

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.0 Chapter Introduction

8.0.1 Chapter Introduction

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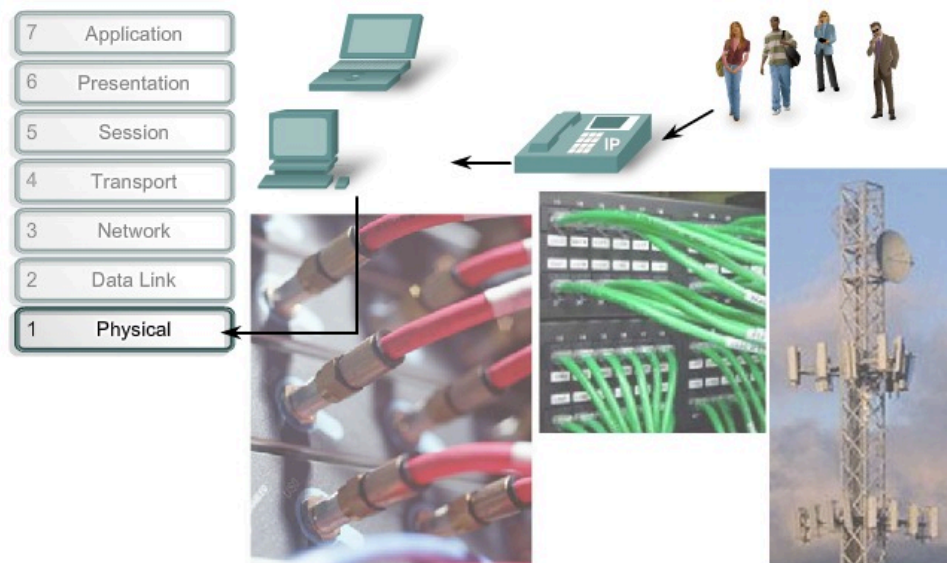
Upper OSI layer protocols prepare data from the human network for transmission to its destination. The Physical layer controls how data is transmitted on the communication media.

The role of the OSI Physical layer is to encode the binary digits that represent Data Link layer frames into signals and to transmit and receive these signals across the physical media - copper wires, optical fiber, and wireless - that connect network devices.

This chapter introduces the general functions of the Physical layer as well as the standards and protocols that manage the transmission of data across local media.

In this chapter, you will learn to:

- Explain the role of Physical layer protocols and services in supporting communication across data networks.
- Describe the purpose of Physical layer signaling and encoding as they are used in networks.
- Describe the role of signals used to represent bits as a frame is transported across the local media.
- Identify the basic characteristics of copper, fiber, and wireless network media.
- Describe common uses of copper, fiber, and wireless network media.



The Physical layer interconnects our data networks.

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8 OSI Physical Layer

8.1 The Physical Layer - Communication Signals

8.1.1 Physical Layer – Purpose

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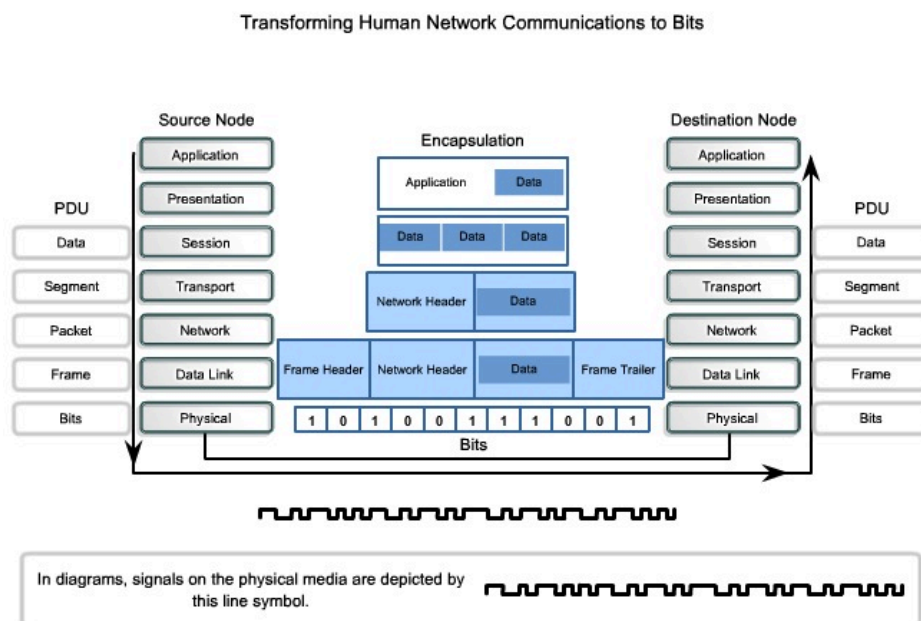
The OSI Physical layer provides the means to transport across the network media the bits that make up a Data Link layer frame. This layer accepts a complete frame from the Data Link layer and encodes it as a series of signals that are transmitted onto the local media. The encoded bits that comprise a frame are received by either an end device or an intermediate device.

The delivery of frames across the local media requires the following Physical layer elements:

- The physical media and associated connectors
- A representation of bits on the media
- Encoding of data and control information
- Transmitter and receiver circuitry on the network devices

At this stage of the communication process, the user data has been segmented by the Transport layer, placed into packets by the Network layer, and further encapsulated as frames by the Data Link layer. **The purpose of the Physical layer is to create the electrical, optical, or microwave signal that represents the bits in each frame.** These signals are then sent on the media one at a time.

It is also the job of the Physical layer to retrieve these individual signals from the media, restore them to their bit representations, and pass the bits up to the Data Link layer as a complete frame.



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8.1 The Physical Layer - Communication Signals

8.1.2 Physical Layer – Operation

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The media does not carry the frame as a single entity. The media carries signals, one at a time, to represent the bits that make up the frame.

There are three basic forms of network media on which data is represented:

- Copper cable
- Fiber
- Wireless

The representation of the bits - that is, the type of signal - depends on the type of media. For copper cable media, the signals are patterns of electrical pulses. For fiber, the signals are patterns of light. For wireless media, the signals are patterns of radio transmissions.

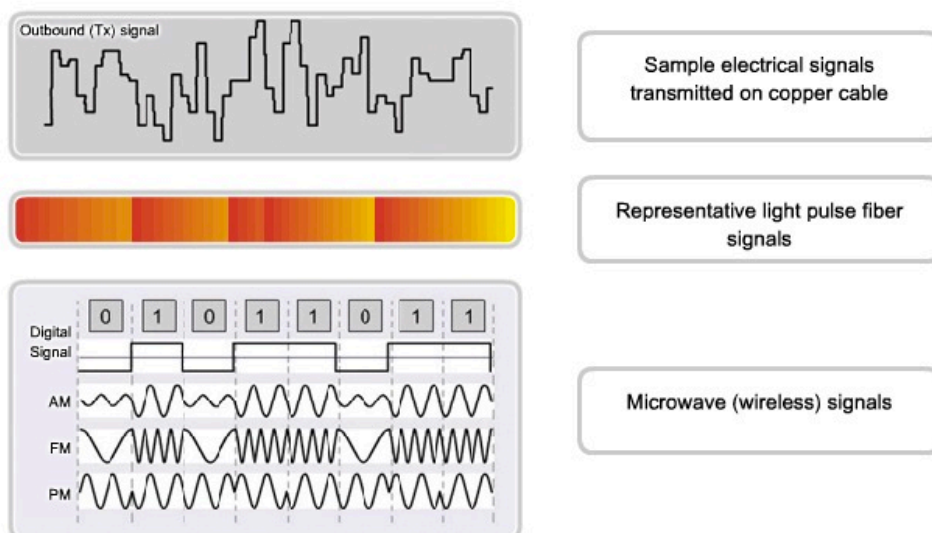
Identifying a Frame

When the Physical layer encodes the bits into the signals for a particular medium, it must also distinguish where one frame ends and the next frame begins. Otherwise, the devices on the media would not recognize when a frame has been fully received. In that case, the destination device would only receive a string of signals and would not be able to properly reconstruct the frame. As described in the previous chapter, indicating the beginning of frame is often a function of the Data Link layer. However, in many technologies, the Physical layer may add its own signals to indicate the beginning and end of the frame.

To enable a receiving device to clearly recognize a frame boundary, the transmitting device adds signals to designate the start and end of a frame. These signals represent particular bit patterns that are only used to denote the start or end of a frame.

The process of encoding a frame of data from the logical bits into the physical signals on the media, and the characteristics of particular physical media, are covered in detail in the following sections of this chapter.

Representations of Signals on the Physical Media



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8.1 The Physical Layer - Communication Signals

8.1.3 Physical Layer – Standards

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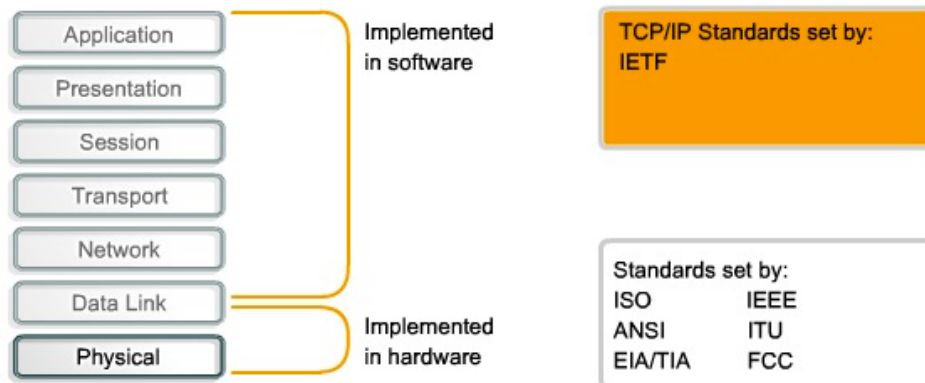
The Physical layer consists of hardware, developed by engineers, in the form of electronic circuitry, media, and connectors. Therefore, it is appropriate that the standards governing this hardware are defined by the relevant electrical and communications engineering organizations.

By comparison, the protocols and operations of the upper OSI layers are performed by software and are designed by software engineers and computer scientists. As we saw in a previous chapter, the services and protocols in the TCP/IP suite are defined by the Internet Engineering Task Force (IETF) in RFCs.

Similar to technologies associated with the Data Link layer, the Physical layer technologies are defined by organizations such as:

- The International Organization for Standardization (ISO)
- The Institute of Electrical and Electronics Engineers (IEEE)
- The American National Standards Institute (ANSI)
- The International Telecommunication Union (ITU)
- The Electronics Industry Alliance/Telecommunications Industry Association ([EIA/TIA](#))
- National telecommunications authorities such as the [Federal Communication Commission \(FCC\)](#) in the USA.

Comparison of Physical Layer Standards and Upper Layer Standards



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8.1.3 Physical Layer – Standards

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Physical Layer Technologies and Hardware

The technologies defined by these organizations include four areas of the Physical layer standards:

- Physical and electrical properties of the media
- Mechanical properties (materials, dimensions, [pinouts](#)) of the connectors
- Bit representation by the signals (encoding)
- Definition of control information signals

Click Signals, Connectors, and Cables in the figure to see the hardware.

Hardware components such as network adapters (NICs), interfaces and connectors, cable materials, and cable designs are all specified in standards associated with the Physical layer.

Standards for the Physical layer specify signal, connector, and cabling requirements.

SIGNALS

Click to learn more.

CONNECTORS

Click to learn more.

CABLES

Click to learn more.

Standards for the Physical layer specify signal, connector, and cabling requirements.

SIGNALS

CONNECTORS

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Standards for the Physical layer specify signal, connector, and cabling requirements.

SIGNALS

CONNECTORS

Click to learn more.

CABLES

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Standards allow different companies to make cables and NICs, knowing they will work together.

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8.1 The Physical Layer - Communication Signals

8.1.4 Physical layer Fundamental Principles

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The three fundamental functions of the Physical layer are:

- The physical components
- Data encoding
- Signaling

The physical elements are the electronic hardware devices, media and connectors that transmit and carry the signals to represent the bits.

Encoding

Encoding is a method of converting a stream of data bits into a predefined code. Codes are groupings of bits used to provide a predictable pattern that can be recognized by both the sender and the receiver. Using predictable patterns helps to distinguish data bits from control bits and provide better media error detection.

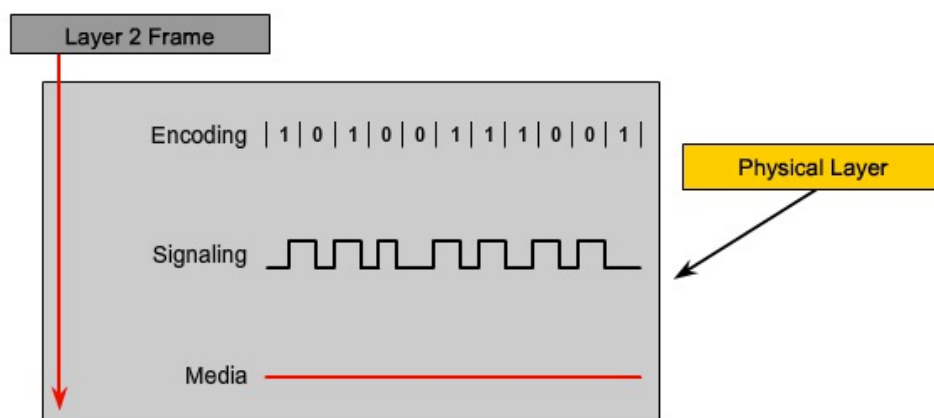
In addition to creating codes for data, encoding methods at the Physical layer may also provide codes for control purposes such as identifying the beginning and end of a frame. The transmitting host will transmit the specific pattern of bits or a code to identify the beginning and end of the frame.

Signaling

The Physical layer must generate the electrical, optical, or wireless signals that represent the "1" and "0" on the media. The method of representing the bits is called the signaling method. The Physical layer standards must define what type of signal represents a "1" and a "0". This can be as simple as a change in the level of an electrical signal or optical pulse or a more complex signaling method.

In the next sections, you will examine different methods of signaling and encoding.

Physical Layer Fundamental Principles



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8.2 Physical Signaling and Encoding: Representing Bits

8.2.1 Signaling Bits for the Media

Page 1:

Eventually, all communication from the human network becomes binary digits, which are transported individually across the physical media.

Although all the bits that make up a frame are presented to the Physical layer as a unit, the transmission of the frame across the media occurs as a stream of bits sent one at a time. The Physical layer represents each of the bits in the frame as a signal. Each signal placed onto the media has a specific amount of time to occupy the media. This is referred to as its *bit time*. Signals are processed by the receiving device and returned to its representation as bits.

At the Physical layer of the receiving node, the signals are converted back into bits. The bits are then examined for the start of frame and end of frame bit patterns to determine that a complete frame has been received. The Physical layer then delivers all the bits of a frame to the Data Link layer.

Successful delivery of the bits requires some method of synchronization between transmitter and receiver. The signals representing the bits must be examined at specific times during the bit time to properly determine if the signal represents a "1" or a "0". The synchronization is accomplished by the use of a clock. In LANs, each end of the transmission maintains its own clock. Many signaling methods use predictable transitions in the signal to provide synchronization between the clocks of the transmitting and the receiving devices.

Signaling Methods

Bits are represented on the medium by changing one or more of the following characteristics of a signal:

- Amplitude
- Frequency
- Phase

The nature of the actual signals representing the bits on the media will depend on the signaling method in use. Some methods may use one attribute of signal to represent a single **0** and use another attribute of signal to represent a single **1**.

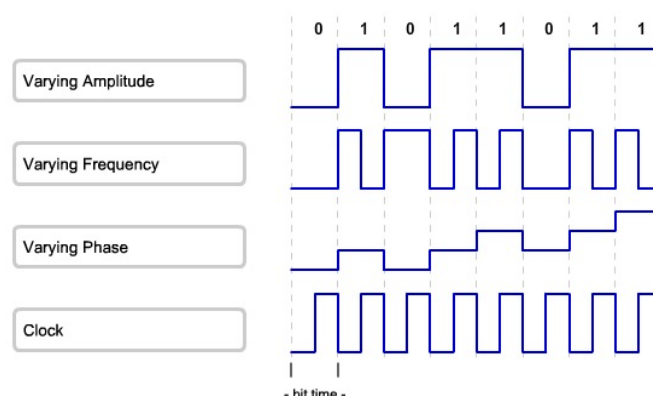
As an example, with Non-Return to Zero (NRZ), a **0** may be represented by one voltage level on the media during the bit time and a **1** might be represented by a different voltage level on the media during the bit time.

There are also methods of signaling that use transitions, or the absence of transitions, to indicate a logic level. For example, Manchester Encoding indicates a **0** by a high to low voltage transition in the middle of the bit time. For a **1** there is a low to high voltage transition in the middle of the bit time.

The signaling method used must be compatible with a standard so that the receiver can detect the signals and decode them. The standard contains an agreement between the transmitter and the receiver on how to represent 1s and 0s. If there is no signaling agreement - that is, if different standards are used at each end of the transmission - communication across the physical medium will fail.

Signaling methods to represent bits on the media can be complex. We will look at two of the simpler techniques to illustrate the concept.

Ways to Represent a Signal on the Medium



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8.2.1 Signaling Bits for the Media

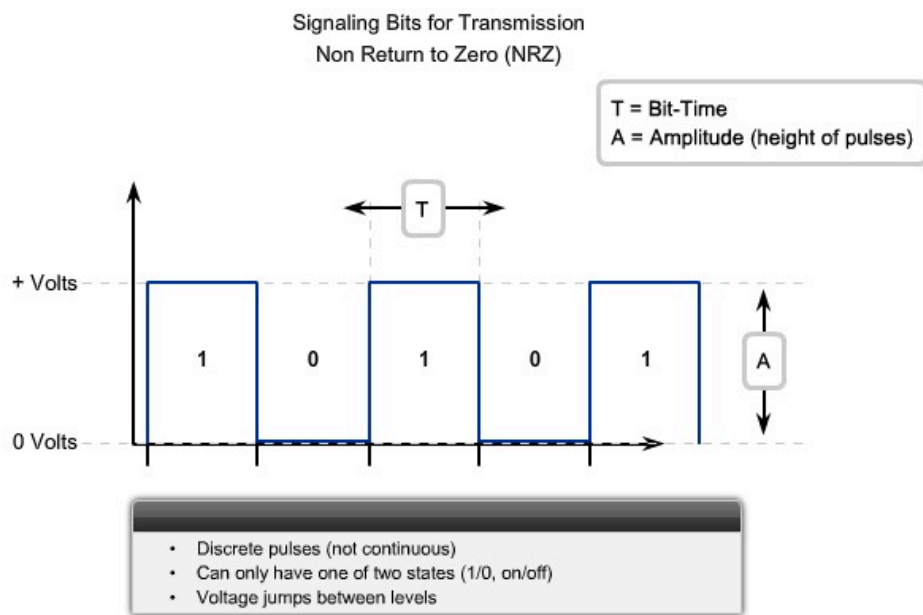
Page 2:

NRZ Signaling

As a first example, we will examine a simple signaling method, Non Return to Zero (NRZ). In NRZ, the bit stream is transmitted as a series of voltage values, as shown in the figure.

A low voltage value represents a logical **0** and a high voltage value represents a logical **1**. The voltage range depends on the particular Physical layer standard in use.

This simple method of signaling is only suited for slow speed data links. NRZ signaling uses bandwidth inefficiently and is susceptible to electromagnetic interference. Additionally, the boundaries between individual bits can be lost when long strings of 1s or 0s are transmitted consecutively. In that case, no voltage transitions are detectable on the media. Therefore, the receiving nodes do not have a transition to use in resynchronizing bit times with the transmitting node.



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8.2 Physical Signaling and Encoding: Representing Bits

8.2.1 Signaling Bits for the Media

Page 3: Manchester Encoding

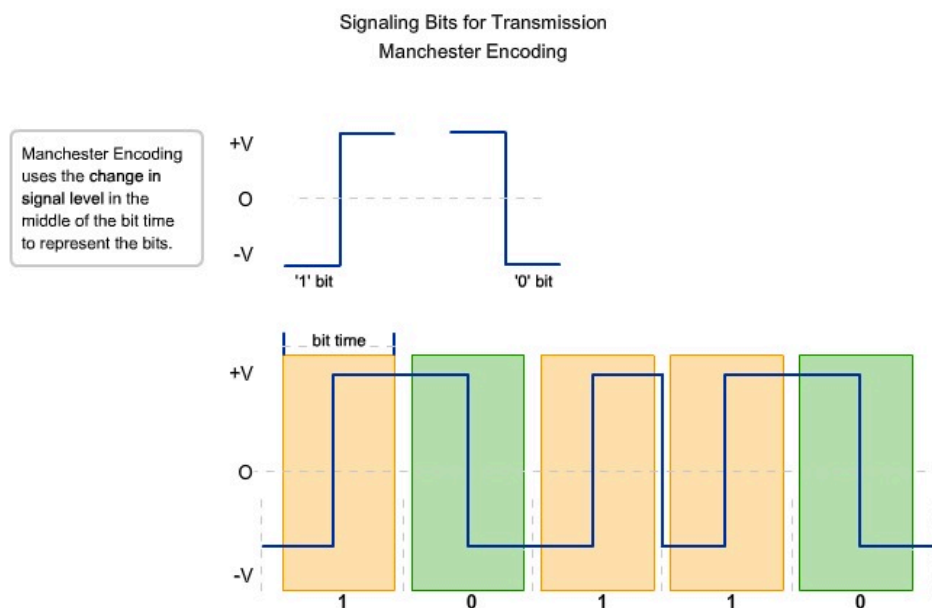
Instead of representing bits as pulses of simple voltage values, in the Manchester Encoding scheme, bit values are represented as voltage transitions.

For example, a transition from a low voltage to a high voltage represents a bit value of 1. A transition from a high voltage to a low voltage represents a bit value of 0.

As shown in the figure, one voltage transition must occur in the middle of each bit time. This transition can be used to ensure that the bit times in the receiving nodes are synchronized with the transmitting node.

The transition in the middle of the bit time will be either the up or down direction for each unit of time in which a bit is transmitted. For consecutive bit values, a transition on the bit boundary "sets up" the appropriate mid-bit time transition that represents the bit value.

Although Manchester Encoding is not efficient enough to be used at higher signaling speeds, it is the signaling method employed by 10BaseT Ethernet (Ethernet running at 10 Megabits per second).



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8.2 Physical Signaling and Encoding: Representing Bits

8.2.2 Encoding - Grouping Bits

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In the prior section, we describe the signaling process as how bits are represented on physical media. In this section, we use the word encoding to represent the symbolic grouping of bits prior to being presented to the media. By using an encoding step before the signals are placed on the media, we improve the efficiency at higher speed data transmission.

As we use higher speeds on the media, we have the possibility that data will be corrupted. By using the coding groups, we can detect errors more efficiently. Additionally, as the demand for data speeds increase, we seek ways to represent more data across the media, by transmitting fewer bits. Coding groups provide a method of making this data representation.

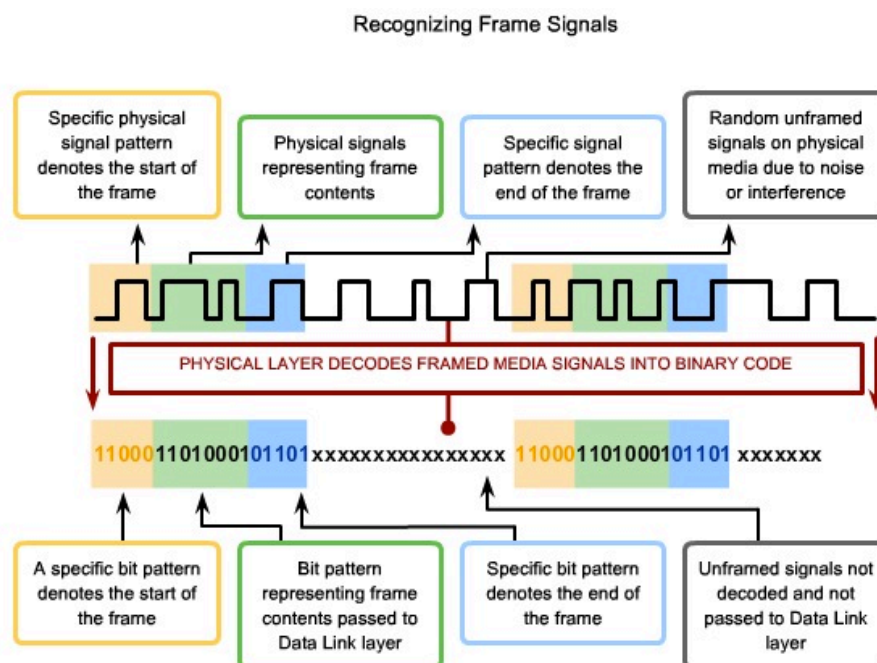
The Physical layer of a network device needs to be able to detect legitimate data signals and ignore random non-data signals that may also be on the physical medium. The stream of signals being transmitted needs to start in such a way that the receiver recognizes the beginning and end of the frame.

Signal Patterns

One way to provide frame detection is to begin each frame with a pattern of signals representing bits that the Physical layer recognizes as denoting the start of a frame. Another pattern of bits will signal the end of the frame. Signal bits not framed in this manner are ignored by the Physical layer standard being used.

Valid data bits need to be grouped into a frame; otherwise, data bits will be received without any context to give them meaning to the upper layers of the networking model. This framing method can be provided by the Data Link layer, the Physical layer, or by both.

The figure depicts some of the purposes of signaling patterns. Signal patterns can indicate: start of frame, end of frame, and frame contents. These signal patterns can be decoded into bits. The bits are interpreted as codes. The codes indicate where the frames start and stop.



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8.2 Physical Signaling and Encoding: Representing Bits

8.2.2 Encoding - Grouping Bits

Page 2: Code Groups

Encoding techniques use bit patterns called symbols. The Physical layer may use a set of encoded symbols - called [code groups](#) - to represent encoded data or control information. **A code group is a consecutive sequence of code bits that are interpreted and mapped as data bit patterns.** For example, code bits 10101 could represent the data bits 0011.

As shown in the figure, code groups are often used as an intermediary encoding technique for higher speed LAN technologies. This step occurs at the Physical layer prior to the generation of signals of voltages, light pulses, or radio frequencies. By transmitting symbols, the error detection capabilities and timing synchronization between transmitting and receiving devices are enhanced. These are important considerations in supporting high speed transmission over the media.

Although using code groups introduces overhead in the form of extra bits to transmit, they improve the robustness of a communications link. This is particularly true for higher speed data transmission.

Advantages using code groups include:

- Reducing bit level error
- Limiting the effective energy transmitted into the media
- Helping to distinguish data bits from control bits
- Better media error detection

Reducing Bit Level Errors

To properly detect an individual bit as a **0** or as a **1**, the receiver must know how and when to sample the signal on the media. This requires that the timing between the receiver and transmitter be synchronized. In many Physical layer technologies, transitions on the media are used for this synchronization. If the bit patterns being transmitted on the media do not create frequent transitions, this synchronization may be lost and individual bit error can occur. Code groups are designed so that the symbols force an ample number of bit transitions to occur on the media to synchronize this timing. They do this by using symbols to ensure that not too many **1s** or **0s** are used in a row.

Limiting Energy Transmitted

In many code groups, the symbols ensure that the number of **1s** and **0s** in a string of symbols are evenly balanced. The process of balancing the number of 1s and 0s transmitted is called DC balancing. This prevents excessive amounts of energy from being injected into the media during transmission, thereby reducing the interference radiated from the media. In many media signaling methods, a logic level, for example a **1**, is represented by the presence of energy being sent into the media while the opposite logic level, a **0**, is represented as the absence of this energy. Transmitting a long series of 1s could overheat the transmitting laser and the photo diodes in the receiver, potentially causing higher error rates.

Distinguish Data from Control

The code groups have three types of symbols:

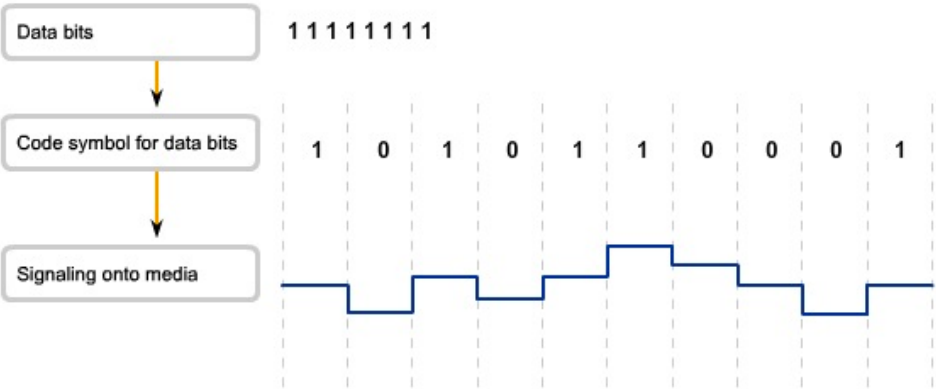
- Data symbols - Symbols that represent the data of the frame as it is passed down to the Physical layer.
- Control symbols - Special codes injected by the Physical layer used to control transmission. These include end-of-frame and idle media symbols.
- Invalid symbols - Symbols that have patterns not allowed on the media. The receipt of an invalid symbol indicates a frame error.

The symbols encoded onto the media are all unique. The symbols representing the data being sent through the network have different bit patterns than the symbols used for control. These differences allow the Physical layer in the receiving node to immediately distinguish data from control information.

Better Media Error Detection

In addition to the data symbols and control symbols, code groups contain invalid symbols. These are the symbols that could create long series of 1s or 0s on the media; therefore, they are not used by the transmitting node. If a receiving node receives one of these patterns, the Physical layer can determine that there has been an error in data reception.

Code Groups



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8.2 Physical Signaling and Encoding: Representing Bits

8.2.2 Encoding - Grouping Bits

Page 3: 4B/5B

An example, we will examine a simple code group called 4B/5B. Code groups that are currently used in modern networks are generally more complex.

In this technique, 4 bits of data are turned into 5-bit code symbols for transmission over the media system. In 4B/5B, each byte to be transmitted is broken into four-bit pieces or *nibbles* and encoded as five-bit values known as symbols. These symbols represent the data to be transmitted as well as a set of codes that help control transmission on the media. Among the codes are symbols that indicate the beginning and end of the frame transmission. Although this process adds overhead to the bit transmissions, it also adds features that aid in the transmission of data at higher speeds.

4B/5B ensures that there is at least one level change per code to provide synchronization. Most of the codes used in 4B/5B balance the number of 1s and 0s used in each symbol.

As shown in the figure, 16 of the possible 32 combinations of code groups are allocated for data bits, and the remaining code groups are used for control symbols and invalid symbols. Six of the symbols are used for special functions identifying the transition from idle to frame data and end of stream delimiter. The remaining 10 symbols indicate invalid codes.

4B/5B Code Symbols

| Data Codes | | Control and Invalid Codes | |
|------------|-----------|---------------------------|-----------|
| 4B Code | 5B Symbol | 4B Code | 5B Symbol |
| 0000 | 11110 | idle | 11111 |
| 0001 | 01001 | start of stream | 11000 |
| 0010 | 10100 | start of stream | 10001 |
| 0011 | 10101 | end of stream | 01101 |
| 0100 | 01010 | end of stream | 00111 |
| 0101 | 01011 | transmit error | 00100 |
| 0110 | 01110 | invalid | 00000 |
| 0111 | 01111 | invalid | 00001 |
| 1000 | 10010 | invalid | 00010 |
| 1001 | 10011 | invalid | 00011 |
| 1010 | 10110 | invalid | 00100 |
| 1011 | 10111 | invalid | 00101 |
| 1100 | 11010 | invalid | 00110 |
| 1101 | 11011 | invalid | 01000 |
| 1110 | 11100 | invalid | 10000 |
| 1111 | 11101 | invalid | 11001 |

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8.2 Physical Signaling and Encoding: Representing Bits

8.2.3 Data Carrying Capacity

Page 1:

Different physical media support the transfer of bits at different speeds. Data transfer can be measured in three ways:

- Bandwidth
- Throughput
- Goodput

Bandwidth

The capacity of a medium to carry data is described as the raw data **bandwidth** of the media. **Digital bandwidth measures the amount of information that can flow from one place to another in a given amount of time.**

Bandwidth is typically measured in kilobits per second (kbps) or megabits per second (Mbps).

The practical bandwidth of a network is determined by a combination of factors: the properties of the physical media and the technologies chosen for signaling and detecting network signals.

Physical media properties, current technologies, and the laws of physics all play a role in determining available bandwidth.

The figure shows the commonly used units of bandwidth.

Units of Bandwidth, Throughput, and Goodput

| Unit of Bandwidth | Abbreviation | Equivalence |
|---------------------|--------------|--|
| Bits per second | bps | 1 bps = fundamental unit of bandwidth |
| Kilobits per second | kbps | 1 kbps = 1,000 bps = 10^3 bps |
| Megabits per second | Mbps | 1 Mbps = 1,000,000 bps = 10^6 bps |
| Gigabits per second | Gbps | 1 Gbps = 1,000,000,000 bps = 10^9 bps |
| Terabits per second | Tbps | 1 Tbps = 1,000,000,000,000 bps = 10^{12} bps |

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8.2 Physical Signaling and Encoding: Representing Bits

8.2.3 Data Carrying Capacity

Page 2: Throughput

Throughput is the measure of the transfer of bits across the media over a given period of time. Due to a number of factors, throughput usually does not match the specified bandwidth in Physical layer implementations such as Ethernet.

Many factors influence throughput. Among these factors are the amount of traffic, the type of traffic, and the number of network devices encountered on the network being measured. In a multi-access topology such as Ethernet, nodes are competing for media access and its use. Therefore, the throughput of each node is degraded as usage of the media increases.

In an internetwork or network with multiple segments, throughput cannot be faster than the slowest link of the path from source to destination. Even if all or most of the segments have high bandwidth, it will only take one segment in the path with low throughput to create a bottleneck to the throughput of the entire network.

Goodput

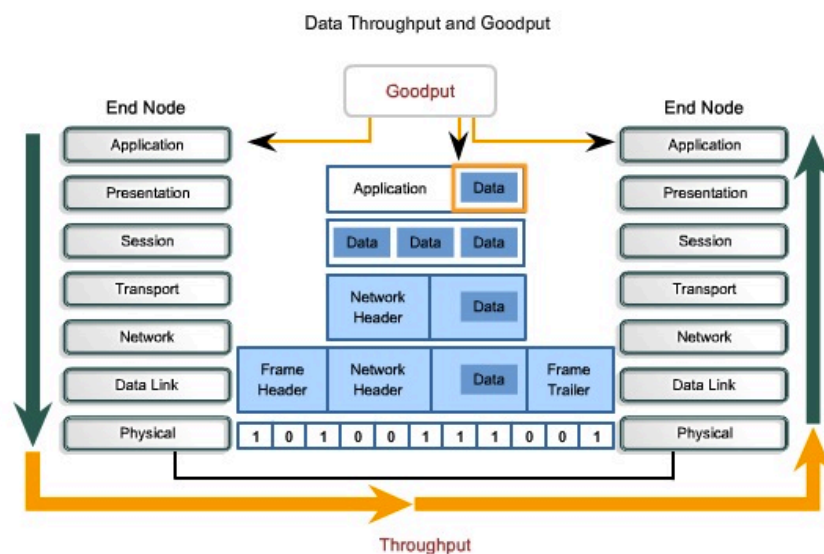
A third measurement has been created to measure the transfer of usable data. That measure is known as [goodput](#).

Goodput is the measure of usable data transferred over a given period of time, and is therefore the measure that is of most interest to network users.

As shown in the figure, goodput measures the effective transfer of user data between Application layer entities, such as between a source web server process and a destination web browser device.

Unlike throughput, which measures the transfer of bits and not the transfer of usable data, goodput accounts for bits devoted to protocol overhead. Goodput is throughput minus traffic overhead for establishing sessions, acknowledgements, and encapsulation.

As an example, consider two hosts on a LAN transferring a file. The bandwidth of the LAN is 100 Mbps. Due to the sharing and media overhead the throughput between the computers is only 60 Mbps. With the overhead of the encapsulation process of the TCP/IP stack, the actual rate of the data received by the destination computer, goodput, is only 40Mbps.



Data **throughput** is actual network performance. **Goodput** is a measure of the transfer of usable data after protocol overhead traffic has been removed.

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8.3 Physical Media - Connecting Communication

8.3.1 Types of Physical Media

Page 1:

The Physical layer is concerned with network media and signaling. This layer produces the representation and groupings of bits as voltages, radio frequencies, or light pulses. Various standards organizations have contributed to the definition of the physical, electrical, and mechanical properties of the media available for different data communications. These specifications guarantee that cables and connectors will function as anticipated with different Data Link layer implementations.

As an example, standards for copper media are defined for the:

- Type of copper cabling used
- Bandwidth of the communication
- Type of connectors used
- Pinout and color codes of connections to the media
- Maximum distance of the media

The figure shows some of the characteristics of networking media.

This section will also describe some of the important characteristics of commonly used copper, optical, and wireless media.

Physical Media - Characteristics

| Ethernet Media | | | | | | | | | |
|------------------------|--|-----------------------------------|----------------------------|------------------|--|--|--|----------------------|----------------------|
| | 10BASE-T | 100BASE-TX | 100BASE-FX | 1000BASE-CX | 1000BASE-T | 1000BASE-SX | 1000BASE-LX | 1000BASE-ZX | 10GBASE-ZR |
| Media | EIA/TIA Category 3, 4, 5 UTP - four pair | EIA/TIA Category 5 UTP - two pair | 50/62.5 m multi mode fiber | STP | EIA/TIA Category 5 (or greater) UTP, four pair | 50/62.5 micron multimode fiber | 50/62.5 micron multimode fiber or 9 micron single mode fiber | 9m single mode fiber | 9m single mode fiber |
| Maximum Segment Length | 100m (328 feet) | 100m (328 feet) | 2 km (6562 ft) | 25 m (82 feet) | 100 m (328 feet) | Up to 550 m (1,804 ft) depending on fiber used | 550 m (MMF) 10 km (SMF) | Approx. 70 km | Up to 80 km |
| Topology | Star | Star | Star | Star | Star | Star | Star | Star | Star |
| Connector | ISO 8877 (RJ-45) | ISO 8877 (RJ-45) | | ISO 8877 (RJ-45) | | | | | |

Ethernet

Wireless

Click to see media characteristics.

Physical Media - Characteristics

| Wireless Media | | | | |
|----------------|-------------------------------|---------------------------------|-------------------------|--------------------------------------|
| Standards | Bluetooth 802.15 | 802.11 (a, b, g, n), HiperLAN 2 | 802, 11, MMDS, LMDS | GSM, GPRS, CDMA, 2.5- 3G |
| Speed | <1 Mbps | 1 - 54+ Mbps | 22 Mbps+ | 10- 384 Kbps |
| Range | Short | Medium | Medium - long | Long |
| Applications | Peer-to-peer device-to-device | Enterprise networks | Fixed, last mile access | PDAs, Mobile phones, Cellular access |

Ethernet

Wireless

Click to see media characteristics.

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8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.2 Copper Media

Page 1:

The most commonly used media for data communications is cabling that uses copper wires to signal data and control bits between network devices. Cabling used for data communications usually consists of a series of individual copper wires that form circuits dedicated to specific signaling purposes.

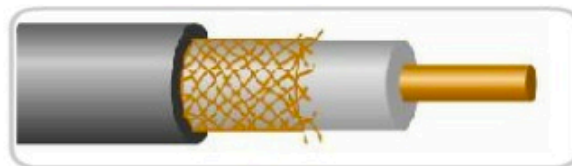
Other types of copper cabling, known as coaxial cable, have a single conductor that runs through the center of the cable that is encased by, but insulated from, the other shield. The copper media type chosen is specified by the Physical layer standard required to link the Data Link layers of two or more network devices.

These cables can be used to connect nodes on a LAN to intermediate devices, such as routers and switches. Cables are also used to connect WAN devices to a data services provider such as a telephone company. Each type of connection and the accompanying devices have cabling requirements stipulated by Physical layer standards.

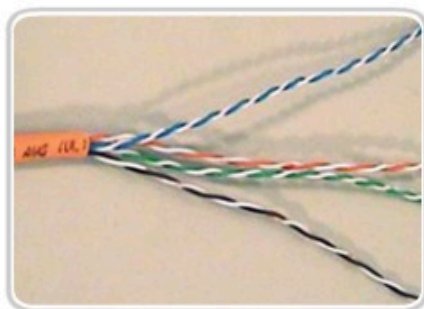
Networking media generally make use of modular jacks and plugs, which provide easy connection and disconnection. Also, a single type of physical connector may be used for multiple types of connections. For example, the RJ-45 connector is used widely in LANs with one type of media and in some WANs with another media type.

The figure shows some commonly used copper media and connectors.

Copper Media



Coaxial cable



Unshielded twisted-pair cable



RJ-45 connections

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8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.2 Copper Media

Page 2:

External Signal Interference

Data is transmitted on copper cables as electrical pulses. A detector in the network interface of a destination device must receive a signal that can be successfully decoded to match the signal sent.

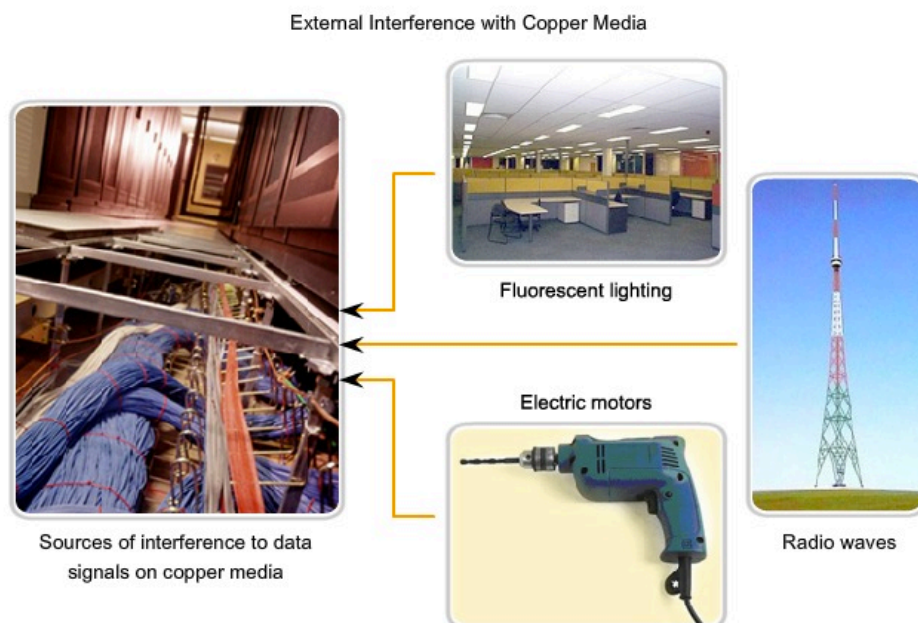
The timing and voltage values of these signals are susceptible to interference or "noise" from outside the communications system. These unwanted signals can distort and corrupt the data signals being carried by copper media. Radio waves and electromagnetic devices such as fluorescent lights, electric motors, and other devices are potential sources of noise.

Cable types with shielding or twisting of the pairs of wires are designed to minimize signal degradation due to electronic noise.

The susceptibility of copper cables to electronic noise can also be limited by:

- Selecting the cable type or category most suited to protect the data signals in a given networking environment
- Designing a cable infrastructure to avoid known and potential sources of interference in the building structure
- Using cabling techniques that include the proper handling and termination of the cables

The figure shows some sources of interference.



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.3 Unshielded Twisted Pair (UTP) Cable

Page 1:

Unshielded twisted-pair (UTP) cabling, as it is used in Ethernet LANs, consists of four pairs of color-coded wires that have been twisted together and then encased in a flexible plastic sheath. As seen in the figure, the color codes identify the individual pairs and wires in the pairs and aid in cable termination.

The twisting has the effect of canceling unwanted signals. When two wires in an electrical circuit are placed close together, external electromagnetic fields create the same interference in each wire. The pairs are twisted to keep the wires in as close proximity as is physically possible. When this common interference is present on the wires in a twisted pair, the receiver processes it in equal yet opposite ways. As a result, the signals caused by electromagnetic interference from external sources are effectively cancelled.

This cancellation effect also helps avoid interference from internal sources called [crosstalk](#). Crosstalk is the interference caused by the magnetic field around the adjacent pairs of wires in the cable. When electrical current flows through a wire, it creates a circular magnetic field around the wire. With the current flowing in opposite directions in the two wires in a pair, the magnetic fields - as equal but opposite forces - have a cancellation effect on each other. Additionally, the different pairs of wires that are twisted in the cable use a different number of twists per meter to help protect the cable from crosstalk between pairs.

UTP Cabling Standards

The UTP cabling commonly found in workplaces, schools, and homes conforms to the standards established jointly by the Telecommunications Industry Association (TIA) and the Electronics Industries Alliance (EIA). TIA/EIA-568A stipulates the commercial cabling standards for LAN installations and is the standard most commonly used in LAN cabling environments. Some of the elements defined are:

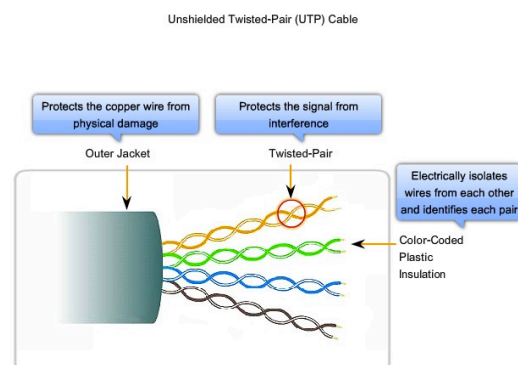
- Cable types
- Cable lengths
- Connectors
- Cable termination
- Methods of testing cable

The electrical characteristics of copper cabling are defined by the Institute of Electrical and Electronics Engineers (IEEE). IEEE rates UTP cabling according to its performance. Cables are placed into categories according to their ability to carry higher bandwidth rates. For example, Category 5 (Cat5) cable is used commonly in 100BASE-TX FastEthernet installations. Other categories include Enhanced Category 5 (Cat5e) cable and Category 6 (Cat6).

Cables in higher categories are designed and constructed to support higher data rates. As new gigabit speed Ethernet technologies are being developed and adopted, Cat5e is now the minimally acceptable cable type, with Cat6 being the recommended type for new building installations.

Some people connect to data network using existing telephone systems. Often the cabling in these systems are some form of UTP that are lower grade than the current Cat5+ standards.

Installing less expensive but lower rated cabling is potentially wasteful and shortsighted. If the decision is later made to adopt a faster LAN technology, total replacement of the installed cable infrastructure may be required.



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.3 Unshielded Twisted Pair (UTP) Cable

Page 2:

UTP Cable Types

UTP cabling, terminated with RJ-45 connectors, is a common copper-based medium for interconnecting network devices, such as computers, with intermediate devices, such as routers and network switches.

Different situations may require UTP cables to be wired according to different wiring conventions. This means that the individual wires in the cable have to be connected in different orders to different sets of pins in the RJ-45 connectors. The following are main cable types that are obtained by using specific wiring conventions:

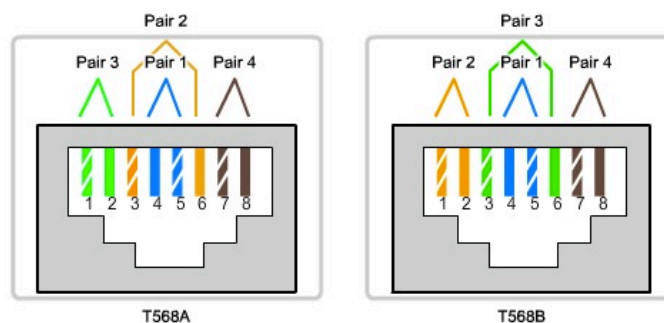
- Ethernet Straight-through
- Ethernet Crossover
- Rollover

The figure shows the typical application of these cables as well as a comparison of these three cable types.

Using a crossover or straight-through cable incorrectly between devices may not damage the devices, but connectivity and communication between the devices will not take place. This is a common error in the lab and checking that the device connections are correct should be the first troubleshooting action if connectivity is not achieved.

Straight-through, Crossover, and Rollover Cable Types

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



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.4 Other Copper Cable

Page 1:

Two other types of copper cable are used:

1. Coaxial
2. Shielded Twisted-Pair (STP)

Coaxial Cable

Coaxial cable consists of a copper conductor surrounded by a layer of flexible insulation, as shown in the figure.

Over this insulating material is a woven copper braid, or metallic foil, that acts as the second wire in the circuit and as a shield for the inner conductor. This second layer, or shield, also reduces the amount of outside electromagnetic interference. Covering the shield is the cable jacket.

All the elements of the coaxial cable encircle the center conductor. Because they all share the same axis, this construction is called coaxial, or coax for short.

Uses of Coaxial Cable

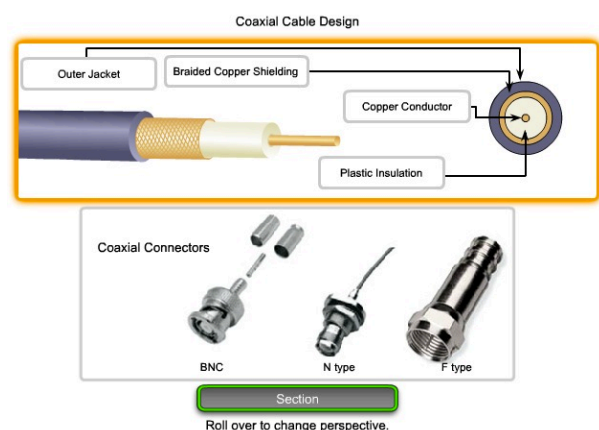
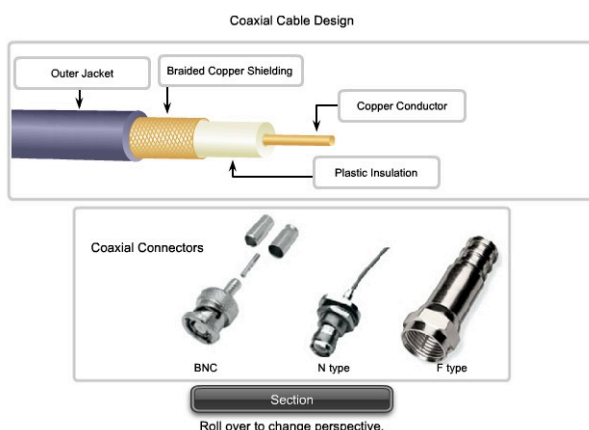
The coaxial cable design has been adapted for different purposes. Coax is an important type of cable that is used in wireless and cable access technologies. Coax cables are used to attach antennas to wireless devices. The coaxial cable carries radio frequency (RF) energy between the antennas and the radio equipment.

Coax is also the most widely used media for transporting high radio frequency signals over wire, especially cable television signals. Traditional cable television, exclusively transmitting in one direction, was composed completely of coax cable.

Cable service providers are currently converting their one-way systems to two-way systems to provide Internet connectivity to their customers. To provide these services, portions of the coaxial cable and supporting amplification elements are replaced with multi-fiber-optic cable. However, the final connection to the customer's location and the wiring inside the customer's premises is still coax cable. This combined use of fiber and coax is referred to as [hybrid fiber coax \(HFC\)](#).

In the past, coaxial cable was used in Ethernet installations. Today UTP offers lower costs and higher bandwidth than coaxial and has replaced it as the standard for all Ethernet installations.

There are different types of connectors used with coax cable. The figure shows some of these connector types.



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.4 Other Copper Cable

Page 2:

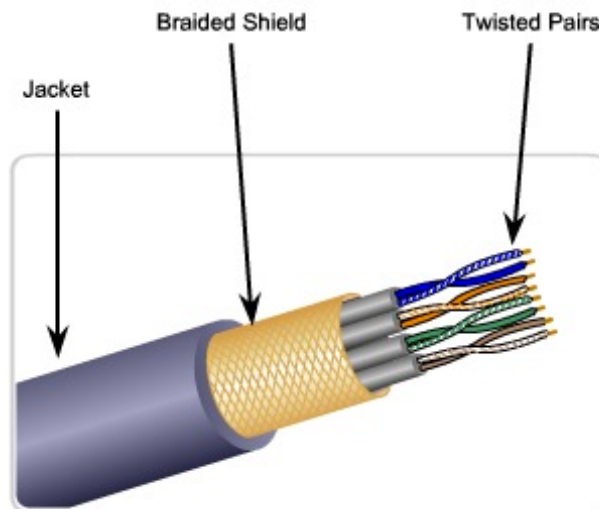
Shielded Twisted-Pair (STP) Cable

Another type of cabling used in networking is shielded twisted-pair (STP). As shown in the figure, STP uses four pairs of wires that are wrapped in an overall metallic braid or foil.

STP cable shields the entire bundle of wires within the cable as well as the individual wire pairs. STP provides better noise protection than UTP cabling, however at a significantly higher price.

For many years, STP was the cabling structure specified for use in Token Ring network installations. With the use of Token Ring declining, the demand for shielded twisted-pair cabling has also waned. The new 10 GB standard for Ethernet has a provision for the use of STP cabling. This may provide a renewed interest in shielded twisted-pair cabling.

Shielded Twisted-Pair (STP) Cable



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8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.5 Copper Media Safety

Page 1:

Electrical Hazards

A potential problem with copper media is that the copper wires could conduct electricity in undesirable ways. This could subject personnel and equipment to a range of electrical hazards.

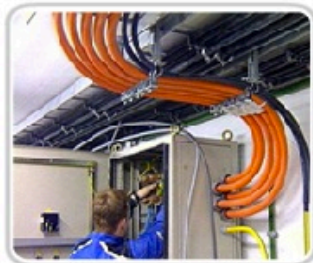
A defective network device could conduct currents to the chassis of other network devices. Additionally, network cabling could present undesirable voltage levels when used to connect devices that have power sources with different ground potentials. Such situations are possible when copper cabling is used to connect networks in different buildings or on different floors of buildings that use different power facilities. Finally, copper cabling may conduct voltages caused by lightning strikes to network devices.

The result of undesirable voltages and currents can include damage to network devices and connected computers, or injury to personnel. It is important that copper cabling be installed appropriately, and according to the relevant specifications and building codes, in order to avoid potentially dangerous and damaging situations.

Fire Hazards

Cable insulation and sheaths may be flammable or produce toxic fumes when heated or burned. Building authorities or organizations may stipulate related safety standards for cabling and hardware installations.

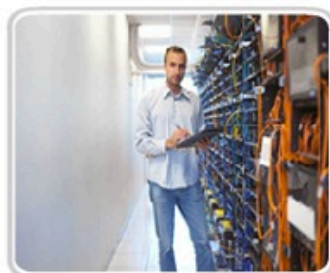
Copper Media Safety



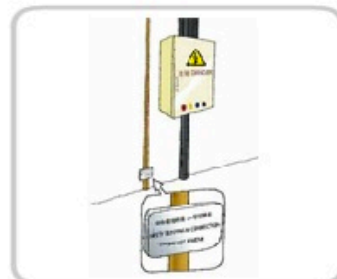
The separation of data and electrical power cabling must comply with safety codes.



Cables must be connected correctly.



Installations must be inspected for damage.



Equipment must be grounded correctly.

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.6 Fiber Media

Page 1:

Fiber-optic cabling uses either glass or plastic fibers to guide light impulses from source to destination. The bits are encoded on the fiber as light impulses. Optical fiber cabling is capable of very large raw data bandwidth rates. Most current transmission standards have yet to approach the potential bandwidth of this media.

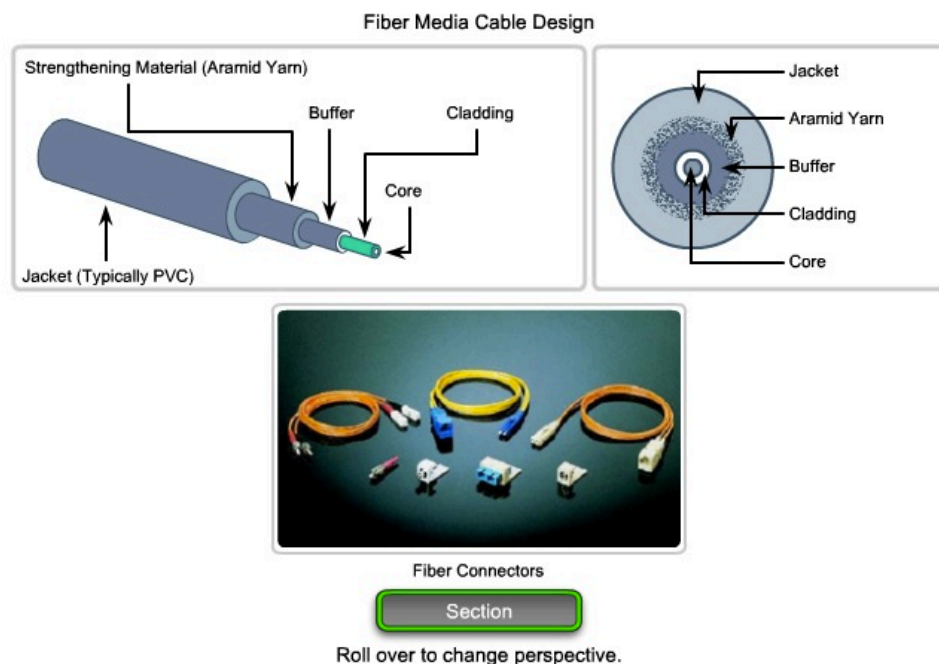
Fiber Compared to Copper Cabling

Given that the fibers used in fiber-optic media are not electrical conductors, the media is immune to electromagnetic interference and will not conduct unwanted electrical currents due to grounding issues. Because optical fibers are thin and have relatively low signal loss, they can be operated at much greater lengths than copper media, without the need for signal regeneration. Some optical fiber Physical layer specifications allow lengths that can reach multiple kilometers.

Optical fiber media implementation issues include:

- More expensive (usually) than copper media over the same distance (but for a higher capacity)
- Different skills and equipment required to terminate and splice the cable infrastructure
- More careful handling than copper media

At present, in most enterprise environments, 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. Because optical fiber does not conduct electricity and has low signal loss, it is well suited for these uses.



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8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.6 Fiber Media

Page 2:

Cable Construction

Optical fiber cables consist of a PVC jacket and a series of strengthening materials that surround the optical fiber and its cladding. The cladding surrounds the actual glass or plastic fiber and is designed to prevent light loss from the fiber. Because light can only travel in one direction over optical fiber, two fibers are required to support full duplex operation. Fiber-optic patch cables bundle together two optical fiber cables and terminate them with a pair of standard single fiber connectors. Some fiber connectors accept both the transmitting and receiving fibers in a single connector.

Fiber Media Cable Design

Fiber provides full duplex communications with a cable dedicated to each direction.



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.6 Fiber Media

Page 3:

Generating and Detecting the Optical Signal

Either lasers or light emitting diodes (LEDs) generate the light pulses that are used to represent the transmitted data as bits on the media. Electronic semi-conductor devices called photodiodes detect the light pulses and convert them to voltages that can then be reconstructed into data frames.

Note: The laser light transmitted over fiber-optic cabling can damage the human eye. Care must be taken to avoid looking into the end of an active optical fiber.

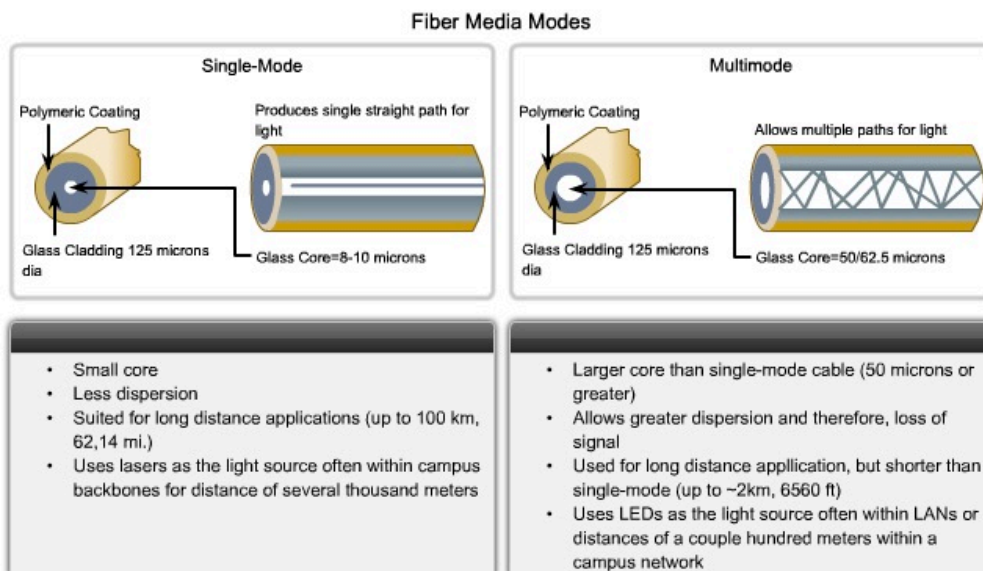
Single-mode and Multimode Fiber

Fiber optic cables can be broadly classified into two types: single-mode and multimode.

Single-mode optical fiber carries a single ray of light, usually emitted from a laser. Because the laser light is uni-directional and travels down the center of the fiber, this type of fiber can transmit optical pulses for very long distances.

Multimode fiber typically uses LED emitters that do not create a single coherent light wave. Instead, light from an LED enters the multimode fiber at different angles. Because light entering the fiber at different angles takes different amounts of time to travel down the fiber, long fiber runs may result in the pulses becoming blurred on reception at the receiving end. This effect, known as [*modal dispersion*](#), limits the length of multimode fiber segments.

Multimode fiber, and the LED light source used with it, are cheaper than single-mode fiber and its laser-based emitter technology.



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

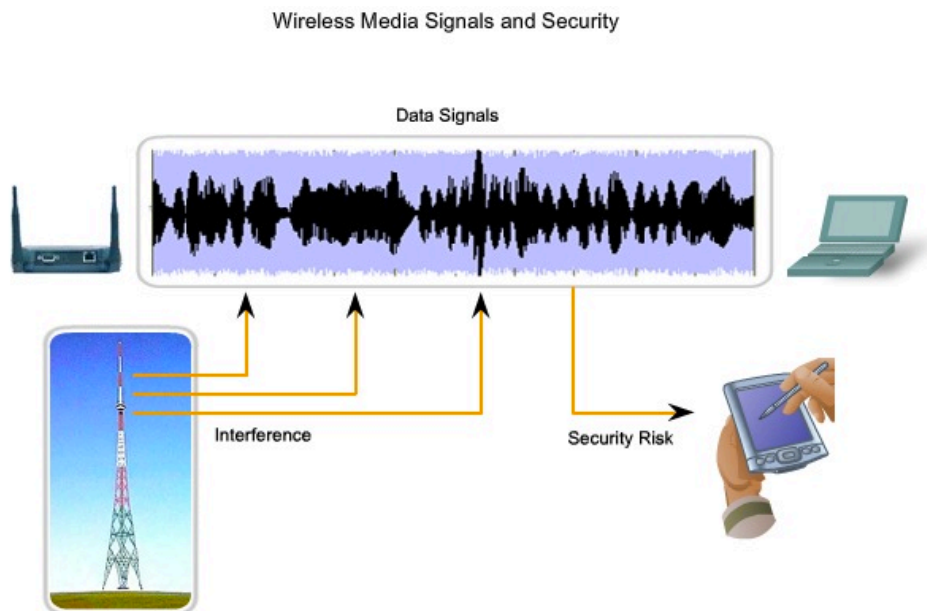
8.3.7 Wireless Media

Page 1:

Wireless media carry electromagnetic signals at radio and microwave frequencies that represent the binary digits of data communications. As a networking medium, wireless is not restricted to conductors or pathways, as are copper and fiber media.

Wireless data communication technologies work well in open environments. However, certain construction materials used in buildings and structures, and the local terrain, will limit the effective coverage. In addition, wireless is susceptible to interference and can be disrupted by such common devices as household cordless phones, some types of fluorescent lights, microwave ovens, and other wireless communications.

Further, because wireless communication coverage requires no access to a physical strand of media, devices and users who are not authorized for access to the network can gain access to the transmission. Therefore, network security is a major component of wireless network administration.



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.7 Wireless Media

Page 2:

Types of Wireless Networks

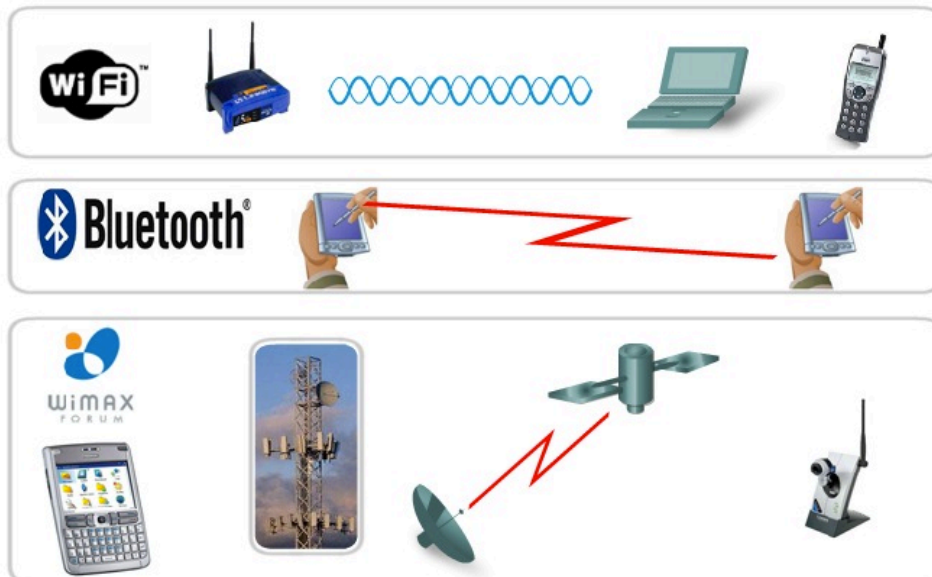
The IEEE and telecommunications industry standards for wireless data communications cover both the Data Link and Physical layers. Four common data communications standards that apply to wireless media are:

- Standard IEEE **802.11** - Commonly referred to as Wi-Fi, is a Wireless LAN (WLAN) technology that uses a contention or non-deterministic system with a Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) media access process.
- Standard IEEE **802.15** - Wireless Personal Area Network (WPAN) standard, commonly known as "Bluetooth", uses a device pairing process to communicate over distances from 1 to 100 meters.
- Standard IEEE **802.16** - Commonly known as Worldwide Interoperability for Microwave Access (WiMAX), uses a point-to-multipoint topology to provide wireless broadband access.
- Global System for Mobile Communications (GSM) - Includes Physical layer specifications that enable the implementation of the Layer 2 General Packet Radio Service (GPRS) protocol to provide data transfer over mobile cellular telephony networks.

Other wireless technologies such as satellite communications provide data network connectivity for locations without another means of connection. Protocols including GPRS enable data to be transferred between earth stations and satellite links.

In each of the above examples, Physical layer specifications are applied to areas that include: data to radio signal encoding, frequency and power of transmission, signal reception and [decoding](#) requirements, and antenna design and construction.

Wireless Media Standards and Types



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.7 Wireless Media

Page 3:

The Wireless LAN

A common wireless data implementation is enabling devices to wirelessly connect via a LAN. In general, a wireless LAN requires the following network devices:

- Wireless Access Point (AP) - Concentrates the wireless signals from users and connects, usually through a copper cable, to the existing copper-based network infrastructure such as Ethernet.
- Wireless NIC adapters - Provides wireless communication capability to each network host.

As the technology has developed, a number of WLAN Ethernet-based standards have emerged. Care needs to be taken in purchasing wireless devices to ensure compatibility and interoperability.

Standards include:

IEEE 802.11a - Operates in the 5 GHz frequency band and offers speeds of up to 54 Mbps. Because this standard operates at higher frequencies, it has a smaller coverage area and is less effective at penetrating building structures. Devices operating under this standard are not interoperable with the 802.11b and 802.11g standards described below.

IEEE 802.11b - Operates in the 2.4 GHz frequency band and offers speeds of up to 11 Mbps. Devices implementing this standard have a longer range and are better able to penetrate building structures than devices based on 802.11a.

IEEE 802.11g - Operates in the 2.4 GHz frequency band and offers speeds of up to 54 Mbps. Devices implementing this standard therefore operate at the same radio frequency and range as 802.11b but with the bandwidth of 802.11a.

IEEE 802.11n - The IEEE 802.11n standard is currently in draft form. The proposed standard defines frequency of 2.4 GHz or 5 GHz. The typical expected data rates are 100 Mbps to 210 Mbps with a distance range of up to 70 meters.

The benefits of wireless data communications technologies are evident, especially the savings on costly premises wiring and the convenience of host mobility. However, network administrators need to develop and apply stringent security policies and processes to protect wireless LANs from unauthorized access and damage.

These wireless standards and Wireless LAN implementations will be covered in more detail in the LAN Switching and Wireless course.

WLAN Access Points and Adapters



Wireless Access Point



Wireless Adapters

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8 OSI Physical Layer

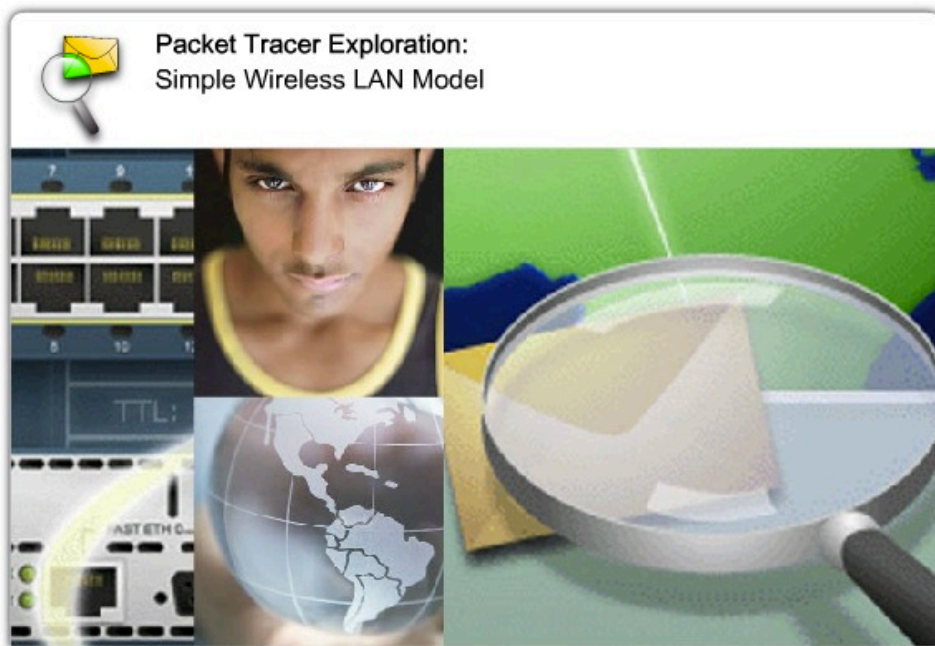
8.3 Physical Media - Connecting Communication

8.3.7 Wireless Media

Page 4:

In this activity, you can explore a wireless router connected to an ISP in a setup typical of a home or small business. You are encouraged to build your own models as well, possibly incorporating such wireless devices.

Click the Packet Tracer icon for more details.



File: 8.3.7 – pka.pka

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.8 Media Connectors

Page 1:

Common Copper Media Connectors

Different Physical layer standards specify the use of different connectors. These standards specify the mechanical dimensions of the connectors and the acceptable electrical properties of each type for the different implementations in which they are employed.

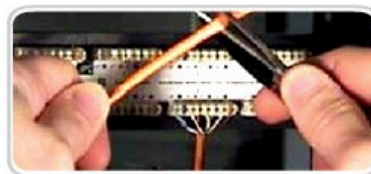
Although some connectors may look the same, they may be wired differently according to the Physical layer specification for which they were designed. The ISO 8877 specified RJ-45 connector is used for a range of Physical layer specifications, one of which is Ethernet. Another specification, EIA-TIA 568, describes the wire color codes to pin assignments (pinouts) for [Ethernet straight-through](#) and crossover cables.

Although many types of copper cables can be purchased pre-made, in some situations, especially in LAN installations, the termination of copper media may be performed onsite. These terminations include crimped connections to terminate Cat5 media with RJ-45 plugs to make patch cables, and the use of punched down connections on 110 patch panels and RJ-45 jacks. The figure shows some of the Ethernet wiring components.

Copper Media Connectors



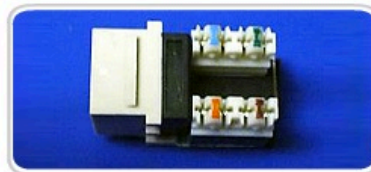
110 punch
block



RJ-45 UTP
Plugs



RJ-45 UTP
Socket



CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.8 Media Connectors

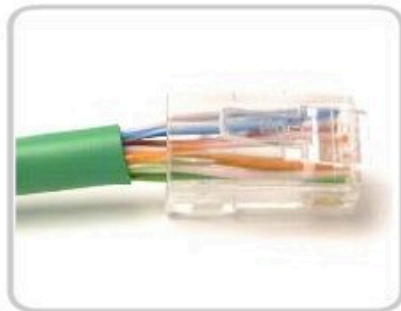
Page 2:

Correct Connector Termination

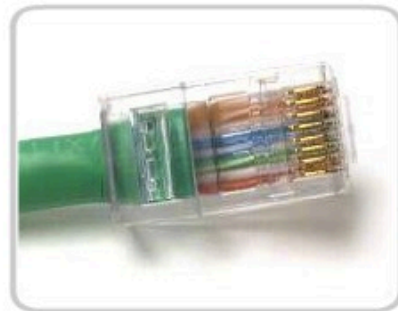
Each time copper cabling is terminated, there is the possibility of signal loss and the introduction of noise to the communication circuit. Ethernet workplace cabling specifications stipulate the cabling necessary to connect a computer to an active network intermediary device. When terminated improperly, each cable is a potential source of Physical layer performance degradation. **It is essential that all copper media terminations be of high quality to ensure optimum performance with current and future network technologies.**

In some cases, for example in some WAN technologies, if an improperly wired RJ-45-terminated cable is used, damaging voltage levels may be applied between interconnected devices. This type of damage will generally occur when a cable is wired for one Physical layer technology and is used with a different technology.

Copper Media Connectors RJ-45 Termination



Bad connector - Wires are untwisted for too great a length.



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

Improper cable termination can impact transmission performance.

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.3 Physical Media - Connecting Communication

8.3.8 Media Connectors

Page 3:

Common Optical Fiber Connectors

Fiber-optic connectors come in a variety of types. The figure shows some of the most common:

Straight-Tip (ST) (trademarked by AT&T) - a very common bayonet style connector widely used with multimode fiber.

Subscriber Connector (SC) - a connector that uses a push-pull mechanism to ensure positive insertion. This connector type is widely used with single-mode fiber.

Lucent Connector (LC) - A small connector becoming popular for use with single-mode fiber and also supports multi-mode fiber.

Terminating and splicing fiber-optic cabling requires special training and equipment. Incorrect termination of fiber optic media will result in diminished signaling distances or complete transmission failure.

Three common types of fiber-optic termination and splicing errors are:

- Misalignment - the fiber-optic media are not precisely aligned to one another when joined.
- End gap - the media do not completely touch at the splice or connection.
- End finish - the media ends are not well polished or dirt is present at the termination.

It is recommended that an Optical Time Domain Reflectometer (OTDR) be used to test each fiber-optic cable segment. This device injects a test pulse of light into the cable and measures back scatter and reflection of light detected as a function of time. The OTDR will calculate the approximate distance at which these faults are detected along the length of the cable.

A field test can be performed by shining a bright flashlight into one end of the fiber while observing the other end of the fiber. If light is visible, then the fiber is capable of passing light. Although this does not ensure the performance of the fiber, it is a quick and inexpensive way to find a broken fiber.

Fiber Media Connectors

ST Connector



Straight Tip (ST) connector is widely used with multimode fiber

SC Connector



Subscriber Connector (SC) is widely used with single-mode fiber

Single-Mode (LC)



Single-Mode Lucent Connector (LC)

Multimode (LC)



Multimode LC Connector

Duplex Multimode (LC)



Duplex Multimode LC Connector

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.4 Lab - Media Connectors

8.4.1 Media Connectors Lab Activity

Page 1:

Effective network troubleshooting requires the ability to both visually distinguish between straight-through and crossover UTP cables and to test for correct and faulty cable terminations.

This lab provides the opportunity to practice physically examining and testing UTP cables.

Click the Lab icon for more details.



File: 8.4.1 - lab - Media Connectors Lab Activity.pdf

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.5 Chapter Summaries

8.5.1 Summary and Review

Page 1:

Layer 1 of the OSI model is responsible for the physical interconnection of devices. Standards at this layer define the characteristics of the electrical, optical, and radio frequency representation of the bits that comprise Data Link layer frames to be transmitted. Bit values can be represented as electronic pulses, pulses of light, or changes in radio waves. Physical layer protocols encode the bits for transmission and decode them at the destination.

Standards at this layer are also responsible for describing the physical, electrical, and mechanical characteristics of the physical media and connectors that interconnect network devices.

Various media and Physical layer protocols have different data-carrying capacities. Raw data bandwidth is the theoretical upper limit of a bit transmission. Throughput and goodput are different measures of observed data transfer over a specific period of time.

In this chapter, you learned to:

- Explain the role of Physical layer protocols and services in supporting communication across data networks.
- Describe the purpose of Physical layer signaling and encoding as they are used in networks.
- Describe the role of signals used to represent bits as a frame is transported across the local media.
- Identify the basic characteristics of copper, fiber, and wireless network media.
- Describe common uses of copper, fiber, and wireless network media.

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.5 Chapter Summaries

8.5.1 Summary and Review

Page 2:

Use this activity to check your understanding of the main points in this chapter.

- A series of questions will be presented. This is not a quiz and your answers are not recorded.
- Click **Answer** to see the answer.
- Click **Next Question** to go to the next question in the series.

Click Here
to Begin

1. Name two ways in which bits are encoded as voltages. How do they differ?

Answer

NRZ (Non-Return to Zero) encoding, a "0" may be represented by one voltage level on the media during the bit time and a "1" might be represented by a different voltage on the media during the bit time.

Manchester Encoding uses transitions, or the absence of transitions, to indicate a logic level. For example, a "0" is indicated by a high to low transition in the middle of the bit time. For a "1" there is a low to high transition in the middle of the bit time.

Next
Question

2. Why may bits be encoded as symbols before transmission?

Answer

2. One encoding technique is the use of symbols. The Physical layer may use a set of encoded symbols to represent encoded data or control information called code groups. A code-group is a consecutive sequence of code-bits interpreted and mapped as data bit patterns. For example, code bits 10101 may represent the data bits 0011.

While code groups introduce overhead in the form of extra bits to transmit, they improve the robustness of a communications link. This is particularly true for higher speed data transmission.

By transmitting symbols, the error detection capabilities and timing synchronization between transmitting and receiving devices are enhanced. These are important considerations in supporting

2. Why may bits be encoded as symbols before transmission?

Answer

By transmitting symbols, the error detection capabilities and timing synchronization between transmitting and receiving devices are enhanced. These are important considerations in supporting high-speed transmission over the media.

Some of these advantages are:

- Reduced bit level error
- Limiting the effective energy transmitted into the media
- Help distinguish data bits from control bits
- Better media error detection

Next
Question

3. What safety issues must be considered when using copper cabling?

Answer

Electrical hazards

Copper wires may conduct electricity in undesirable ways. This may subject personnel and equipment to a range of electrical hazards. A defective network device may conduct currents to the chassis of other network device. Additionally, network cabling could present undesirable voltage levels when used to connect devices that have power sources with different ground potentials. Also copper cabling may conduct voltages caused by lightning strikes to network devices. The result of undesirable voltages and currents can include damage to network devices and connected computers, or injury to personnel.

3. What safety issues must be considered when using copper cabling?

Answer

levels when used to connect devices that have power sources with different ground potentials. Also copper cabling may conduct voltages caused by lightning strikes to network devices. The result of undesirable voltages and currents can include damage to network devices and connected computers, or injury to personnel.

Fire hazards

Cable insulation and sheaths may be flammable or produce toxic fumes when heated or burned. Building authorities or organizations may also stipulate related safety standards for cabling and hardware installations.

Next
Question

4. In what situations is fiber optic cabling preferred over copper cabling?

Answer

Given that the glass fibers used in fiber optic media are not electrical conductors, the media is immune to electromagnetic interference and will not conduct unwanted electrical currents due to grounding issues. Because optical fibers are thin and have relatively low signal loss, they can be operated at much greater lengths than copper media, without the need for signal regeneration.

Next
Question

5. Name several copper and fiber optic connector types.

Answer

Copper: RJ-45, RJ-11

Fiber: Straight-Tip (ST), Subscriber Connector (SC), Lucent Connector (LC)

This concludes this chapter's
Problems and Discussion
questions.

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.5 Chapter Summaries

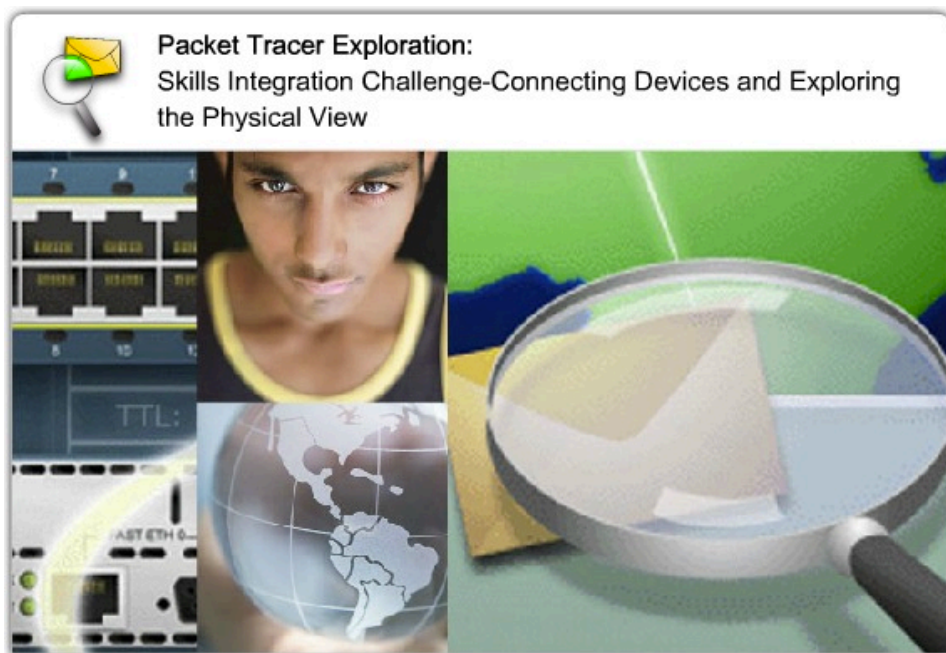
8.5.1 Summary and Review

Page 3:

In this activity, you will examine how Packet Tracer provides a representation of the physical location and appearance of the virtual networking devices you have been creating in logical topology mode.

[Packet Tracer Skills Integration Instructions \(PDF\)](#)

Click the Packet Tracer icon to launch the Packet Tracer activity.



File: 8.5.1 - pka.pka

CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.5 Chapter Summaries

8.5.1 Summary and Review

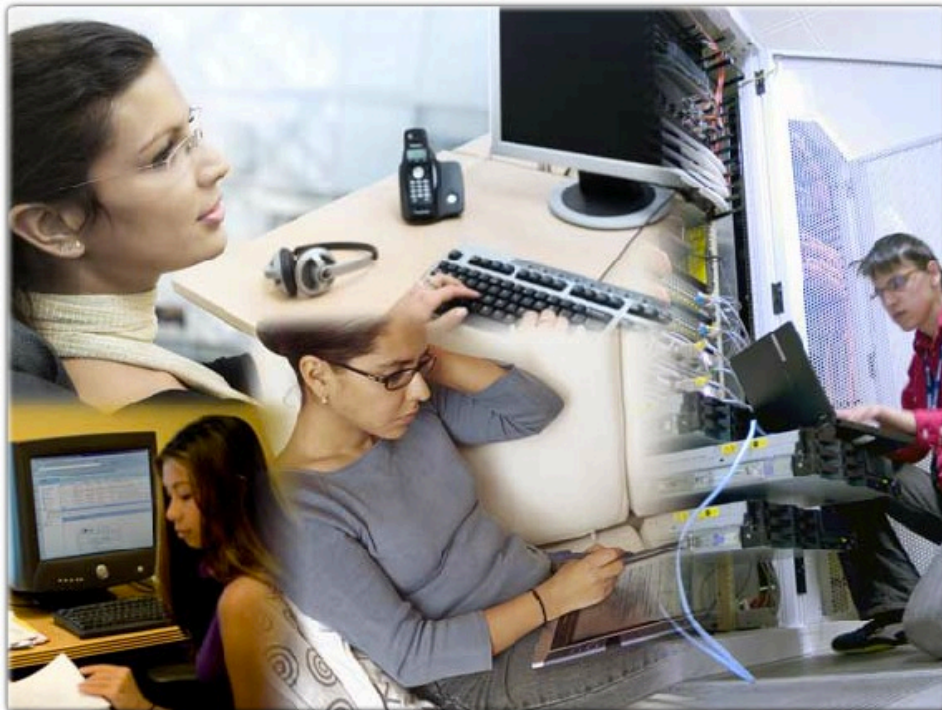
Page 4:

To Learn More

Reflection Questions

Discuss how copper media, optical fiber, and wireless media could be used to provide network access at your academy. Review what networking media are used now and what could be used in the future.

Discuss the factors that might limit the widespread adoption of wireless networks despite the obvious benefits of this technology. How might these limitations be overcome?



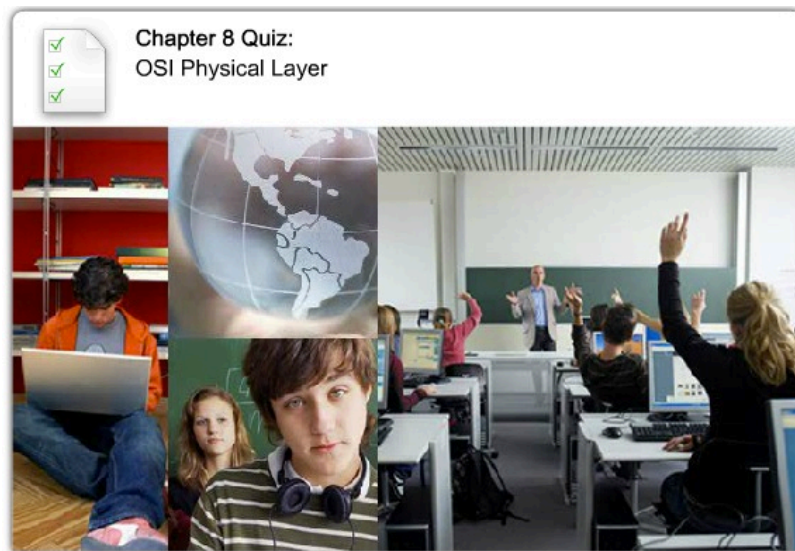
CCNA Exploration - Network Fundamentals

8 OSI Physical Layer

8.6 Chapter Quiz

8.6.1 Chapter Quiz

Page 1:



1 Match the colors to the numbers that represent the wiring pinouts for 568B patch cables.

| | | |
|----|--------|---------|
| 2 | | |
| 3 | | |
| 4 | orange | 7 and 8 |
| 5 | blue | 1 and 2 |
| 6 | green | 3 and 6 |
| 7 | | |
| 8 | brown | 4 and 5 |
| 9 | | |
| 10 | | |

Check

1 Match the colors to the numbers that represent the wiring pinouts for 568B patch cables.

| | |
|----|----------|
| 2 | |
| 3 | |
| 4 | |
| 5 | ✓ brown |
| 6 | ✓ orange |
| 7 | ✓ green |
| 8 | ✓ blue |
| 9 | |
| 10 | |

Check Percent Correct 10%

1 Place each pin on the left onto the correct pin on the right to properly create a RJ-45 connector for a router console cable.

| | | |
|----|-------|-------|
| 2 | | |
| 3 | | |
| 4 | Pin 1 | Pin 1 |
| 5 | Pin 2 | Pin 2 |
| 6 | Pin 3 | Pin 3 |
| 7 | Pin 4 | Pin 4 |
| 8 | Pin 5 | Pin 5 |
| 9 | Pin 6 | Pin 6 |
| 10 | Pin 7 | Pin 7 |
| | Pin 8 | Pin 8 |

Check Percent Correct 10%

1 Place each pin on the left onto the correct pin on the right to properly create a RJ-45 connector for a router console cable.

| | |
|----|---------|
| 2 | |
| 3 | |
| 4 | ✓ Pin 8 |
| 5 | ✓ Pin 7 |
| 6 | ✓ Pin 6 |
| 7 | ✓ Pin 5 |
| 8 | ✓ Pin 4 |
| 9 | ✓ Pin 3 |
| 10 | ✓ Pin 2 |
| | ✓ Pin 1 |

Check Percent Correct 20%

What kind of connection is represented in the graphic?

RJ-45-to-RJ-45 Rollover Cable

PC

RJ-45-to-DB-9 Adapter labeled TERMINAL

- ☒ console connection
- ☐ Ethernet connection
- ☐ ISDN connection
- ☐ leased line connection

Check Percent Correct: 30%

What is the purpose of encoding?

- ☐ Identification of start and stop bits in a frame.
- ☐ Denotes the physical layers connectors of computers in relation to the way they connect to the network media.
- ☐ Controls the way frames are placed on the media at the Data link layer.
- ☒ Represents the data bits by using different voltages, light patterns or electromagnetic waves as they are placed onto the physical media.

Check Percent Correct: 40%

What best describes the purpose of the Physical Layer?

- ☐ Ensures reliable transmission of data across a physical link.
- ☐ Determines connectivity and path selection between two end systems.
- ☐ Establishes the physical addressing, network topology and media access.
- ☒ Defines the functional specifications for link between end systems and the electrical, optical, and radio signals.

Check Percent Correct: 50%

Through what process does UTP cable help to avoid crosstalk?

- ☐ shielding of cable
- ☒ twisting of pairs
- ☐ grounding the end points
- ☐ cladding in cable

Check Percent Correct: 60%

Refer to the exhibit. The network in the exhibit is wired with Cat 5e cable and Workstation "C" is unable to communicate with the network. What Physical Layer problem would cause the problem of Workstation "C" not connecting to the network?

192.168.1.11/24

192.168.1.12/24

192.168.1.13/24

125 Meters

75 Meters

- ☐ wrong operating system
- ☐ incorrect IP address
- ☒ cable length
- ☐ incorrect prefix
- ☐ switch type

Check Percent Correct: 70%

What are the advantages of using fiber optic cable over copper cable? (Choose three.)

- ☐ copper is more expensive
- ☒ immunity to electromagnetic interference
- ☐ careful cable handling
- ☒ longer maximum cable length
- ☐ efficient electrical current transfer
- ☒ greater bandwidth potential

Check Percent Correct: 80%

1 What cable type would be used to connect a computer directly to another computer?

2

3

4

5

6 ☒ Crossover

7

8

9

10

Check

Percent Correct 90%

1 Refer to the exhibit. What is the purpose of cladding in fiber optic cables?

2

3

4

5

6

7

8

9

10

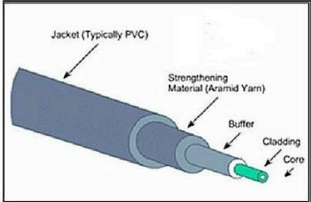


Diagram labels: Jacket (Typically PVC), Strengthening Material (Aramid Yarn), Buffer, Cladding, Core.

Check

Percent Correct 100%

CCNA Exploration - Network Fundamentals

MODULE 8 (version 4.0)

1. An installed fiber run can be checked for faults, integrity, and the performance of the media by using what device?
light injector
OTDR
TDR
multimeter
2. In LAN installations where potential electrical hazards or electromagnetic interference may be present, what type of media is recommended for backbone cabling?
coax
fiber
Cat5e UTP
Cat6 UTP
STP
3. What are three measures of data transfer? (Choose three.)
goodput
frequency
amplitude
throughput
crosstalk
bandwidth
4. When is a rollover cable used in a network?
for connecting a host to a Fast Ethernet port on a switch
for connecting a router to another router
for connecting two routers through their AUX ports
for connecting to a switch through its console port
5. With the use of unshielded twisted-pair copper wire in a network, what causes crosstalk within the cable pairs?
the magnetic field around the adjacent pairs of wire
the use of braided wire to shield the adjacent wire pairs
the reflection of the electrical wave back from the far end of the cable
the collision caused by two nodes trying to use the media simultaneously
6. Which of the following is a characteristic of single-mode fiber-optic cable?
generally uses LEDs as the light source
relatively larger core with multiple light paths
less expensive than multimode
generally uses lasers as the light source
7. Which connector is used with twisted-pair cabling in an Ethernet LAN?





8. Which type of cable run is most often associated with fiber-optic cable?

backbone cable

horizontal cable

patch cable

work area cable

9. What is a purpose of the physical layer in data communication?

to wrap data packets into frames

to make sure that MAC addresses are unique in each frame

to control the access sequence of frames to the transmission media

to convert a frame into a series of signals to be transmitted on the local media

10. Compared with UTP cable, what extra characteristic of STP cable helps reduce the effects of interference?

the metal braiding in the shielding

the reflective cladding around the core

the twisting of the wires in the cable

the insulating material in the outer jacket

11. A customer installs a wireless access point at home in the closet next to the kitchen. The customer mentions that the wireless communication performance seems degraded when the cordless phone or the microwave oven is in use. What is the possible reason for this degradation?

The access point is close to walls.

The cordless phone joins the WLAN and shares the available bandwidth.

The wireless signal is in the same radio frequency range as the household devices are in.

The access point is on the same electrical circuit as the phone base unit and microwave oven are.

The surge of electricity when a microwave oven is in use disrupts the operation of the access point.

12. Which OSI layer is responsible for managing optical signals used for data communication?

presentation

data link

transport

physical

13. Which data communications standard provides broadband access in a wireless network?

GSM

Wi-Fi

WiMAX

Bluetooth

14. What is a possible effect of improperly applying a connector to a network cable?

Data will be forwarded to the wrong node.

Data transmitted through that cable may experience signal loss.

An improper signaling method will be implemented for data transmitted on that cable.

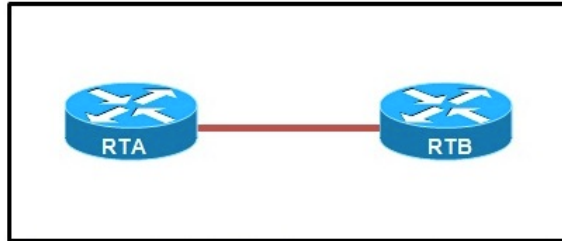
The encoding method for data sent on that cable will change to compensate for the improper connection.

15. Which fiber connector supports full duplex Ethernet?



16. Refer to the exhibit. An ISP donates some decommissioned Cisco 2600 series routers to a local high school. The high school plans to use these routers in their networking classrooms for students to practice. Which type of cable is used to make an Ethernet connection between routers RTA and RTB?

coax cable
rollover cable
crossover cable
straight-through cable



17. Which characteristics describe fiber optic cable? (Choose two.)

It is not affected by EMI or RFI.

Each pair of cables is wrapped in metallic foil.

It combines the technique of cancellation, shielding and twisting to protect data.

It has a maximum speed of 100 Mbps.

It is the most expensive type of LAN cabling.