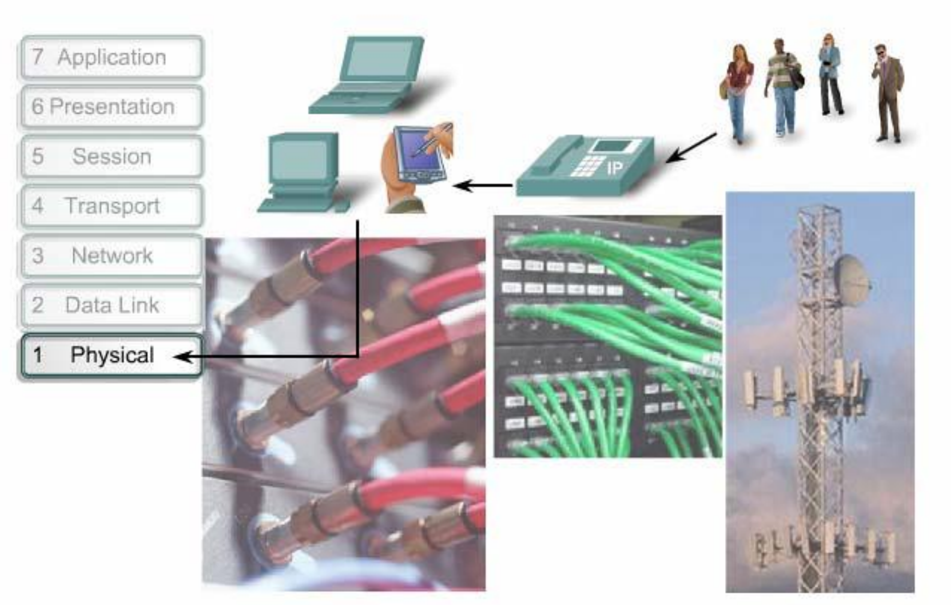
Chapter 8 OSI Physical Layer

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

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 that 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.

Figure 1.

8.1 The Physical Layer – Communication Signals

8.1.1 The Physical Layer – Purposes

The OSI Physical layer provides the means to transport across the network media. 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

The Physical Layers purposes:

1- 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.
2- 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.

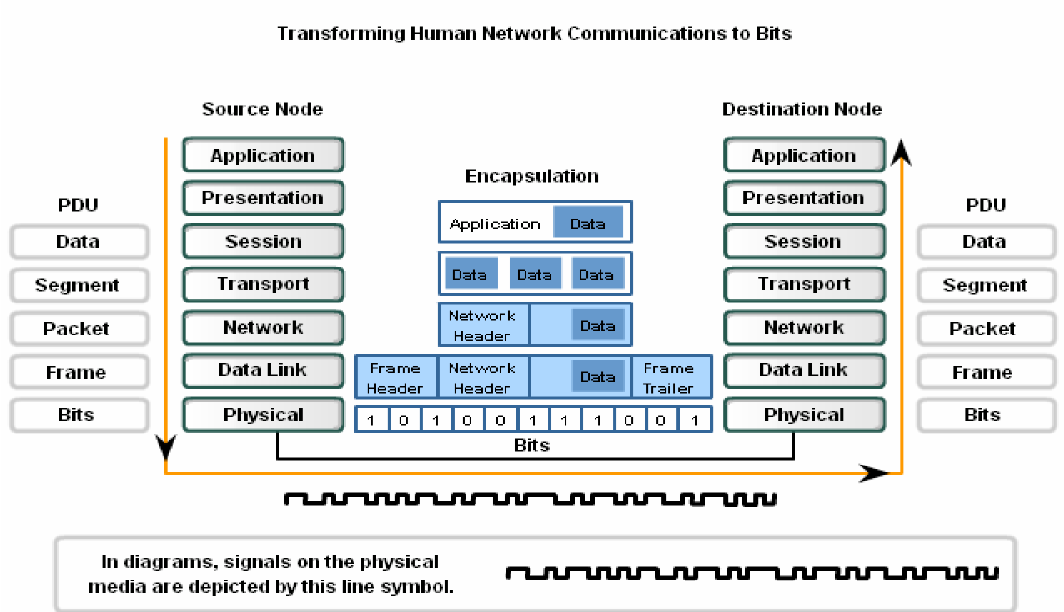


Figure 2: Transforming human network communication to bits.

8.1.2 The Physical Layer – Operation

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

• Copper cable: the signals are patterns of electrical pulses.

• Fiber: the signals are patterns of light.

• Wireless: the signals are patterns of radio transmissions.

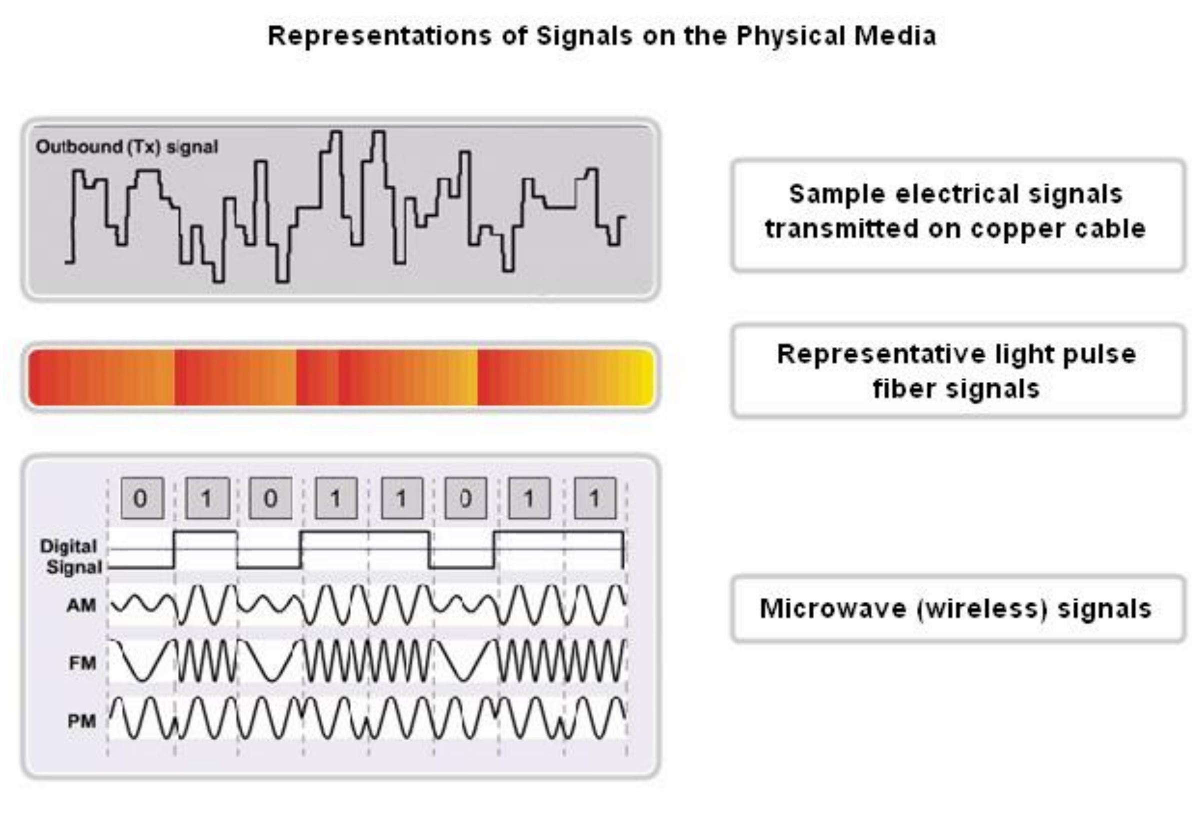


Figure 3: Representations of signals on the physical media.

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. 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.

8.1.3 The Physical Layer – Standards

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.

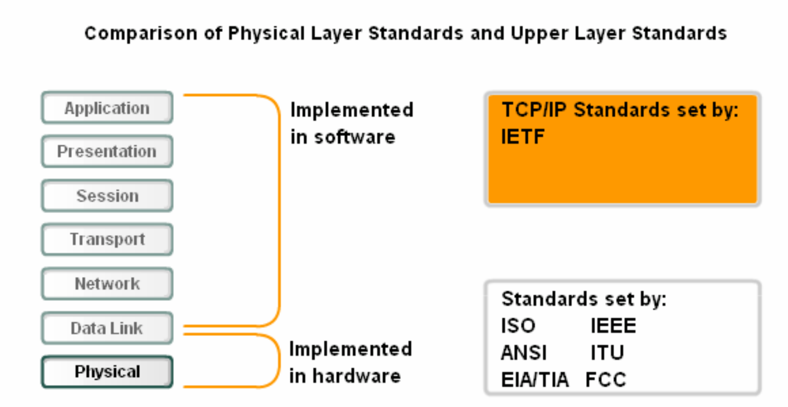


Figure 4.

Note: Internet Engineering Task Force (IETF)

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

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

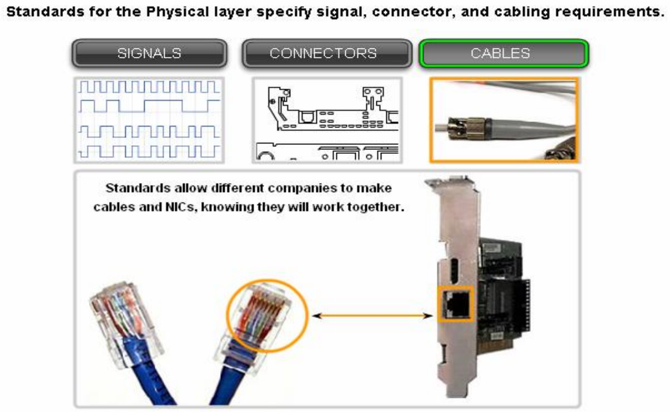


Figure 5.

8.1.4 Physical Layer Fundamental Principles

The three fundamental functions of the Physical layer are:

- The physical components
- Data encoding
- Signaling

Encoding is a method of converting a stream of data bits into a predefined code.

1- To provide a predictable pattern that can be recognized by both the sender and the received.

2- To distinguish data bits from control bits and provide better media error detection.

3- To provide codes for control purposes such as identifying the beginning and end of a frame.

Signaling, the Physical layer must generate the electrical, optical, or wireless signals that represent the "1" and "0" on the media.

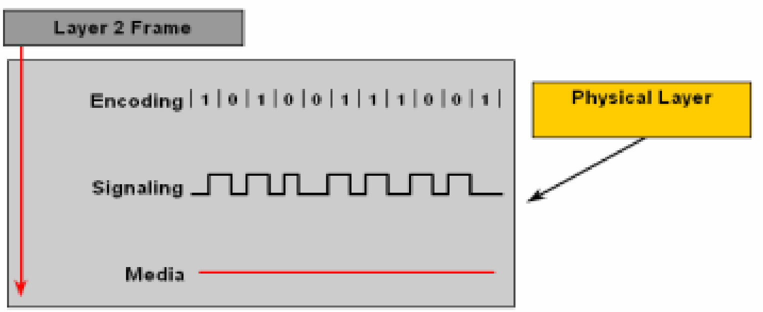


Figure 6: Physical layer fundamental principles.

8.2 Physical Signaling and Encoding: Representing Bits

8.2.1 Signaling Bits for the Media

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 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. In LANs, each end of the transmission maintains its own clock.

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

• Amplitude
• Frequency
• Phase

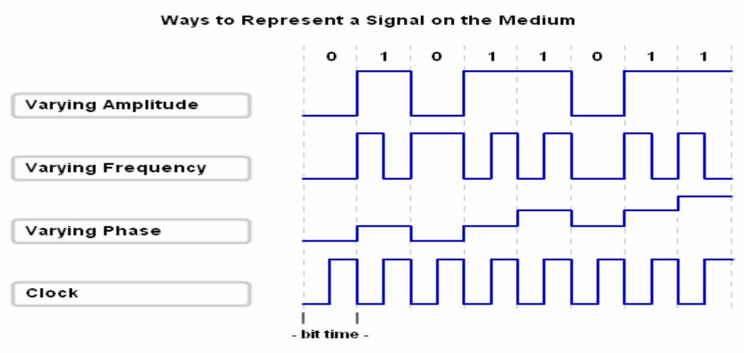


Figure 7: Signal representation methods.

Non Return to Zero (NRZ) Signaling Method

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.

- NRZ is only suited for slow speed data links.
- NRZ signaling uses bandwidth inefficiently and is susceptible to electromagnetic interference.
- 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.

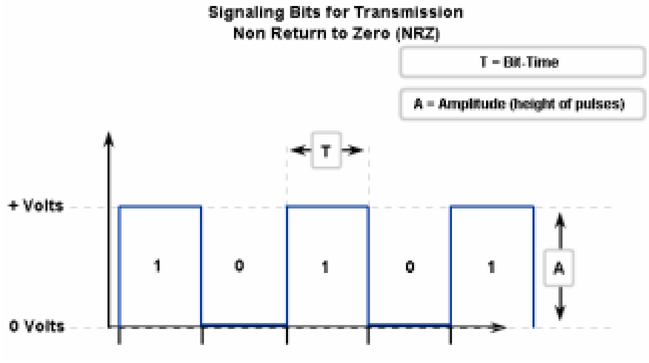


Figure 8: Non Return to Zero (NRZ).

Manchester Encoding Method

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 (Figure 9).

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

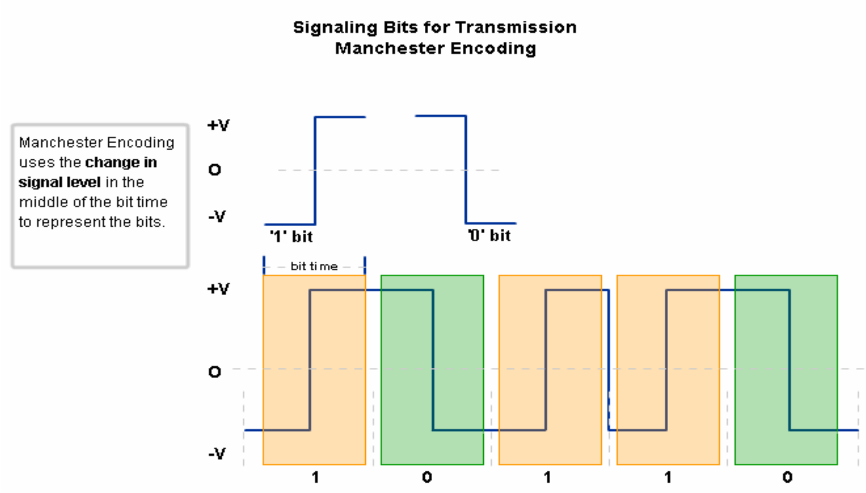


Figure 9: Manchester Encoding.

8.2.2 Encoding – Grouping Bits

Encoding is grouping of bits prior to being presented to the media.

- To improve the efficiency at higher speed data transmission
- To detect errors.
- To represent more data across the media, by transmitting fewer bits.

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 and end each frame with a pattern of signals representing bits.

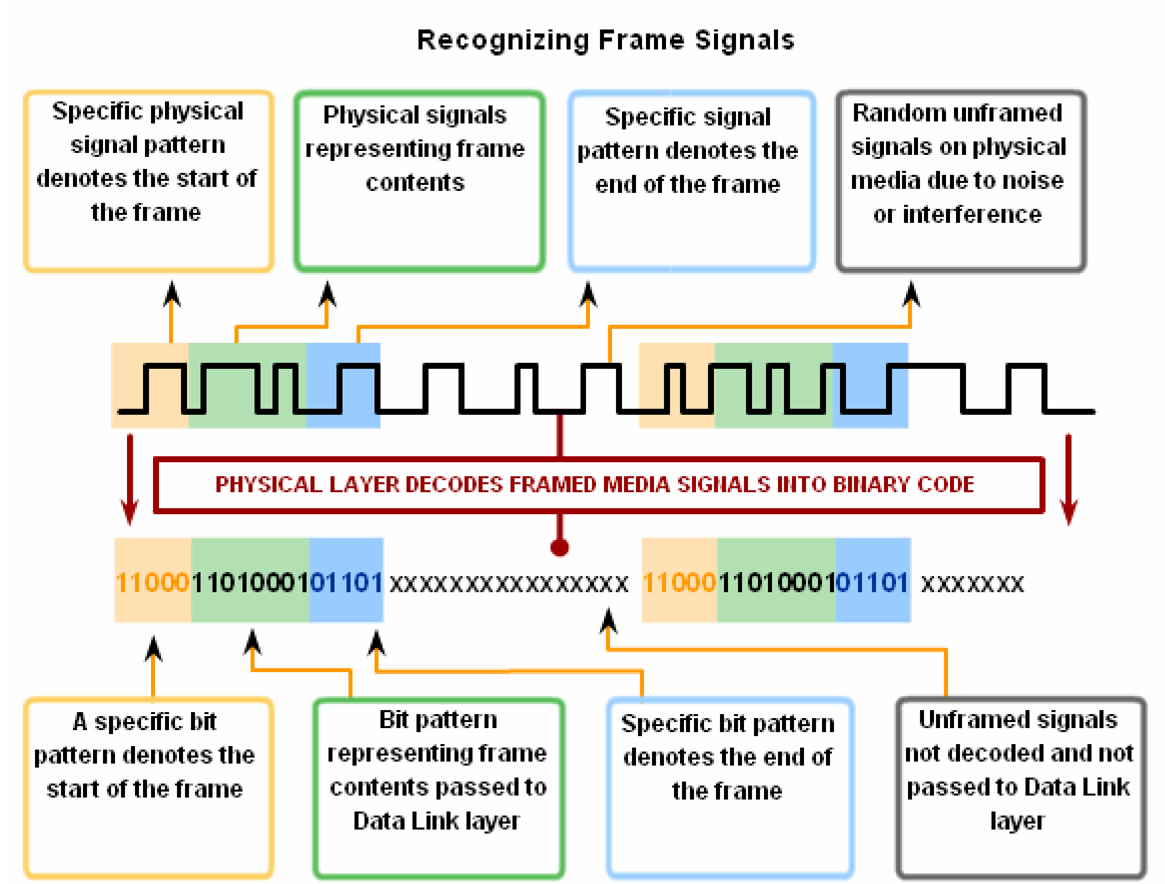


Figure 10: Recognizing frame signals.