equipment, ensure compatibility, and interoperability.

Network Administrators must develop and apply stringent security policies and processes to protect WLANs from unauthorized access and damage.
Module Practice and Quiz

What did I learn in this module?

• Before any network communications can occur, a physical connection to a local network, either wired or wireless, must be established.
• The physical layer consists of electronic circuitry, media, and connectors developed by engineers.
• The physical layer standards address three functional areas: physical components, encoding, and signaling.
• Three types of copper cabling are: UTP, STP, and coaxial cable (coax).
• UTP cabling conforms to the standards established jointly by the TIA/EIA. The electrical characteristics of copper cabling are defined by the Institute of Electrical and Electronics Engineers (IEEE).
• The main cable types that are obtained by using specific wiring conventions are Ethernet Straight-through and Ethernet Crossover.
What did I learn in this module (Cont.)?

• Optical fiber cable transmits data over longer distances and at higher bandwidths than any other networking media.
• There are four types of fiber-optic connectors: ST, SC, LC, and duplex multimode LC.
• Fiber-optic patch cords include SC-SC multimode, LC-LC single-mode, ST-LC multimode, and SC-ST single-mode.
• Wireless media carry electromagnetic signals that represent the binary digits of data communications using radio or microwave frequencies. Wireless does have some limitations, including coverage area, interference, security, and the problems that occur with any shared medium.
• Wireless standards include the following: Wi-Fi (IEEE 802.11), Bluetooth (IEEE 802.15), WiMAX (IEEE 802.16), and Zigbee (IEEE 802.15.4).
• Wireless LAN (WLAN) requires a wireless AP and wireless NIC adapters.
Module 5: Number Systems

Introduction to Networks v7.0 (ITN)
5.1 Binary Number System
Binary Number System

Binary and IPv4 Addresses

• Binary numbering system consists of 1s and 0s, called bits
• Decimal numbering system consists of digits 0 through 9
• Hosts, servers, and network equipment using binary addressing to identify each other.
• Each address is made up of a string of 32 bits, divided into four sections called octets.
• Each octet contains 8 bits (or 1 byte) separated by a dot.
• For ease of use by people, this dotted notation is converted to dotted decimal.
The binary positional notation system operates as shown in the tables below.

<table>
<thead>
<tr>
<th>Radix</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position in Number</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Calculate</td>
<td>(2^7)</td>
<td>(2^6)</td>
<td>(2^5)</td>
<td>(2^4)</td>
<td>(2^3)</td>
<td>(2^2)</td>
<td>(2^1)</td>
</tr>
<tr>
<td>Position Value</td>
<td>128</td>
<td>64</td>
<td>32</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Positional Value</th>
<th>128</th>
<th>64</th>
<th>32</th>
<th>16</th>
<th>8</th>
<th>4</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary Number (11000000)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Calculate</td>
<td>1x128</td>
<td>1x64</td>
<td>0x32</td>
<td>0x16</td>
<td>0x8</td>
<td>0x4</td>
<td>0x2</td>
<td>0x1</td>
</tr>
<tr>
<td>Add Them Up…</td>
<td>128</td>
<td>+ 64</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>Result</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>192</td>
</tr>
</tbody>
</table>
### Binary Number System

#### Convert Binary to Decimal

Convert `11000000.10101000.00001011.00001010` to decimal.

<table>
<thead>
<tr>
<th>Positional Value</th>
<th>128</th>
<th>64</th>
<th>32</th>
<th>16</th>
<th>8</th>
<th>4</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary Number (11000000)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Calculate</td>
<td>1x128</td>
<td>1x64</td>
<td>0x32</td>
<td>0x16</td>
<td>0x8</td>
<td>0x4</td>
<td>0x2</td>
<td>0x1</td>
</tr>
<tr>
<td>Add Them Up…</td>
<td>128</td>
<td>+ 64</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>Binary Number (10101000)</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Calculate</td>
<td>1x128</td>
<td>0x64</td>
<td>1x32</td>
<td>0x16</td>
<td>1x8</td>
<td>0x4</td>
<td>0x2</td>
<td>0x1</td>
</tr>
<tr>
<td>Add Them Up…</td>
<td>128</td>
<td>+ 0</td>
<td>+ 32</td>
<td>+ 0</td>
<td>+ 8</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
</tr>
<tr>
<td>Binary Number (00001011)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Calculate</td>
<td>0x128</td>
<td>0x64</td>
<td>0x32</td>
<td>0x16</td>
<td>1x8</td>
<td>0x4</td>
<td>1x2</td>
<td>1x1</td>
</tr>
<tr>
<td>Add Them Up…</td>
<td>0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 8</td>
<td>+ 0</td>
<td>+ 2</td>
<td>+ 1</td>
</tr>
<tr>
<td>Binary Number (00001010)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Calculate</td>
<td>0x128</td>
<td>0x64</td>
<td>0x32</td>
<td>0x16</td>
<td>1x8</td>
<td>0x4</td>
<td>1x2</td>
<td>0x1</td>
</tr>
<tr>
<td>Add Them Up…</td>
<td>0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 0</td>
<td>+ 8</td>
<td>+ 0</td>
<td>+ 2</td>
<td>+ 0</td>
</tr>
</tbody>
</table>

192.168.11.10
Binary Number System
Decimal to Binary Conversion

The binary positional value table is useful in converting a dotted decimal IPv4 address to binary.

- Start in the 128 position (the most significant bit). Is the decimal number of the octet (n) equal to or greater than 128?
- If no, record a binary 0 in the 128 positional value and move to the 64 positional value.
- If yes, record a binary 1 in the 128 positional value, subtract 128 from the decimal number, and move to the 64 positional value.
- Repeat these steps through the 1 positional value.
Binary Number System

Decimal to Binary Conversion Example

• Convert decimal 168 to binary

  Is 168 > 128?
  - Yes, enter 1 in 128 position and subtract 128 (168-128=40)
  Is 40 > 64?
  - No, enter 0 in 64 position and move on
  Is 40 > 32?
  - Yes, enter 1 in 32 position and subtract 32 (40-32=8)
  Is 8 > 16?
  - No, enter 0 in 16 position and move on
  Is 8 > 8?
  - Equal. Enter 1 in 8 position and subtract 8 (8-8=0)
  No values left. Enter 0 in remaining binary positions

<table>
<thead>
<tr>
<th>128</th>
<th>64</th>
<th>32</th>
<th>16</th>
<th>8</th>
<th>4</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Decimal 168 is written as 10101000 in binary
Routers and computers only understand binary, while humans work in decimal. It is important for you to gain a thorough understanding of these two numbering systems and how they are used in networking.
5.2 Hexadecimal Number System
Hexadecimal and IPv6 Addresses

- To understand IPv6 addresses, you must be able to convert hexadecimal to decimal and vice versa.
- Hexadecimal is a base sixteen numbering system, using the digits 0 through 9 and letters A to F.
- It is easier to express a value as a single hexadecimal digit than as four binary bit.
- Hexadecimal is used to represent IPv6 addresses and MAC addresses.
IPv6 addresses are 128 bits in length. Every 4 bits is represented by a single hexadecimal digit. That makes the IPv6 address a total of 32 hexadecimal values.

The figure shows the preferred method of writing out an IPv6 address, with each X representing four hexadecimal values.

Each four hexadecimal character group is referred to as a hextet.
Hexadecimal Number System

Decimal to Hexadecimal Conversions

Follow the steps listed to convert decimal numbers to hexadecimal values:
• Convert the decimal number to 8-bit binary strings.
• Divide the binary strings in groups of four starting from the rightmost position.
• Convert each four binary numbers into their equivalent hexadecimal digit.

For example, 168 converted into hex using the three-step process.
• 168 in binary is 10101000.
• 10101000 in two groups of four binary digits is 1010 and 1000.
• 1010 is hex A and 1000 is hex 8, so 168 is A8 in hexadecimal.
Hexadecimal Number System
Hexadecimal to Decimal Conversions

Follow the steps listed to convert hexadecimal numbers to decimal values:
• Convert the hexadecimal number to 4-bit binary strings.
• Create 8-bit binary grouping starting from the rightmost position.
• Convert each 8-bit binary grouping into their equivalent decimal digit.

For example, D2 converted into decimal using the three-step process:
• D2 in 4-bit binary strings is 1101 and 0010.
• 1101 and 0010 is 11010010 in an 8-bit grouping.
• 11010010 in binary is equivalent to 210 in decimal, so D2 is 210 in decimal
5.3 Module Practice and Quiz
Module Practice and Quiz

What did I learn in this module?

- Binary is a base two numbering system that consists of the numbers 0 and 1, called bits.
- Decimal is a base ten numbering system that consists of the numbers 0 through 9.
- Binary is what hosts, servers, and networking equipment uses to identify each other.
- Hexadecimal is a base sixteen numbering system that consists of the numbers 0 through 9 and the letters A to F.
- Hexadecimal is used to represent IPv6 addresses and MAC addresses.
- IPv6 addresses are 128 bits long, and every 4 bits is represented by a hexadecimal digit for a total of 32 hexadecimal digits.
- To convert hexadecimal to decimal, you must first convert the hexadecimal to binary, then convert the binary to decimal.
- To convert decimal to hexadecimal, you must first convert the decimal to binary and then the binary to hexadecimal.