Data And Signals

The data usable to a person or application are not in a form that can be transmitted over a network. For example, a photograph must first be changed to a form that transmission media can accept. Transmission media work by conducting energy along a physical path.

To be transmitted, data must be transformed to electromagnetic signals.

ANALOG AND DIGITAL

Both **data and the signals** that represent them can be either **analog or digital** in form.

Analog and Digital Data

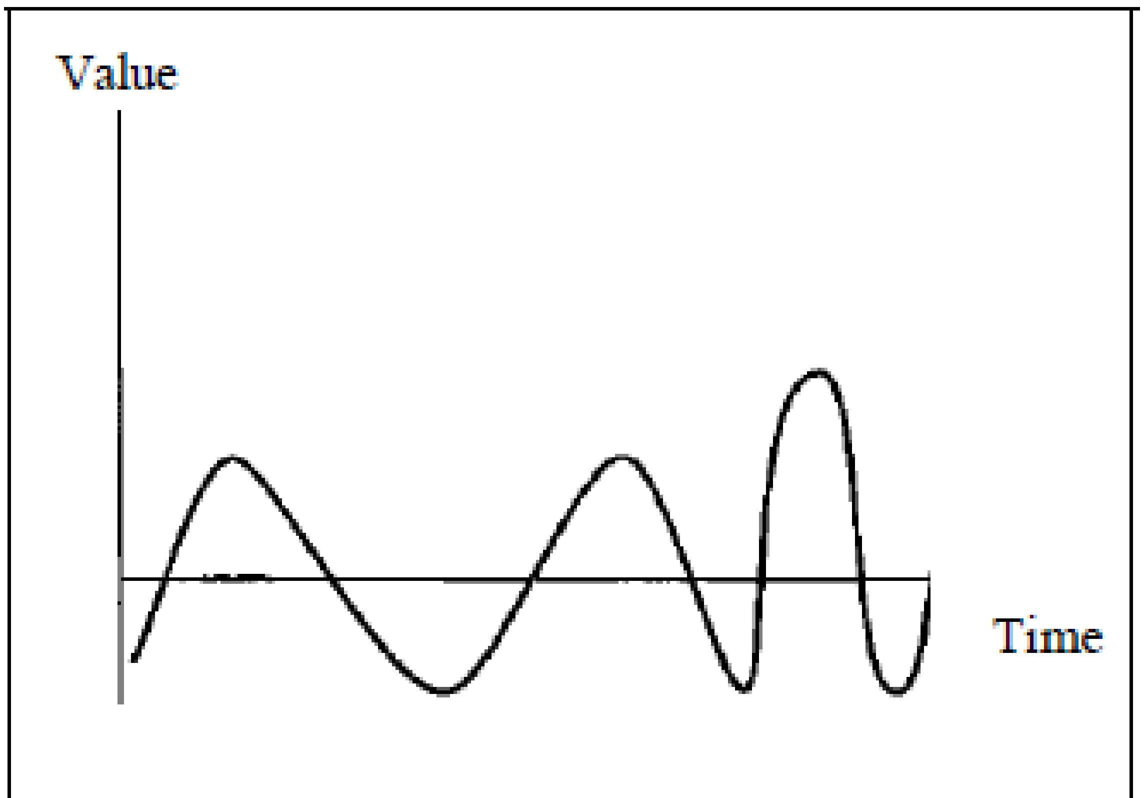
- Data can be analog or digital.
- The term analog data refers to information that is **continuous**; digital data refers to information that has **discrete states**.
- **Analog data take on continuous values**. For example, the sounds made by a human voice. This can be captured by a microphone and converted to an analog signal or sampled and converted to a digital signal.
- **Digital data take on discrete values**. For example, data are stored in computer memory in the form of 0s and 1s. They can be converted to a digital signal or modulated into an analog signal for transmission across a medium.

Analog and Digital Signals

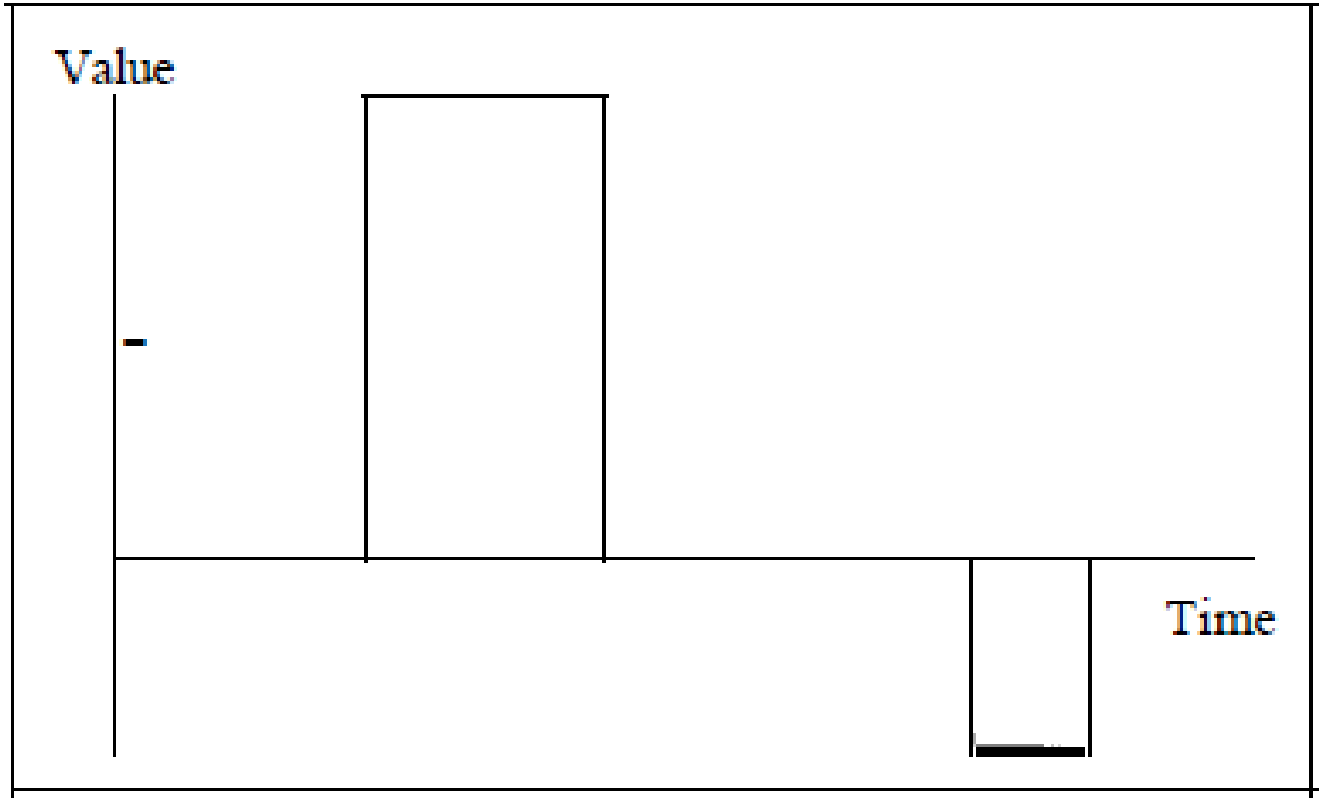
- ❖ Signals can be either analog or digital.
- ❖ Analog signals can have an infinite number of values in a range. As the wave moves from value A to value B, it passes through and includes an infinite number of values along its path.
- ❖ A digital signal can have only a limited number of defined values. Although each value can be any number, it is often as simple as 1 and 0.

The simplest way to show signals is by plotting them on a pair of perpendicular axes.

Comparison of analog and digital signals



a. Analog signal



b. Digital signal

Periodic and Nonperiodic Signals

- Both analog and digital signals can take one of two forms: *periodic or nonperiodic.*
- A periodic signal completes a pattern within a measurable time frame, called a period, and repeats that pattern over subsequent identical periods. The completion of one full pattern is called a cycle.
- A nonperiodic signal changes without exhibiting a pattern or cycle that repeats over time.
- In data communications, we commonly use periodic analog signals and nonperiodic digital signals.

PERIODIC ANALOG SIGNALS

✓ Periodic analog signals can be classified as simple or composite.

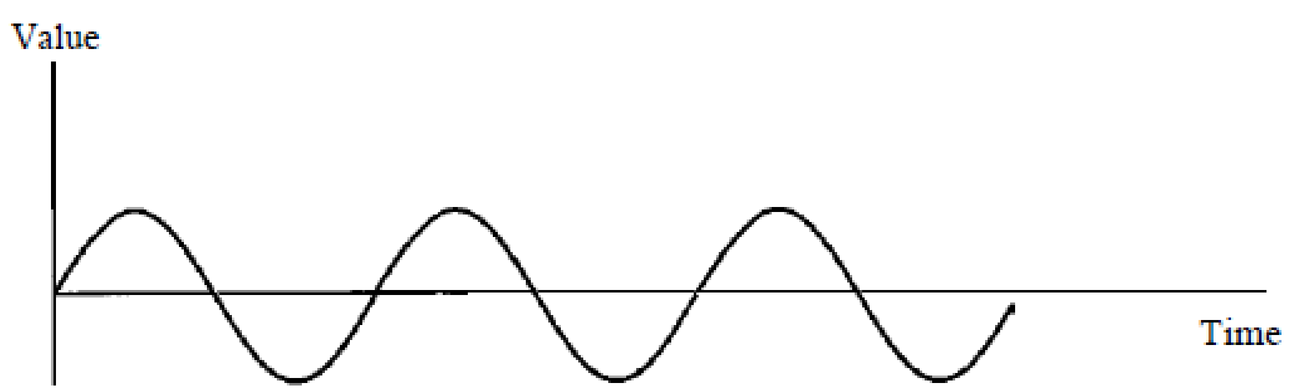
✓ A simple periodic analog signal cannot be decomposed into simpler signals. Eg: A sine wave.

✓ A composite periodic analog signal is composed of multiple sine waves.

Sine Wave

The sine wave is the most fundamental form of a periodic analog signal. When we visualize it as a simple oscillating curve, its change over the course of a cycle is smooth and consistent, a continuous, rolling flow.

A sine wave

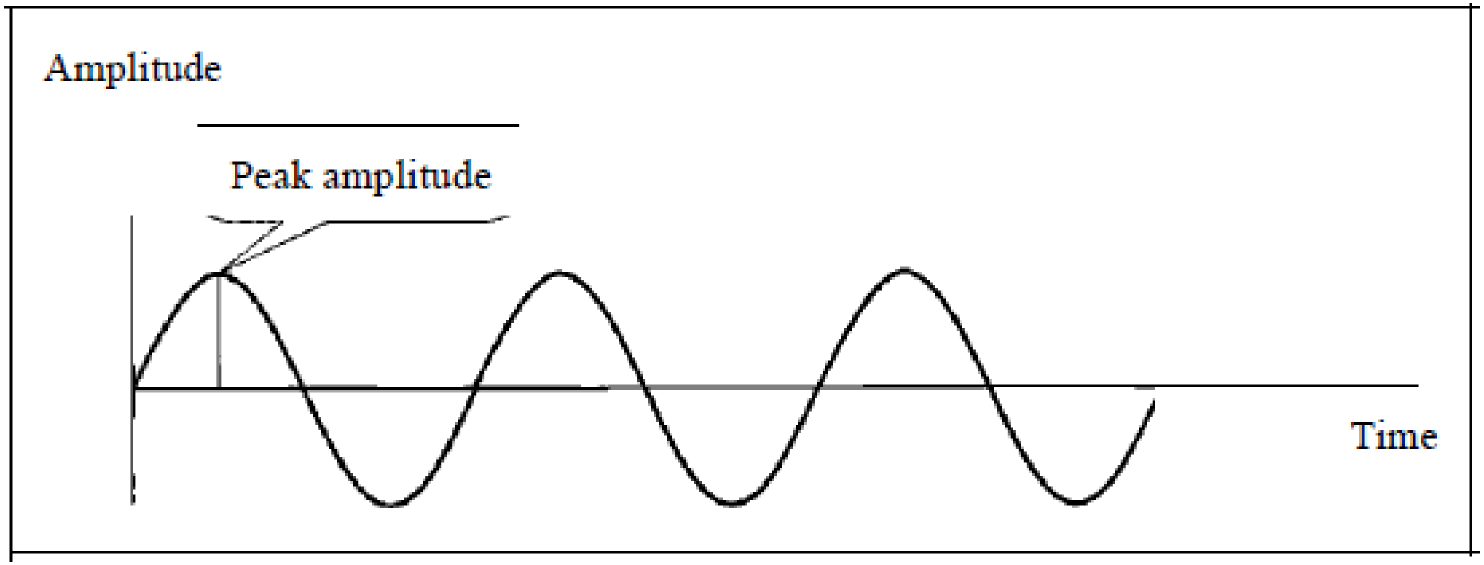


A sine wave can be represented by three parameters:

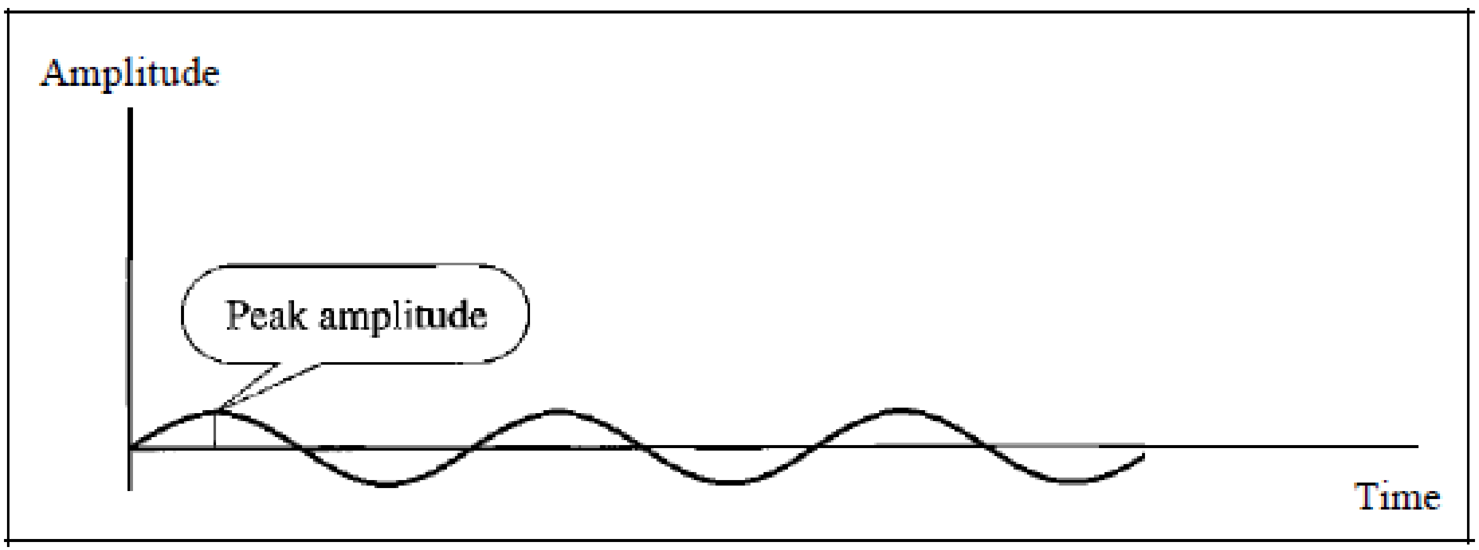
1. The peak amplitude
2. The frequency
3. The phase.

Peak Amplitude

The peak amplitude of a signal is the absolute value of its highest intensity, proportional to the energy it carries. For electric signals, peak amplitude is normally measured in **volts.**



a. A signal with high peak amplitude



b. A signal with low peak amplitude

Period and Frequency

Period refers to the amount of time, in seconds, a signal needs to complete 1 cycle.

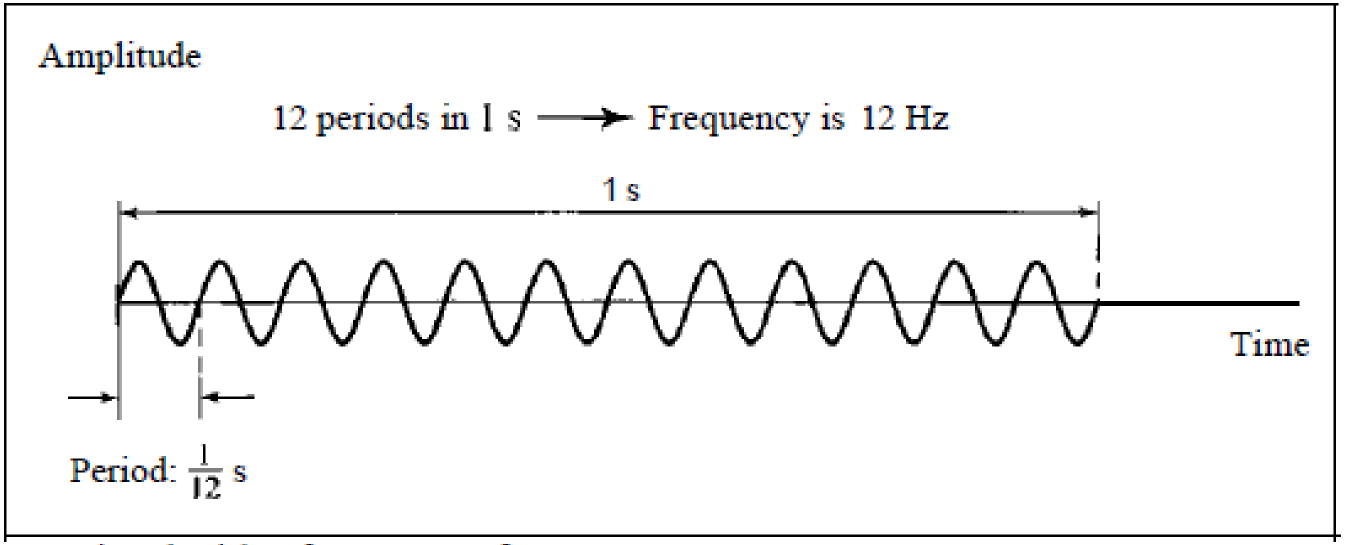
Frequency refers to the number of periods in I s.

Frequency and period are the inverse of each other.

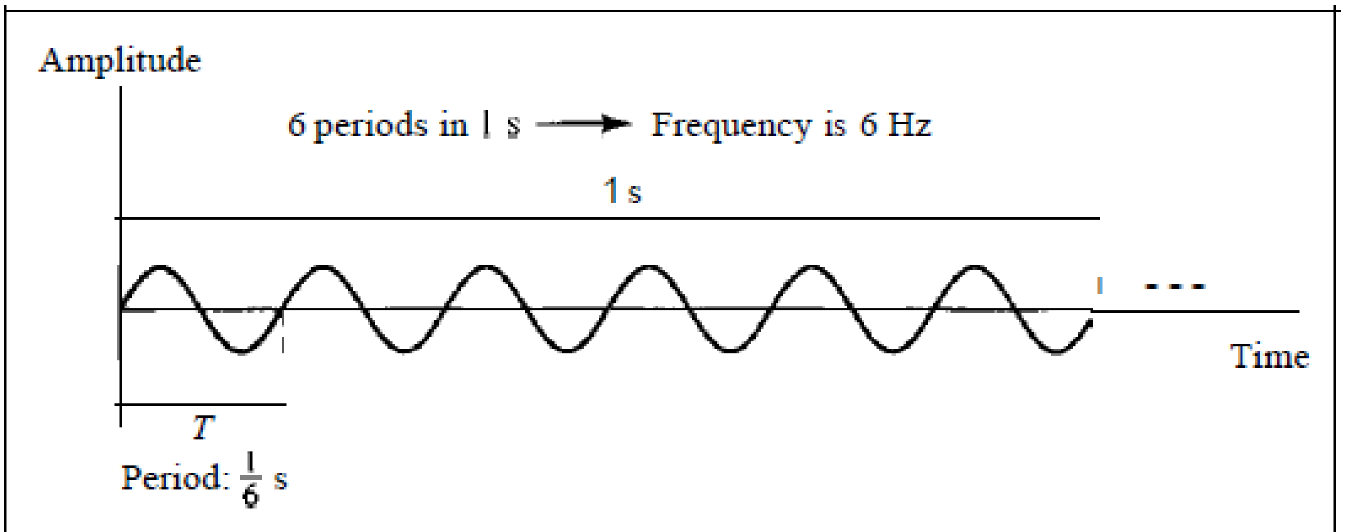
$$f = \frac{1}{T} \quad \text{and} \quad T = \frac{1}{f}$$

Figure below shows two signals and their frequencies.

Two signals with the same amplitude and phase, but different frequencies



a. A signal with a frequency of 12 Hz



b. A signal with a frequency of 6 Hz

- Period is formally expressed in seconds. Frequency is formally expressed in Hertz (Hz), which is cycle per second.

- Frequency is the rate of change with respect to time. Change in a short span of time means high frequency. Change over a long span of time means low frequency.

- If a signal does not change at all, its frequency is zero. If a signal changes instantaneously, its frequency is infinite.

Table:- *Units of period and frequency*

Unit	*Equivalent*	*Unit*	*Equivalent*
Seconds (s)	1 s	Hertz (Hz)	1 Hz
Milliseconds (ms)	10^{-3} s	Kilohertz (kHz)	10^{3} Hz
Microseconds (μs)	10-6 s	Megahertz (MHz)	10^{6} Hz
Nanoseconds (ns)	10^{-9} s	Gigahertz (GHz)	10^{9} Hz
Picoseconds (ps)	10^{-12} s	Terahertz (THz)	10^{12} Hz

Phase

Phase describes the position of the waveform relative to time 0.

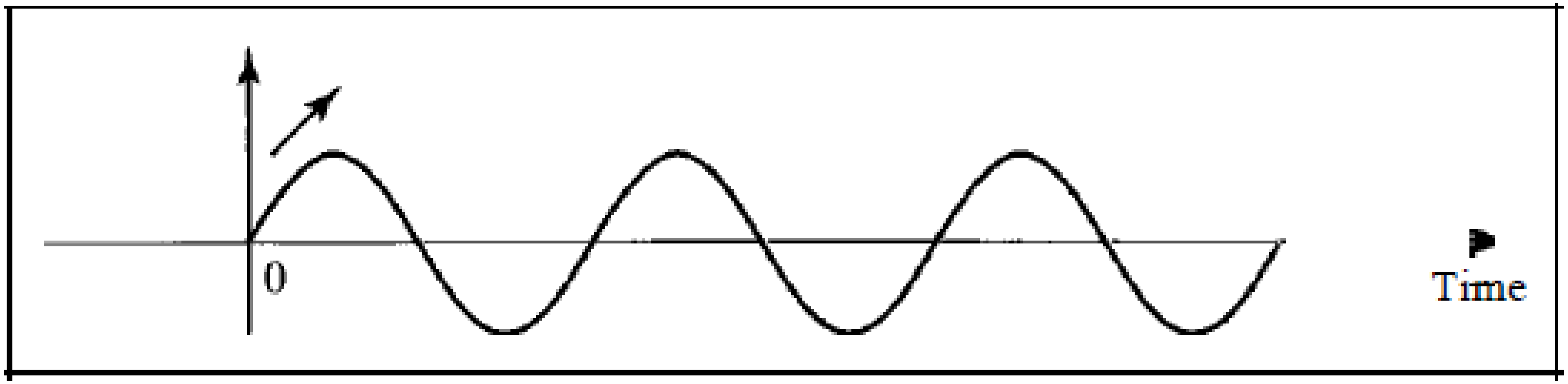
Phase is measured in degrees or radians [360° is 2π rad; $1°$ is $2\pi / 360$ rad, and 1 rad is $360/(2\pi)$].

A phase shift of 360° corresponds to a shift of a complete period.

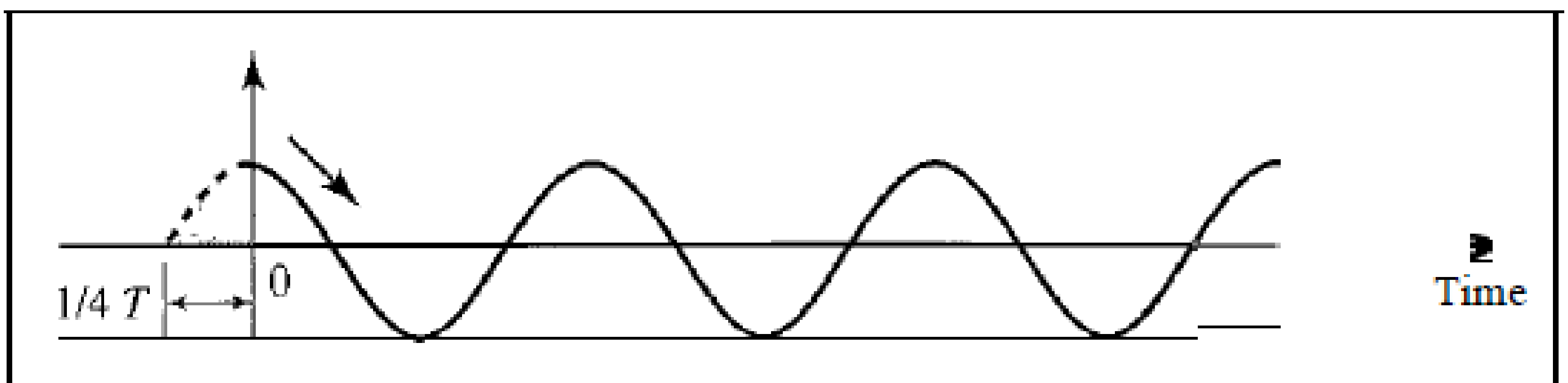
A phase shift of 180° corresponds to a shift of one-half of a period.

A phase shift of 90° corresponds to a shift of one-quarter of a period.

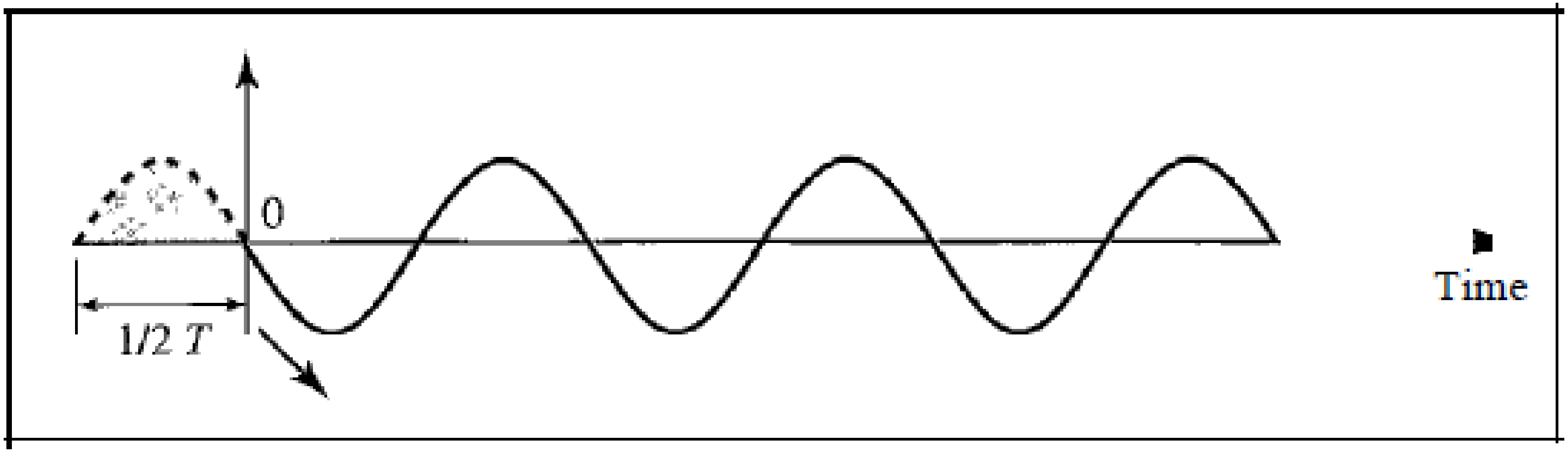
Three sine waves with the same amplitude andfrequency, but different phases



a. 0 degrees



b. 90 degrees



c. 180 degrees

Wavelength

Wavelength is a property of any type of signal. The wavelength is the distance a simple signal can travel in one period.

Wavelength binds the period or the frequency of a simple sine wave to the propagation speed of the medium.

While the frequency of a signal is independent of the medium, the wavelength depends on both the frequency and the medium.

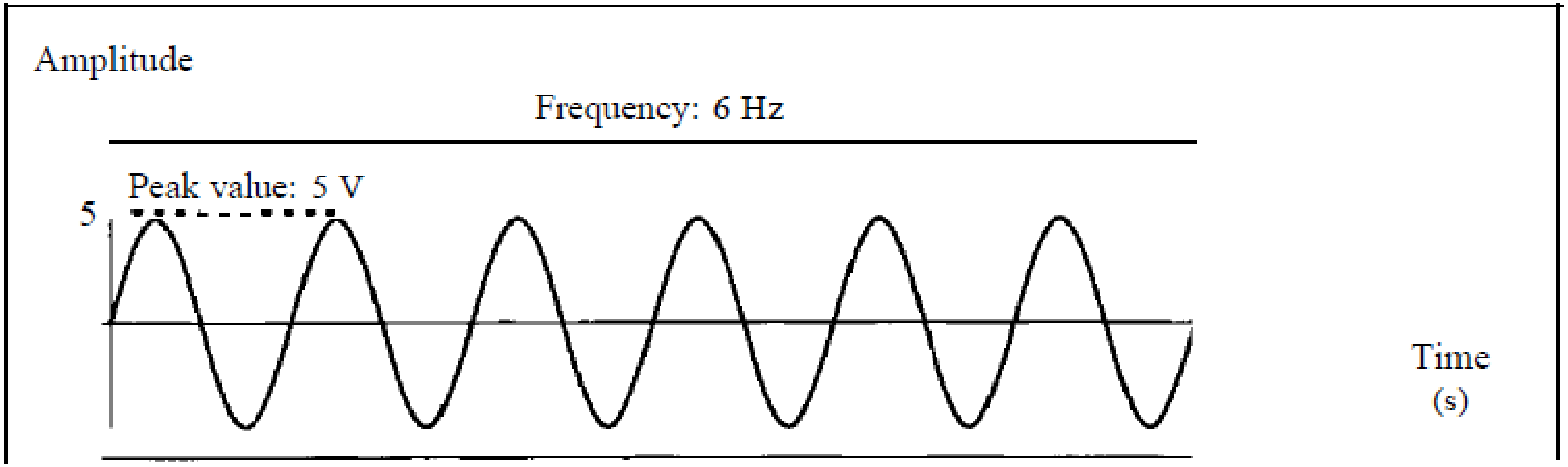
If we represent wavelength by λ, propagation speed by c (speed of light), and frequency by *f, we get*

$$\text{Wavelength} = \text{propagation speed} \times \text{period} = \frac{\text{propagation speed}}{\text{frequency}}$$

$$\lambda = \frac{c}{f}$$

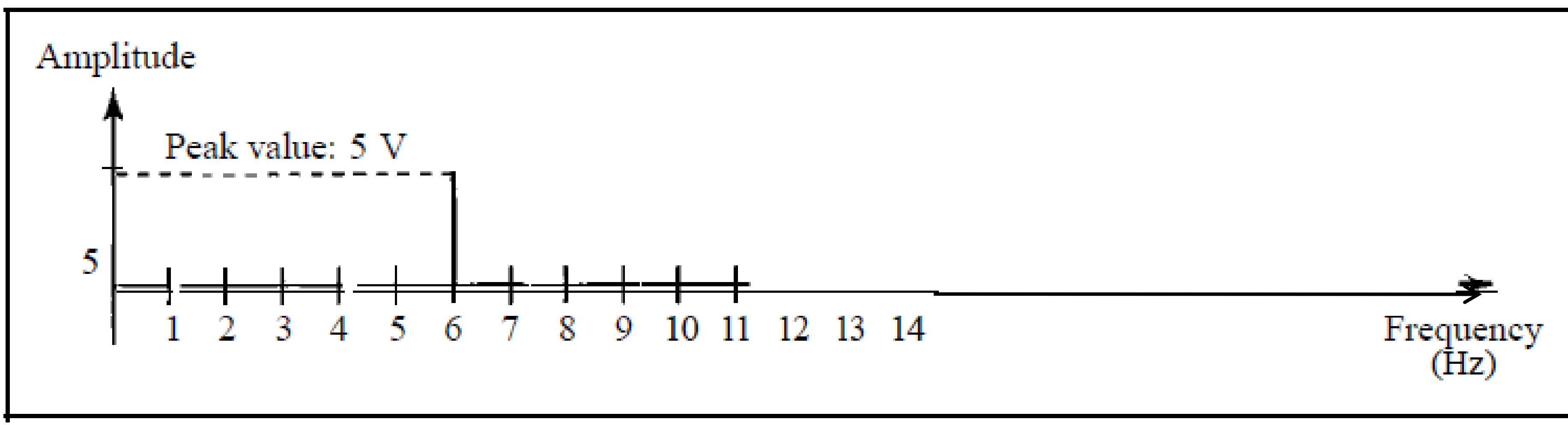
Time and Frequency Domain Plot

The time-domain plot shows changes in signal amplitude with respect to time.



a. A sine wave in the time domain (**peak** value: 5 V, frequency: 6 Hz)

A frequency-domain plot is concerned with only the peak value and the frequency.



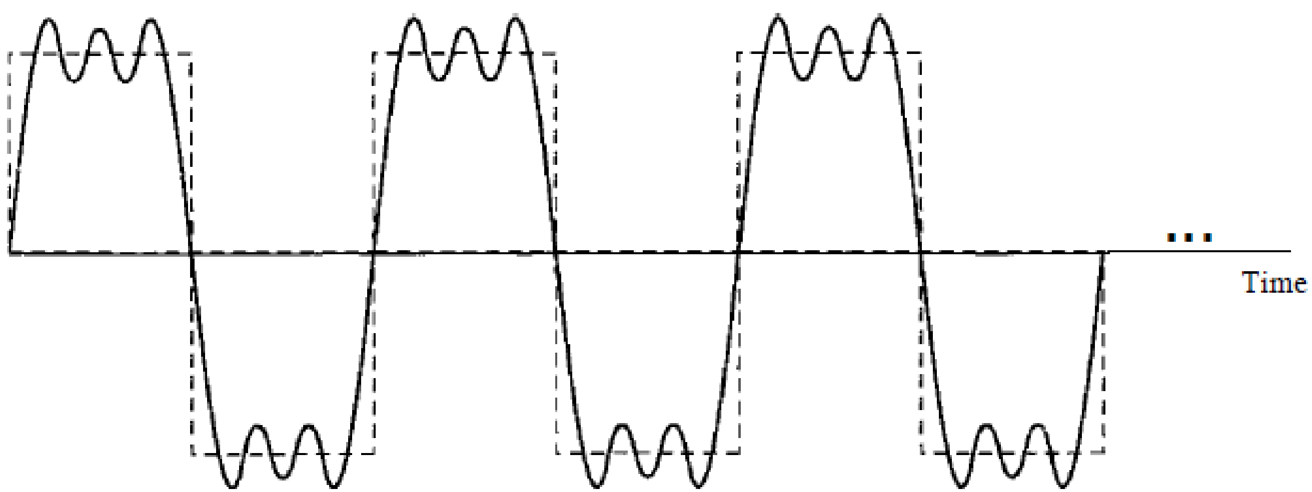
b. The same sine wave in the frequency domain (peak value: 5 V, frequency: 6 Hz)

Composite Signals

- A single frequency sine wave is not useful in data communications; we need to send a composite signal, a signal made of many simple sine waves.
- The French mathematician Jean-Baptiste Fourier showed that any composite signal is actually a combination of simple sine waves with different frequencies, amplitudes, and phases.
- According to Fourier analysis, any composite signal is a combination of simple sine waves with different frequencies, amplitudes, and phases.

❖ If the composite signal is periodic, the decomposition gives a series of signals with discrete frequencies; If the composite signal is non periodic, the decomposition gives a combination of sine waves with continuous frequencies.

A composite periodic signal

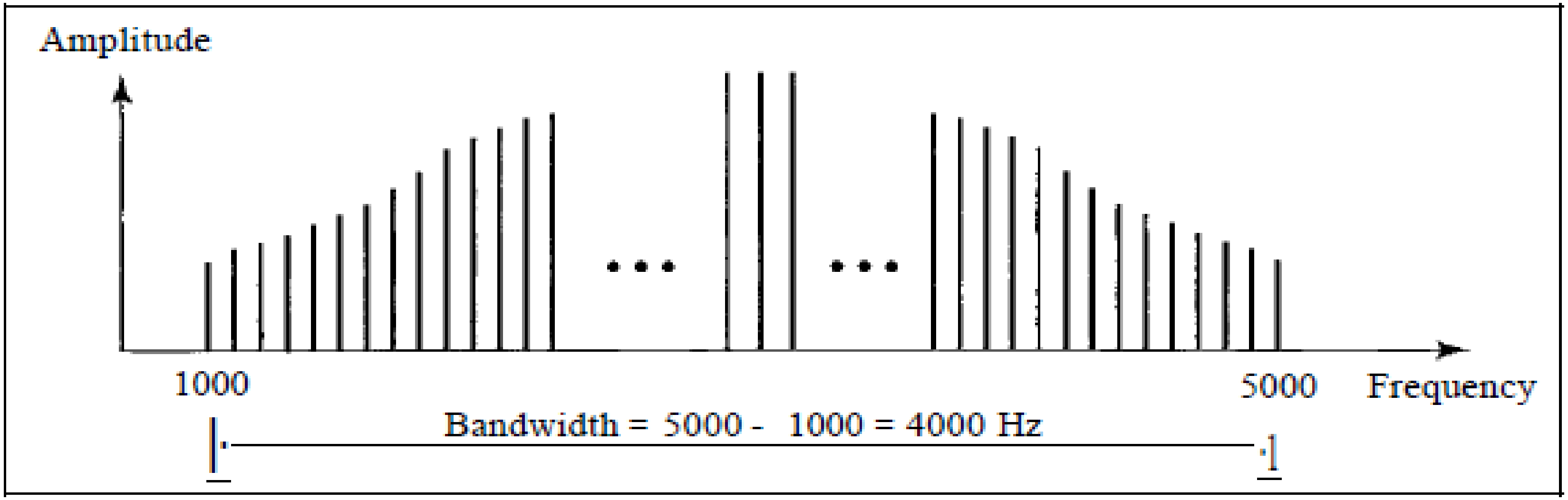


Bandwidth

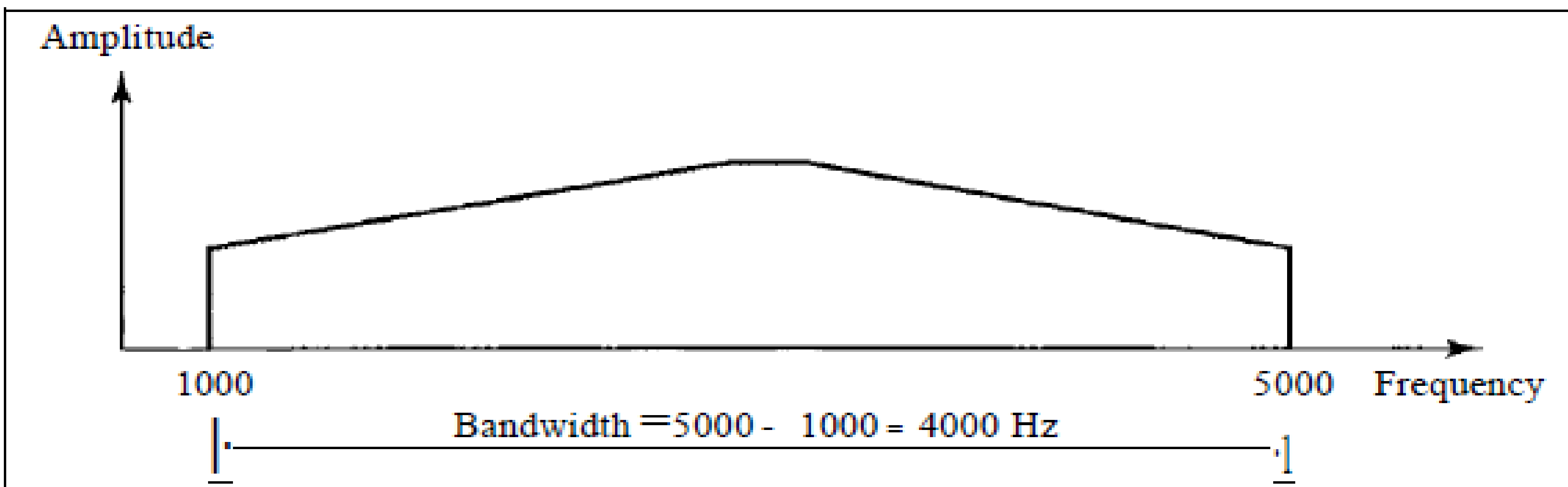
The bandwidth of a composite signal is the difference between the highest and the lowest frequencies contained in that signal. For example, if a composite signal contains frequencies between 1000 and 5000, its bandwidth is 5000 - 1000, or 4000.

The figure depicts two composite signals, one periodic and the other nonperiodic. The bandwidth of the periodic signal contains all integer frequencies between 1000 and 5000 (1000, 100 l, 1002, ...). The bandwidth of the nonperiodic signals has the same range, but the frequencies are continuous.

Figure :- *The bandwidth of periodic and nonperiodic composite signals*



a. Bandwidth of a periodic signal



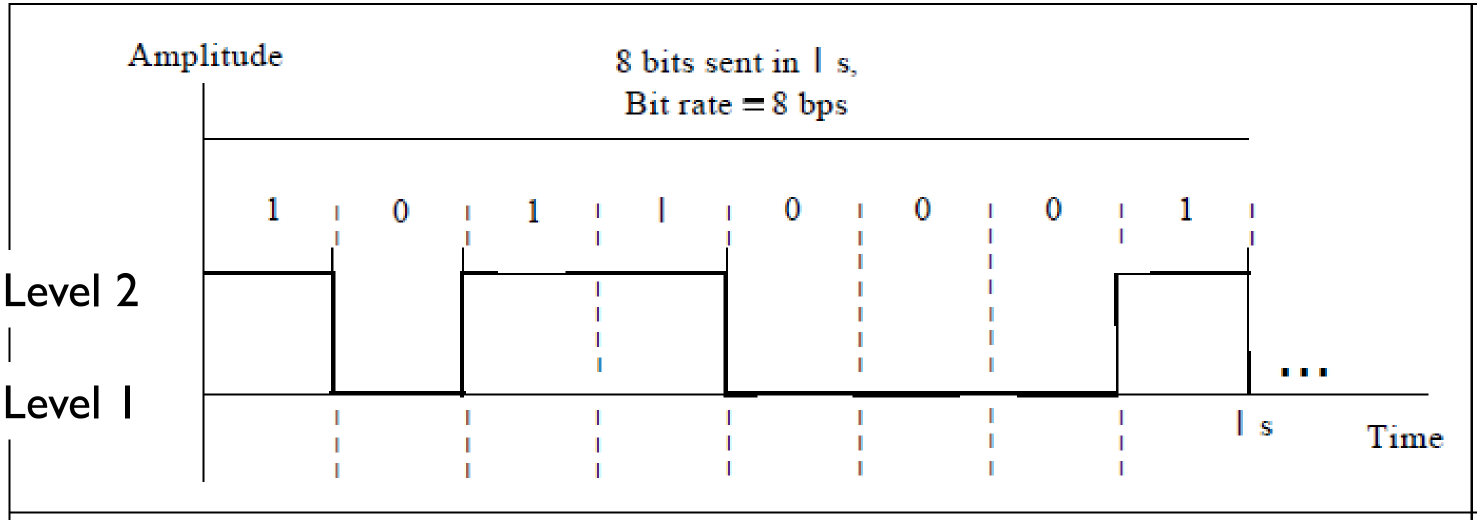
b. Bandwidth of a nonperiodic signal

DIGITAL SIGNALS

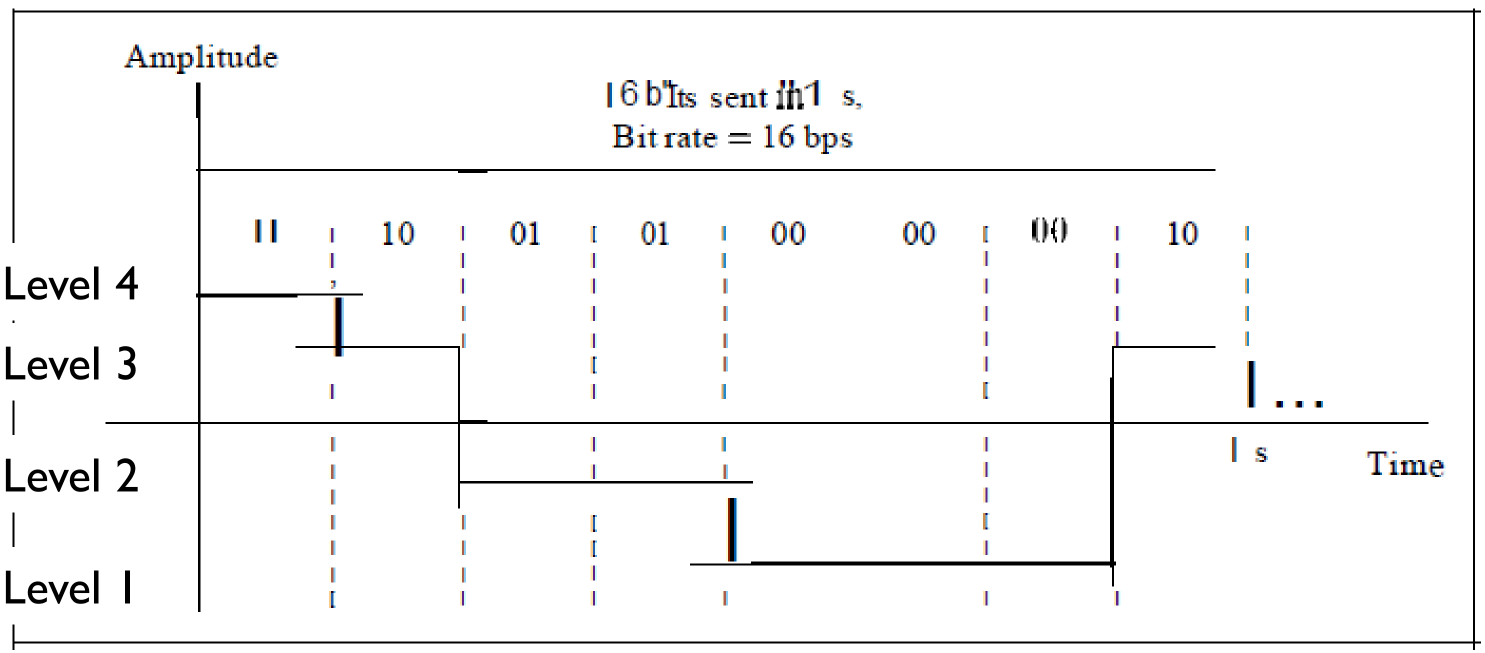
In digital signal, a 1 can be encoded as a positive voltage and a 0 as zero voltage. A digital signal can have more than two levels. In this case, we can send more than 1 bit for each level.

In general, if a signal has *L levels, each level needs* $log_2 L$ *bits*.

Figure *Two digital signals: one with two signal levels and the other with four signal levels*



a. A digital signal with two levels



b. A digital signal with four levels

Bit Rate
(data rate)

•The bit rate is the number of bits sent in 1s, expressed in bits per second (bps).

Figure above shows the bit rate for two signals.

Bit Length

•The bit length is the distance one bit occupies on the transmission medium.

Bit length =propagation speed x bit duration

Baud rate
(Signal rate or pulse rate or modulation rate)

- The number of signal elements transmitted per second.
- Data elements are the bits that are being carried. Signal elements are used to carry data elements.
- A signal element consists of one or more bits.
- Baud rate is measured as number of times a signal state is changed in a communication channel.
- It is expressed in baud.

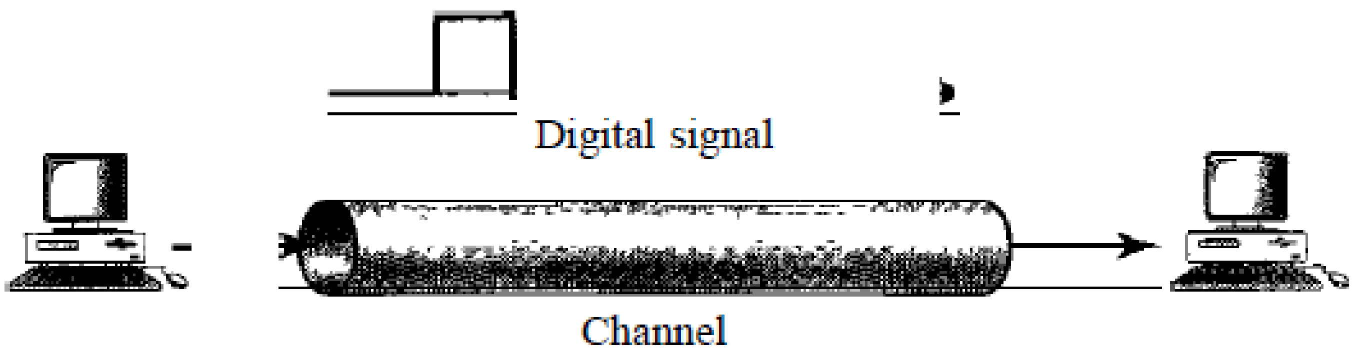
Transmission of Digital Signals

We can transmit a digital signal by using one of two different approaches: baseband transmission or broadband transmission (using modulation).

Baseband Transmission

Baseband transmission means sending a digital signal over a channel without changing the digital signal to an analog signal. Figure shows baseband transmission.

Baseband transmission



Baseband transmission requires that we have a **low-pass channel,** a channel with a bandwidth that starts from zero.

Broadband Transmission (Using Modulation)

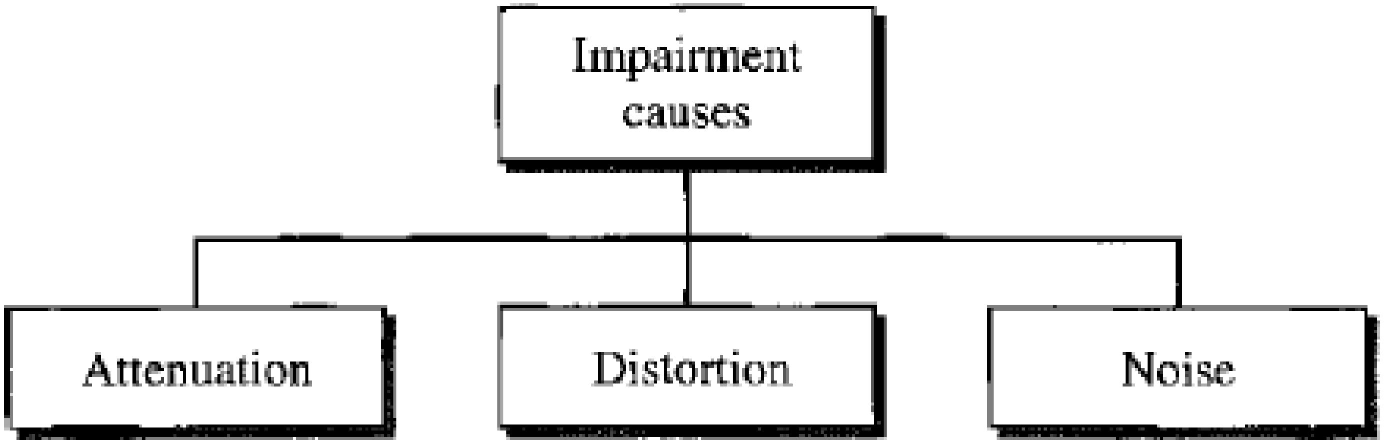
- Broadband transmission or modulation means changing the digital signal to an analog signal for transmission.
- Modulation allows us to use a **band pass channel -** a channel with a bandwidth that does not start from zero.

If the available channel is a band pass channel, we cannot send the digital signal directly to the channel; we need to convert the digital signal to an analog signal before transmission.

TRANSMISSION IMPAIRMENT

Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium.

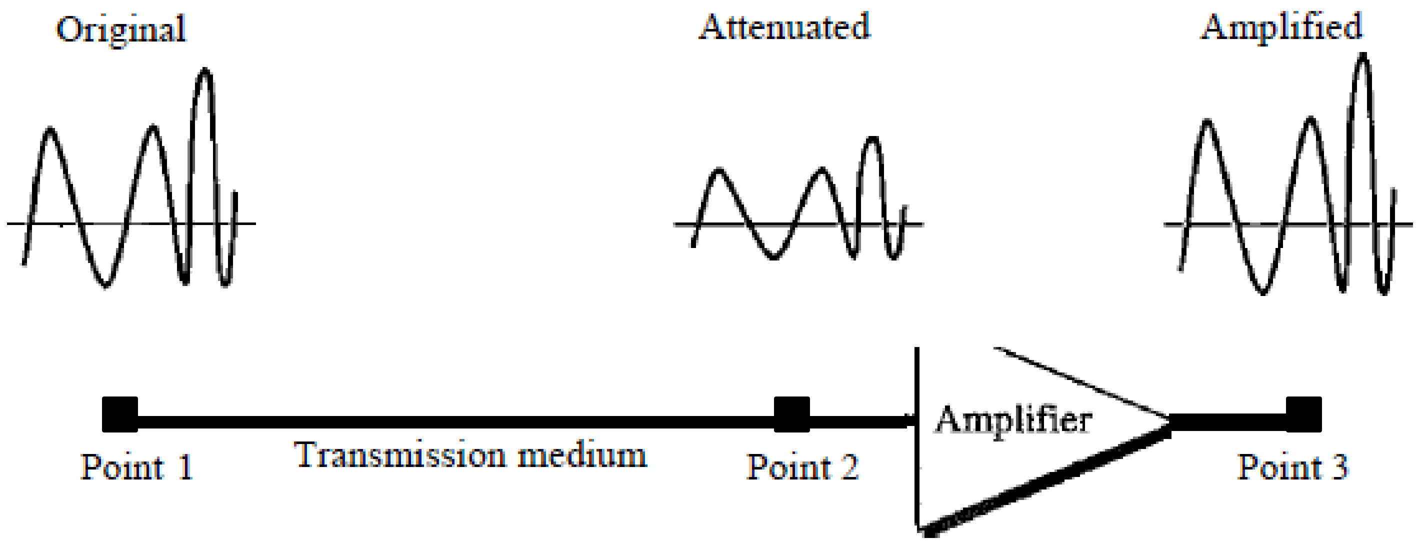
Causes of impairment



Attenuation

Attenuation means a loss of energy. When a signal, simple or composite, travels through a medium, it loses some of its energy in overcoming the resistance of the medium. Some of the electrical energy in the signal is converted to heat. To compensate for this loss, **amplifiers** are used to amplify the signal.

Figure shows the effect of attenuation and amplification.



Decibel

- To show that a signal has lost or gained strength, engineers use the unit of the **decibel**.
- The decibel (dB) measures the relative strengths of two signals or one signal at two different points. Note that the decibel is **negative** if a signal is attenuated and **positive** if a signal is amplified.

$$dB = 10 \log_{10} \frac{P_2}{P_1}$$

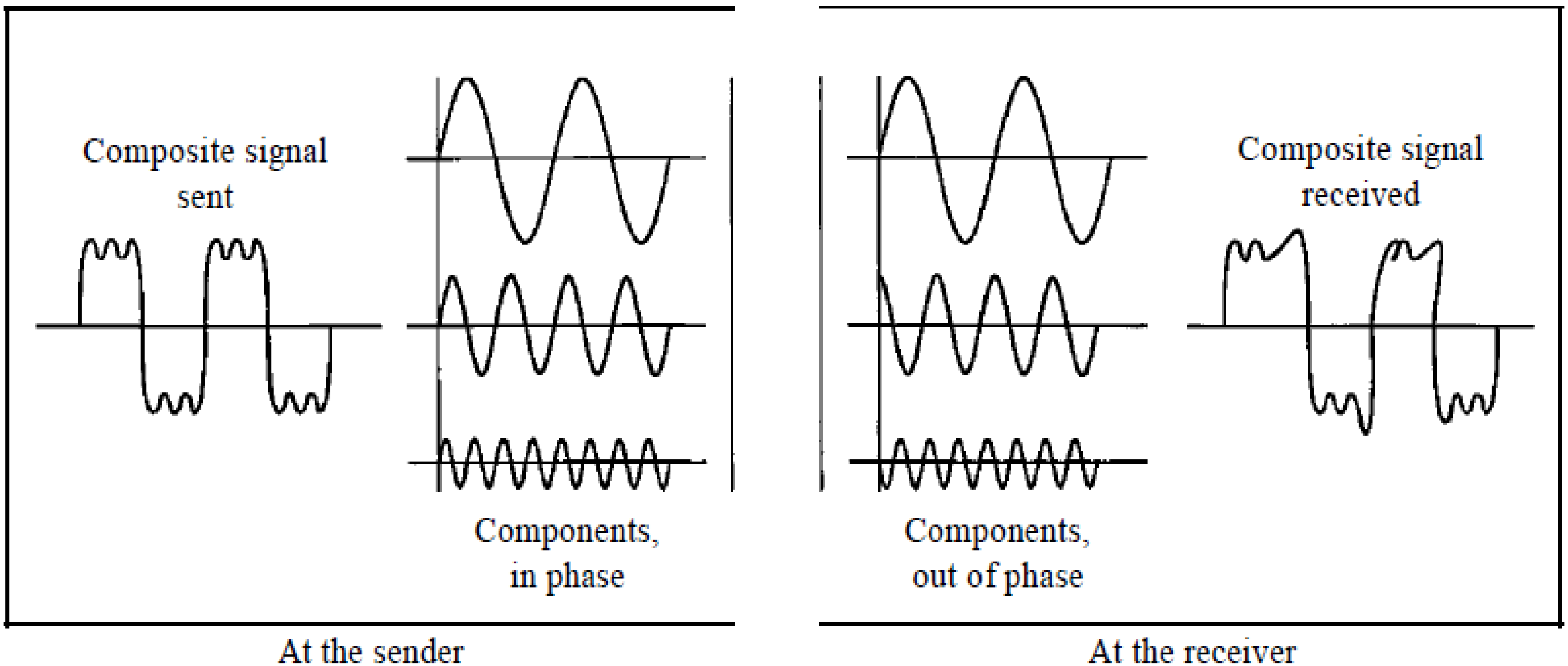
Variables PI and P2 are the powers of a signal at points I and 2, respectively.

Distortion

•Distortion means that the signal changes its form or shape. Distortion can occur in a composite signal made of different frequencies.

•Each signal component has its own propagation speed through a medium and, therefore, its own delay in arriving at the final destination. Differences in delay may create a difference in phase. Signal components at the receiver have phases different from what they had at the sender. The shape of the composite signal is therefore not the same.

Figure shows the effect of distortion.



Noise

Noise is another cause of impairment. Several types of noise, such as thermal noise, induced noise, crosstalk, and impulse noise, may corrupt the signal.

Thermal noise is the random motion of electrons in a wire which creates an extra signal not originally sent by the transmitter.

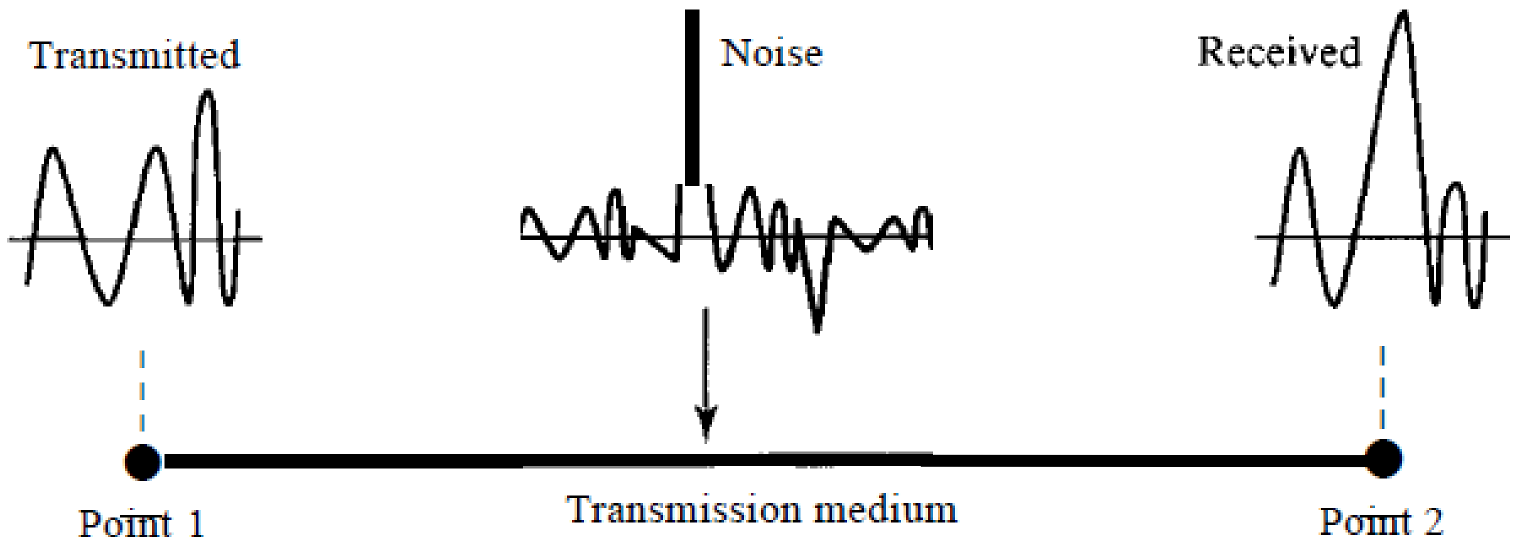
Induced noise comes from sources such as motors and appliances. These devices act as a sending antenna, and the transmission medium acts as the receiving antenna.

Crosstalk is the effect of one wire on the other. One wire acts as a sending antenna and the other as the receiving antenna.

Impulse noise is a spike that comes from power lines, lightning, and so on.

Figure below shows the effect of noise on a signal.

Noise



Signal-to-Noise Ratio (SNR)

The signal-to-noise ratio is defined as

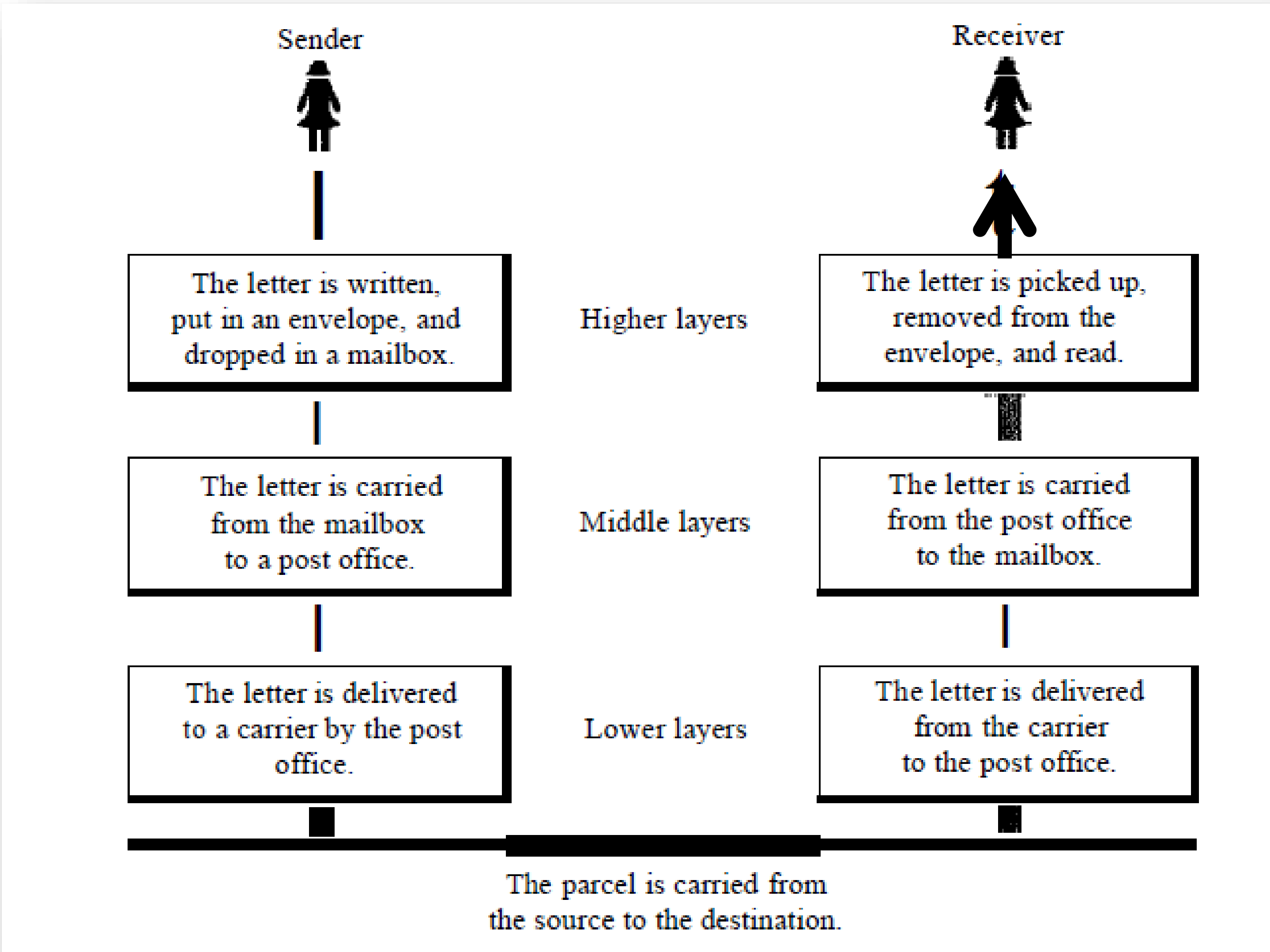
$$\text{SNR} = \frac{\text{average signal power}}{\text{average noise power}}$$

SNR is actually the ratio of what is wanted (signal) to what is not wanted (noise). A high SNR means the signal is less corrupted by noise; a low SNR means the signal is more corrupted by noise. Because SNR is the ratio of two powers, it is often described in decibel units, **SNRdB**.

NETWORK MODELS

LAYERED TASKS

We use the concept of layers in our daily life. As an example, let us consider two friends who communicate through postal mail.



THE OSI MODEL

The International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards. An ISO standard that covers all aspects of network communications is the **Open Systems Interconnection Model**.

- The purpose of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hardware and software.

- The OSI model is not a protocol; it is a model for understanding and designing a network architecture that is flexible, robust, and interoperable.

- ISO is the organization. OSI is the model.

Seven layers of the OSI model

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data link

1 Physical

Layered Architecture

The OSI model is composed of seven ordered layers:

Layer 1 - Physical Layer

Layer 2 - Data link Layer

Layer 3 - Network Layer

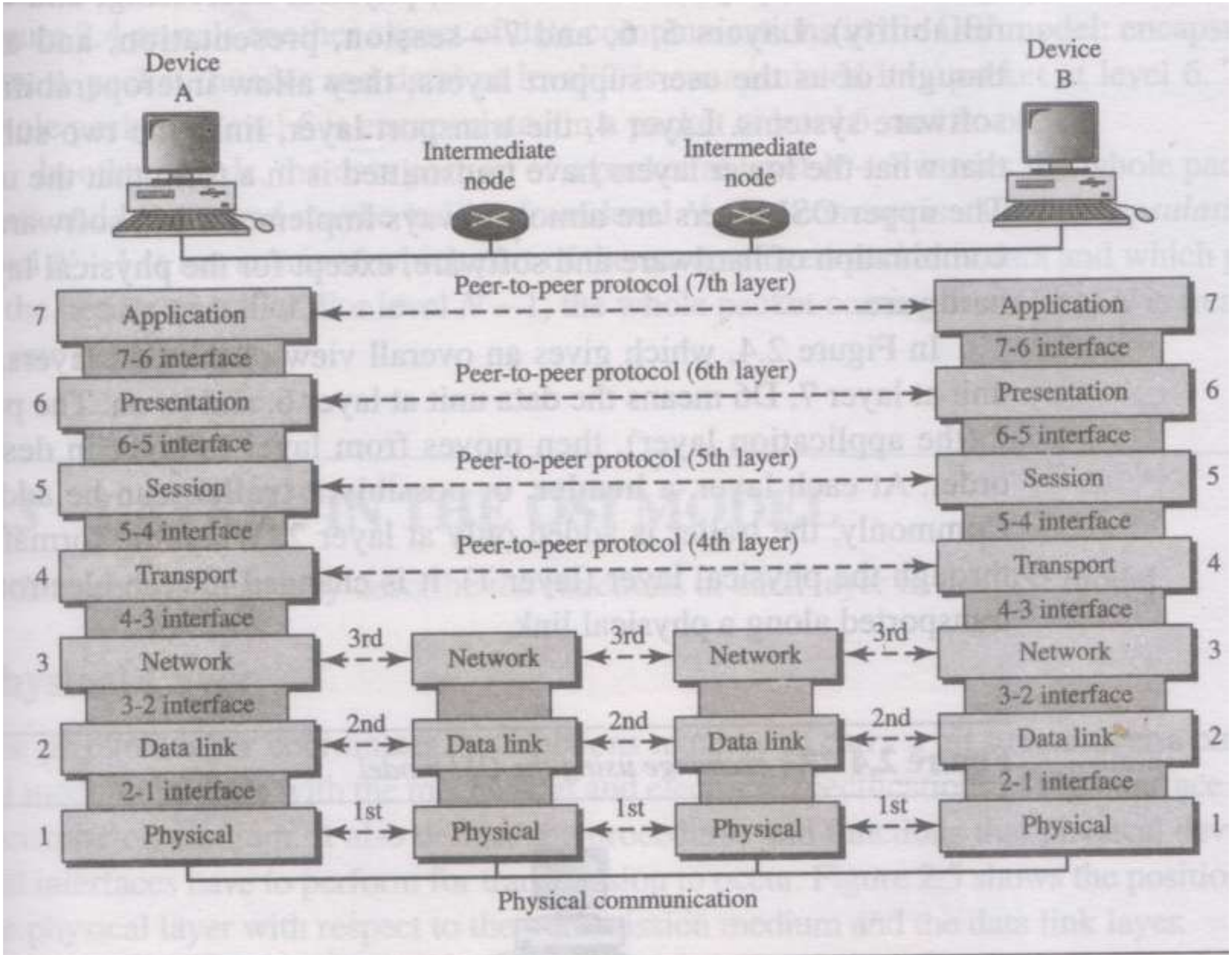
Layer 4 - Transport Layer

Layer 5 - Session Layer

Layer 6 - Presentation Layer

Layer 7 - Application Layer

Figure shows the layers involved when a message is sent from device A to device B.


Device A
Device B
Intermediate node
Intermediate node
Peer-to-peer protocol (7th layer)
Peer-to-peer protocol (6th layer)
Peer-to-peer protocol (5th layer)
Peer-to-peer protocol (4th layer)
7 Application
7-6 interface
6 Presentation
6-5 interface
5 Session
5-4 interface
4 Transport
4-3 interface
3 Network
3-2 interface
2 Data link
2-1 interface
1 Physical
3rd
2nd
1st
Network
Data link
Physical
Physical communication

Within a single machine, each layer calls upon the services of the layer just below it. Layer 3, for example, uses the services provided by layer 2 and provides services for layer 4. Between machines, layer *x on one machine communicates with layer x on* another machine.

Peer-to-Peer Processes

The processes on each machine that communicate at a given layer are called peer-to-peer processes.

At the physical layer, communication is direct.

In Figure, device A sends a stream of bits to device B.

At the higher layers, however, communication must move down through the layers on device A, over to device B, and then back up through the layers. Each layer in the sending device adds its own information to the message it receives from the layer just above it and passes the whole package to the layer just below it.

At layer 1 the entire package is converted to a form that can be transmitted to the receiving device. At the receiving machine, the message is unwrapped layer by layer, with each process receiving and removing the data meant for it.

Interfaces Between Layers

Each interface defines the information and services a layer must provide for the layer above it. Well-defined interfaces and layer functions provide modularity to a network.

Organization of the Layers

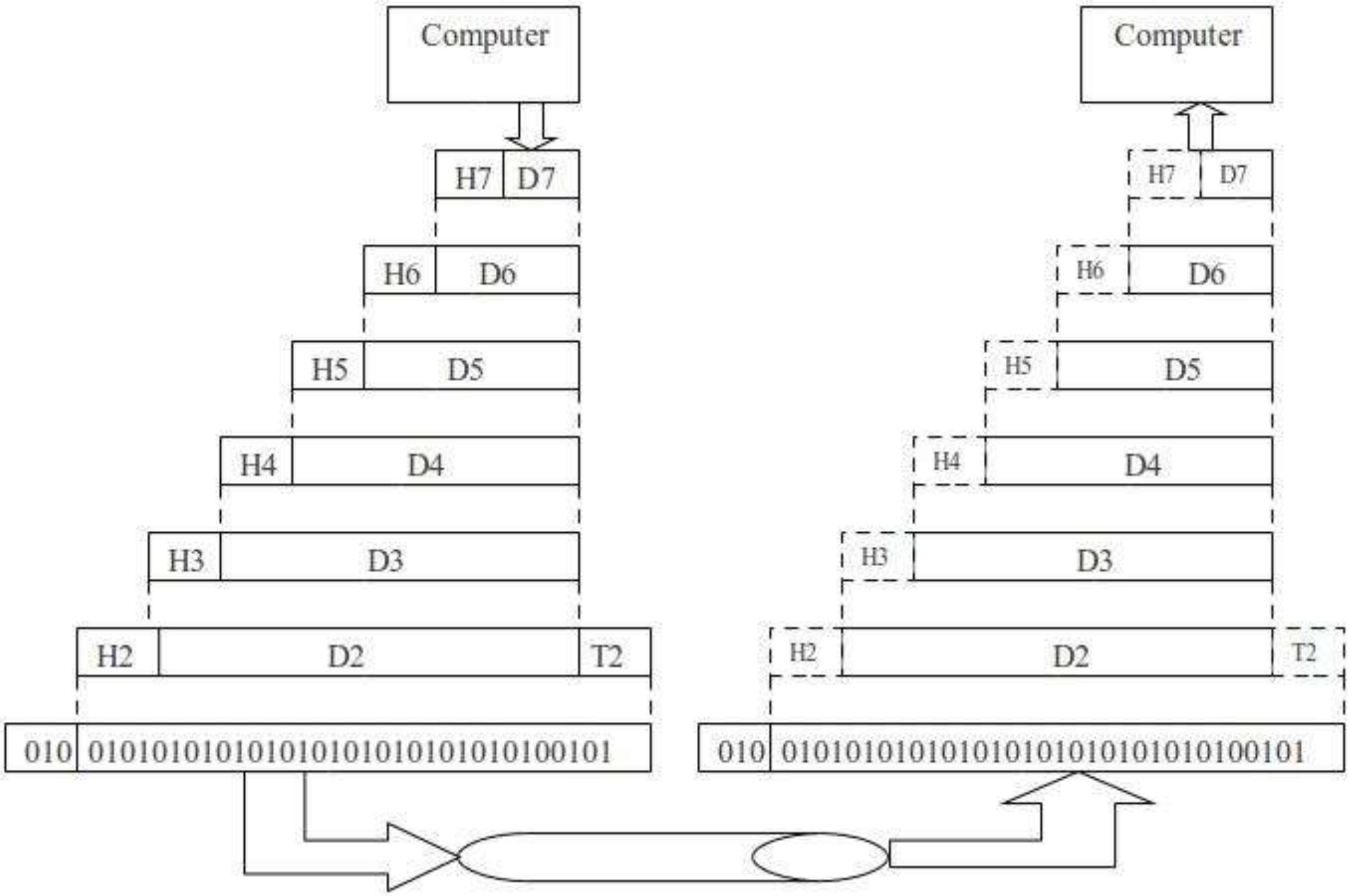
The seven layers can be thought of as belonging to three subgroups.

Layers 1, 2, and 3-physical, data link, and network-are the **network support layers**; the physical aspects of moving data from one device to another.

Layers 5, 6, and 7 -session, presentation, and application-can be thought of as the **user support layers;** they allow interoperability among unrelated software systems.

Layer 4, the transport layer, links the two subgroups and ensures that what the lower layers have transmitted is in a form that the upper layers can use.

Figure: An exchange using the OSI model



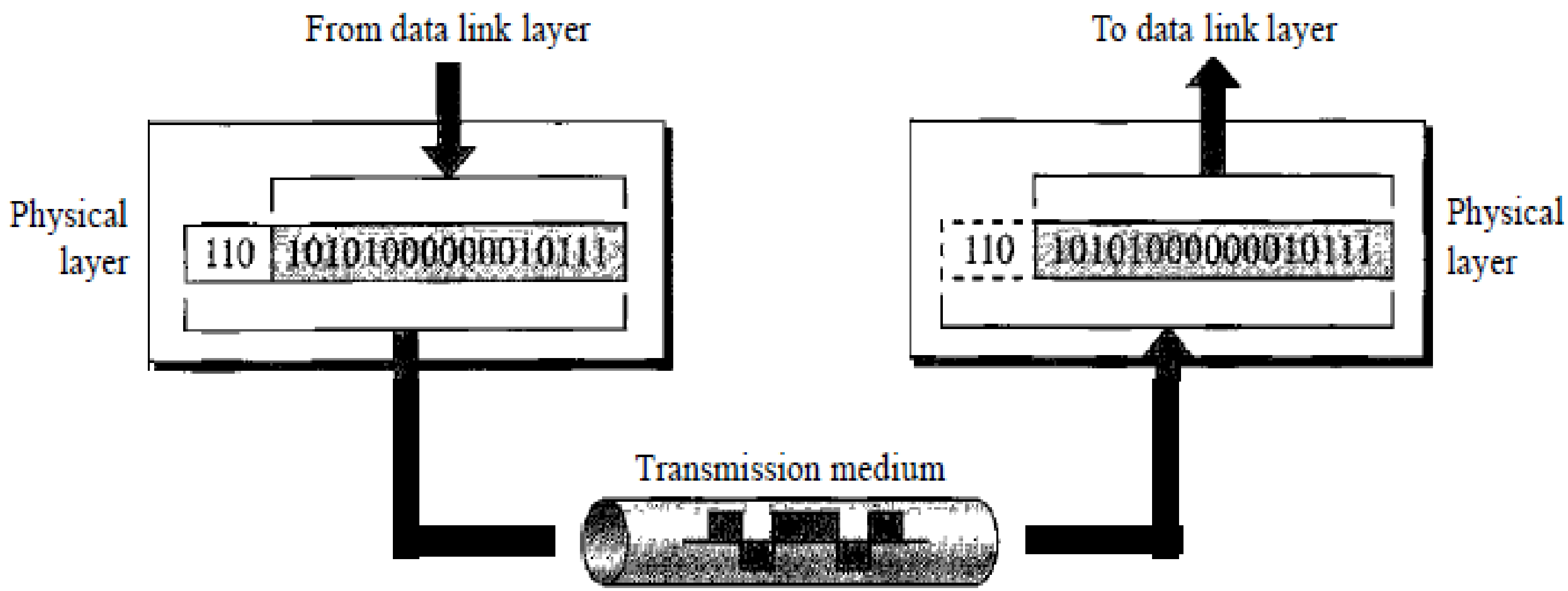
In Figure, which gives an overall view of the OSI layers, D7 means the data unit at layer 7, D6 means the data unit at layer 6, and so on. The process starts at layer 7 (the application layer), then moves from layer to layer in descending, sequential order. At each layer, a **header, or possibly a trailer, can be added to the data unit.** Commonly, the trailer is added only at layer 2. When the formatted data unit passes through the physical layer (layer 1), it is changed into an electromagnetic signal and transported along a physical link.

LAYERS IN THE OSI MODEL

Physical Layer

Physical layer deals with the mechanical and electrical specifications of the interface and transmission medium. Figure shows the position of the physical layer with respect to the transmission medium and the data link layer.

The physical layer is responsible for movements of individual bits from one hop (node) to the next.


From data link layer
To data link layer
Physical
layer
110
10101000000010111
110
10101000000010111
Physical
layer
Transmission medium

The physical layer is also concerned with the following:

- **Physical characteristics of interfaces and medium.** The physical layer defines the characteristics of the interface between the devices and the transmission medium. It also defines the type of transmission medium.

- **Representation of bits.** The physical layer data consists of a stream of bits (sequence of 0s or 1s) with no interpretation. To be transmitted, bits must be encoded into signals--electrical or optical. The physical layer defines the type of encoding.

- **Data rate.** The transmission rate-the number of bits sent each second-is also defined by the physical layer.

- **Synchronization of bits.** The sender and receiver not only must use the same bit rate but also must be synchronized at the bit level.

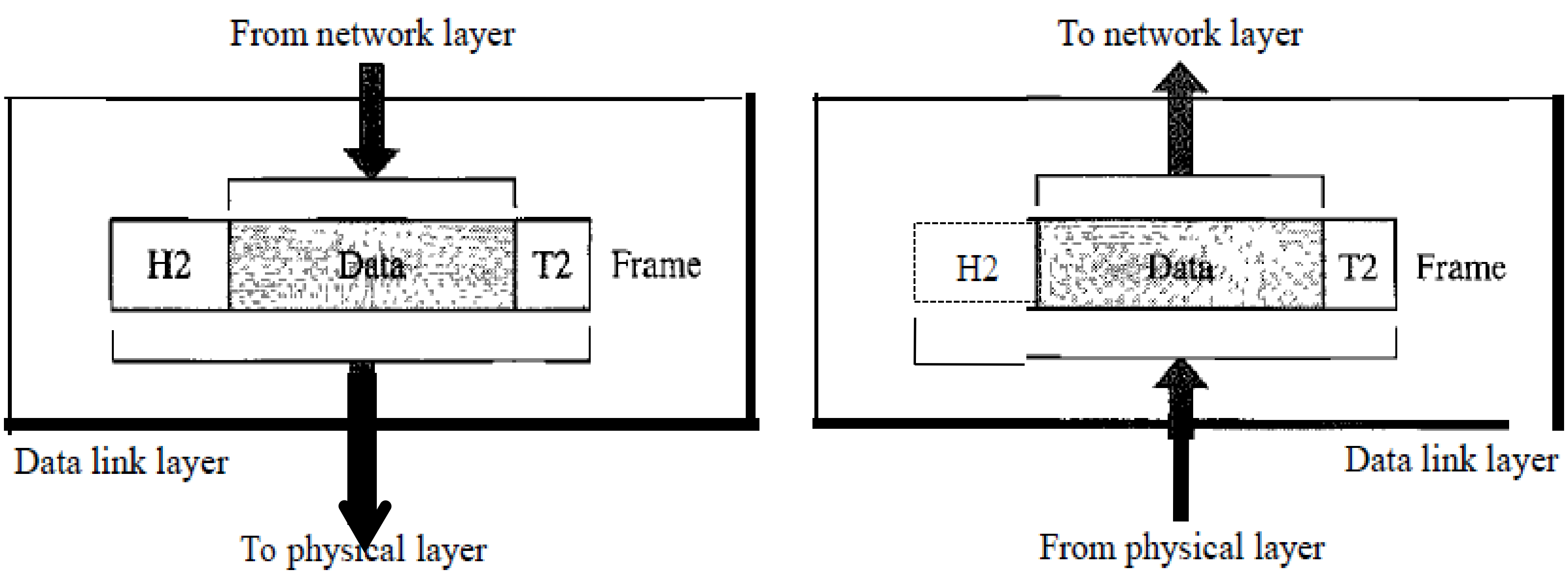
- **Line configuration.** The physical layer is concerned with the connection of devices to the media ie, point-to-point configuration and multipoint configuration.

- **Physical topology.** The physical topology defines how devices are connected to make a network. Topologies are mesh topology , star topology, ring topology , bus topology and hybrid topology

- **Transmission mode.** The physical layer also defines the direction of transmission between two devices: **simplex, half-duplex, or full-duplex.**
  - In simplex mode, only one device can send; the other can only receive.
  - In the half-duplex mode, two devices can send and receive, but not at the same time.
  - In a full-duplex mode, two devices can send and receive at the same time.

Data Link Layer

The data link layer transforms the physical layer, a raw transmission facility, to a reliable link. Figure shows the relationship of the data link layer to the network and physical layers.



The data link layer is responsible for moving frames from one hop (node) to the next.

Other responsibilities of the data link layer include the following:

- **Framing**. The data link layer divides the stream of bits received from the network layer into manageable data units called frames.

- **Physical addressing.** If frames are to be distributed to different systems on the network, the data link layer adds a header to the frame to define the sender and/or receiver of the frame. If the frame is intended for a system outside the sender‘s network, the receiver address is the address of the device that connects the network to the next one.

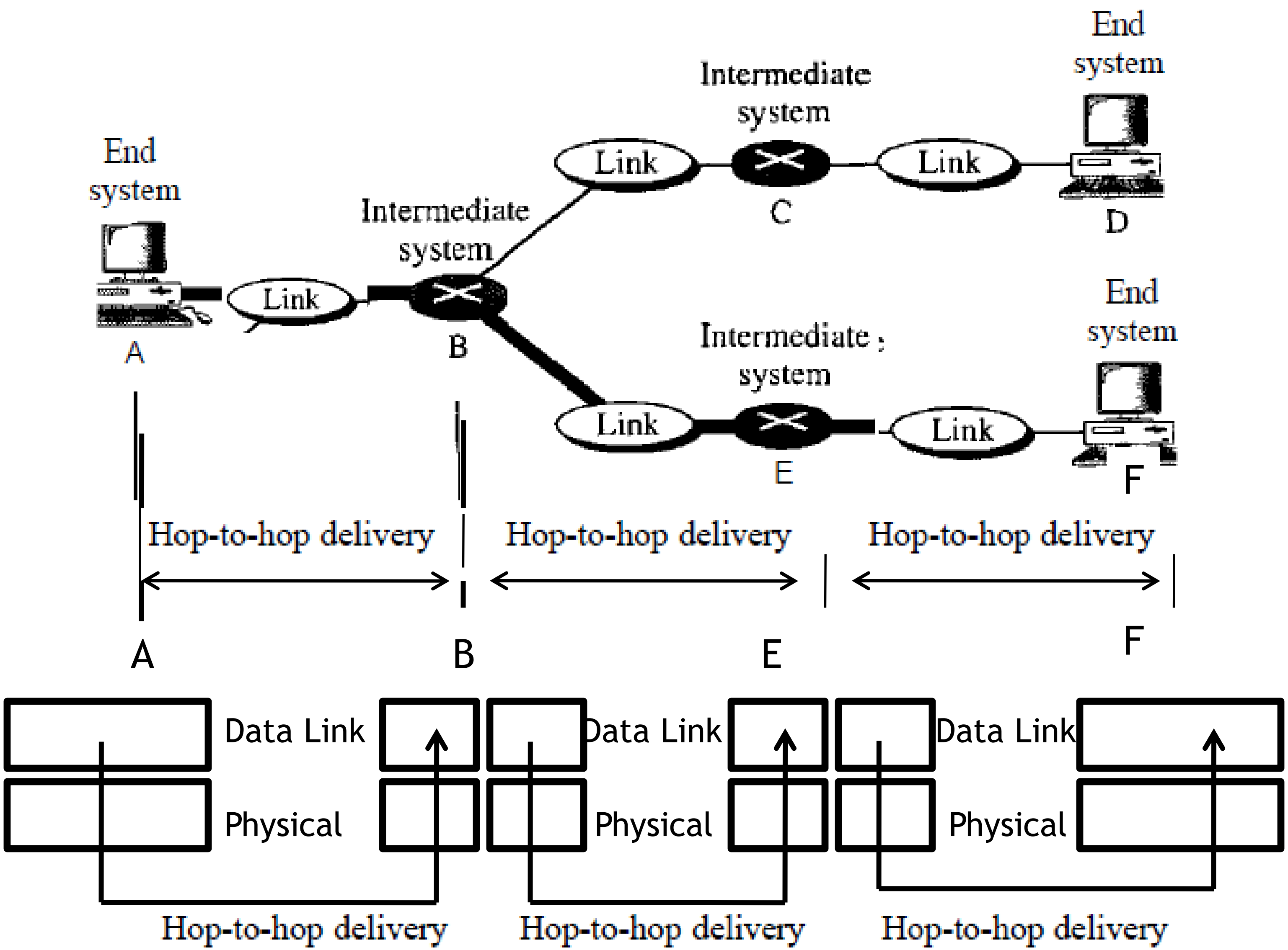
- **Flow control.** If the rate at which the data are absorbed by the receiver is less than the rate at which data are produced in the sender, the data link layer imposes a flow control mechanism to avoid overwhelming the receiver.

- **Error control.** The data link layer adds reliability to the physical layer by adding mechanisms to detect and retransmit damaged or lost frames. It also uses a mechanism to recognize duplicate frames.

- **Access control.** When two or more devices are connected to the same link, data link layer protocols are necessary to determine which device has control over the link at any given time.

Hop-to-hop delivery

Figure illustrates hop-to-hop (node-to-node) delivery by the data link layer.


End system
A
Link
Intermediate system
B
Link
Intermediate system
C
Link
End system
D
Link
Intermediate system
E
Link
End system
F
Hop-to-hop delivery
Hop-to-hop delivery
Hop-to-hop delivery
A
B
E
F
Data Link
Physical
Data Link
Physical
Data Link
Physical
Hop-to-hop delivery
Hop-to-hop delivery
Hop-to-hop delivery

As the figure shows, communication at the data link layer occurs between two adjacent nodes. To send data from A to F, three partial deliveries are made.

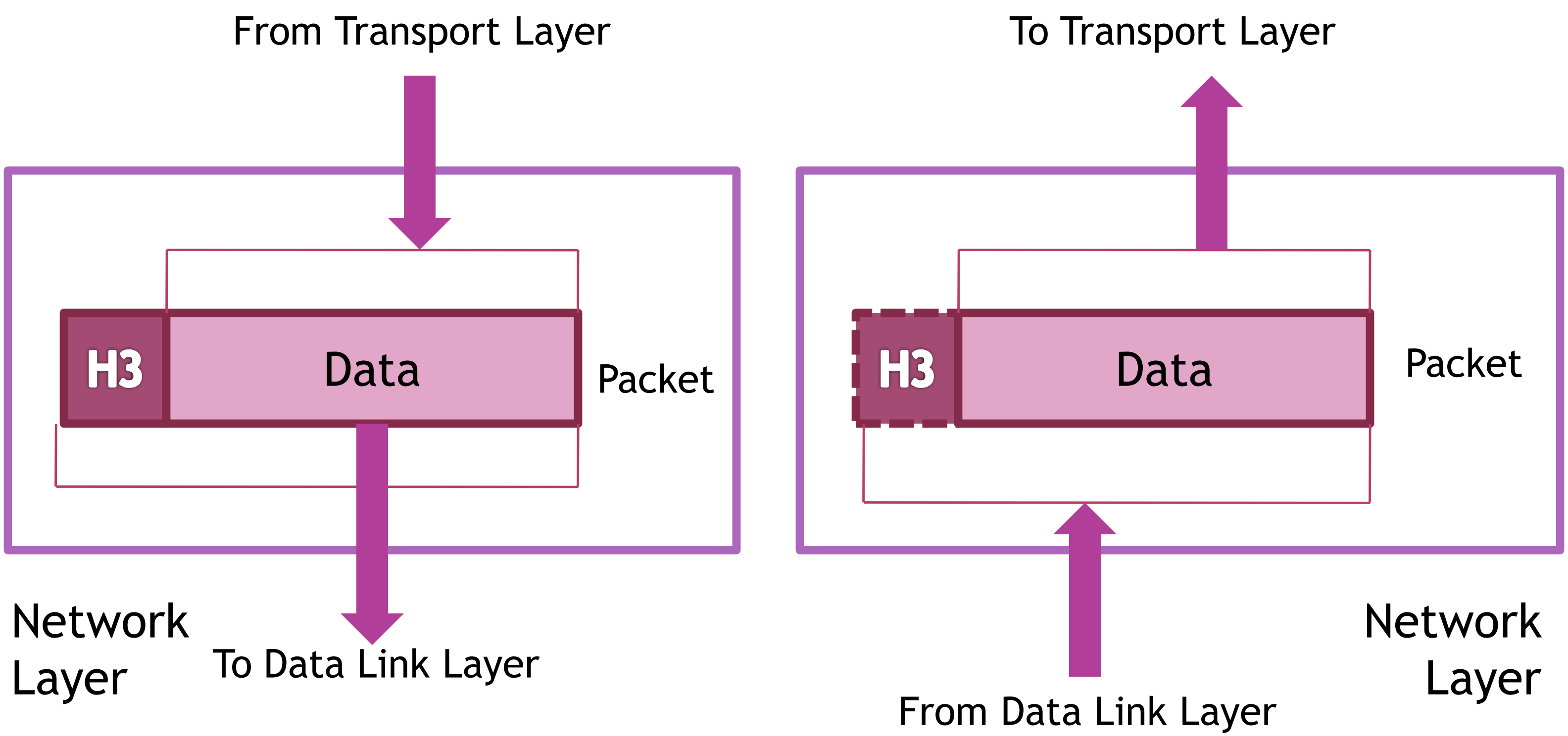
First, the data link layer at A sends a frame to the data link layer at B (a router). Second, the data link layer at B sends a new frame to the data link layer at E. Finally, the data link layer at E sends a new frame to the data link layer at F.

Note that the frames that are exchanged between the three nodes have different values in the headers. The frame from A to B has B as the destination address and A as the source address. The frame from B to E has E as the destination address and B as the source address. The frame from E to F has F as the destination address and E as the source address. The values of the trailers can also be different if error checking includes the header of the frame.

Network Layer

The network layer is responsible for the source-to-destination delivery of a packet, possibly across multiple networks (links). If two systems are connected to the same link, there is usually no need for a network layer. If the two systems are attached to different networks (links) with connecting devices between the networks (links), there is often a need for the network layer to accomplish source-to-destination delivery.

Figure shows the relationship of the network layer to the data link and transport layers.



The network layer is responsible for the delivery of individual packets from the source host to the destination host.

Other responsibilities of the network layer,

- Logical addressing. The physical addressing implemented by the data link layer handles the addressing problem locally. If a packet passes the network boundary, we need another addressing system to help distinguish the source and destination systems. The network layer adds a header to the packet coming from the upper layer that includes the logical addresses of the sender and receiver.

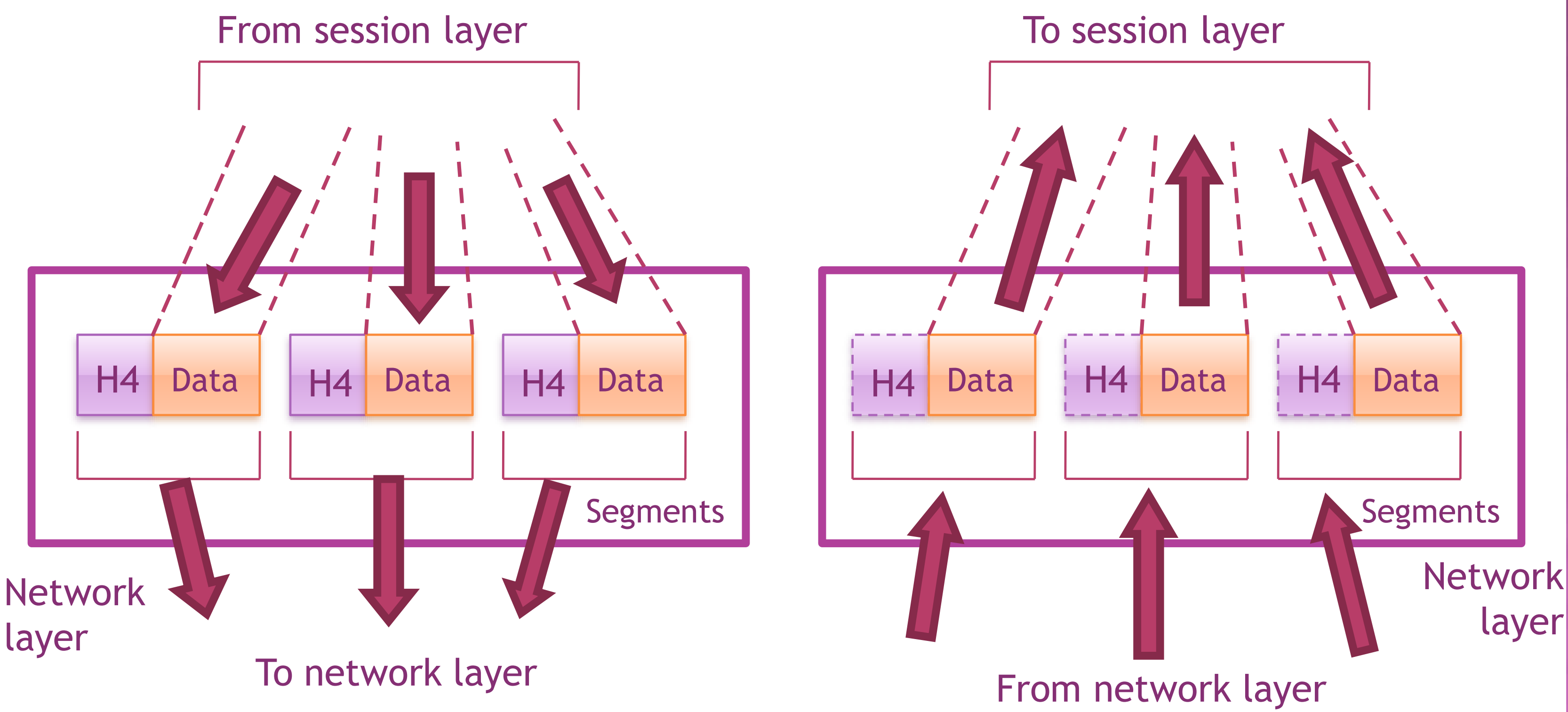
- Routing. When independent networks or links are connected to create *internetworks* (network of networks) or a large network, the connecting devices (called *routers* or *switches) route or switch the packets to their final destination*.

Transport Layer

The transport layer is responsible for process-to-process delivery of the entire message. The network layer oversees source-to-destination delivery of individual packets, it does not recognize any relationship between those packets. The transport layer ensures that the whole message arrives intact and in order, overseeing both error control and flow control at the source-to-destination level.

The transport layer is responsible for the delivery of a message from one process to another.

Figure shows the relationship of the transport layer to the network and session layers.



Other responsibilities of the transport layer

- **Service-point addressing.** Computers often run several programs at the same time. The transport layer header must therefore include a type of address called a service-point address (or port address). The network layer gets each packet to the correct computer; the transport layer gets the entire message to the correct process on that computer.

- **Segmentation and reassembly.** A message is divided into transmittable segments, with each segment containing a sequence number. These numbers enable the transport layer to reassemble the message correctly upon arriving at the destination and to identify and replace packets that were lost in transmission.

- **Connection control.** The transport layer can be either connectionless or connection oriented. A connectionless transport layer treats each segment as an independent packet and delivers it to the transport layer at the destination machine. A connection oriented transport layer makes a connection with the transport layer at the destination machine first before delivering the packets. After all the data are transferred, the connection is terminated.

- Flow control. The transport layer is responsible for flow control. Flow control at this layer is performed end to end.

- Error control. The transport layer is responsible for error control. Error control at this layer is performed process-to process. The sending transport layer makes sure that the entire message arrives at the receiving transport layer without error.

Session Layer

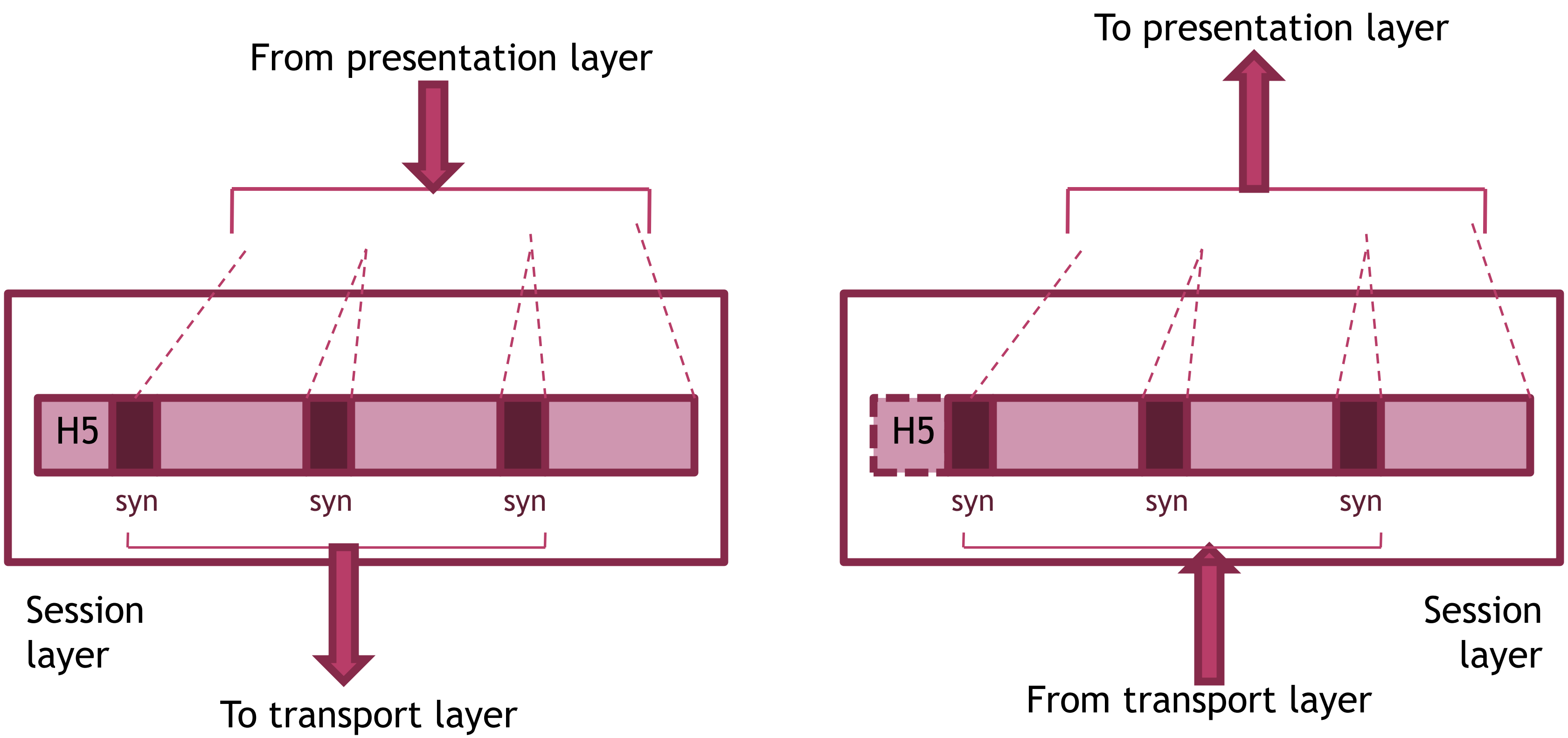
The services provided by the first three layers are not sufficient for some processes. The session layer is the network *dialog controller.*

The session layer is responsible for dialog control and synchronization.

Responsibilities of the session layer:

- Dialog control. The session layer allows two systems to enter into a dialog. It allows the communication between two processes to take place in either half-duplex or full-duplex mode.

- Synchronization. The session layer allows a process to add checkpoints, or synchronization points, to a stream of data. For example, if a system is sending a file of 2000 pages, it is advisable to insert checkpoints after every 100 pages to ensure that each 100-page unit is received and acknowledged independently. In this case, if a crash happens during the transmission of page 523, the only pages that need to be resent after system recovery are pages 501 to 523. Figure below shows Session Layer.



Presentation Layer

The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems.

The presentation layer is responsible for translation, compression, and encryption.

Responsibilities of the presentation layer,

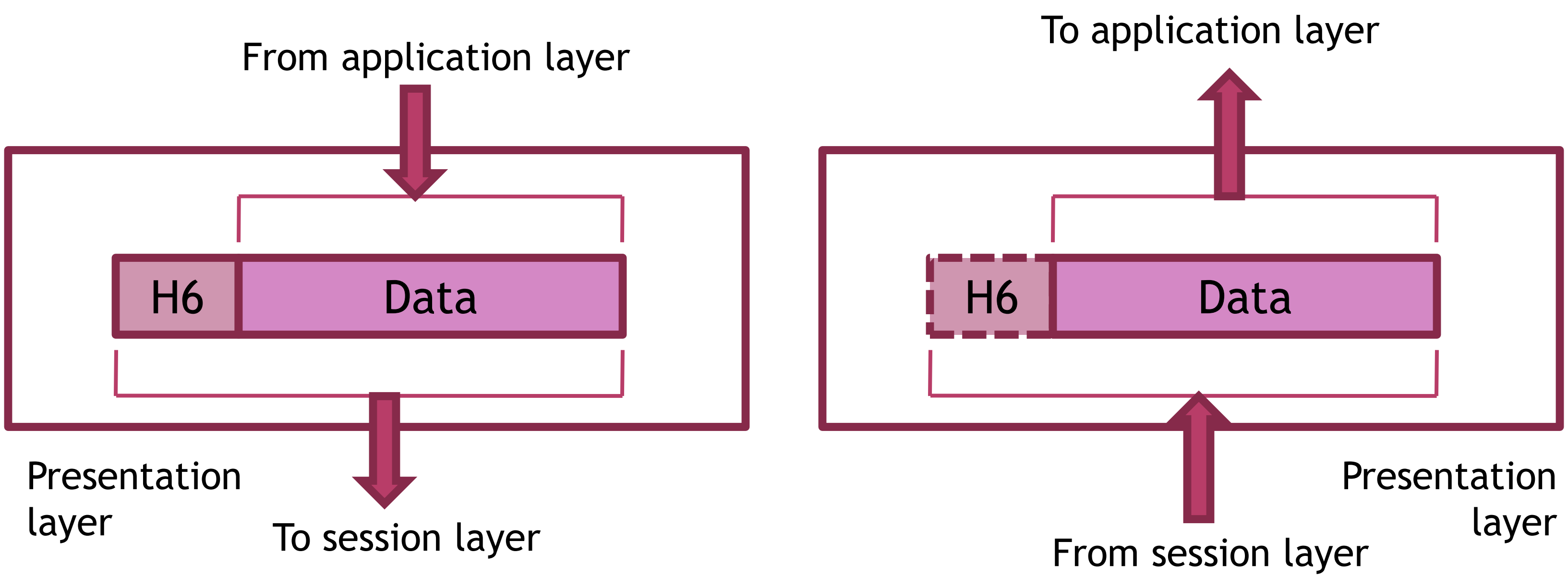
- Translation. The processes (running programs) in two systems are usually exchanging information in the form of character strings, numbers, and so on. The information must be changed to bit streams before being transmitted.

The presentation layer at the sender changes the information from its sender-dependent format into a common format. The presentation layer at the receiving machine changes the common format into its receiver-dependent format.

- **Encryption**. To carry sensitive information, a system must be able to ensure privacy. Encryption means that the sender transforms the original information to another form and sends the resulting message out over the network. Decryption reverses the original process to transform the message back to its original form.

❑ Compression. Data compression reduces the number of bits contained in the information, important in the transmission of multimedia such as text, audio, and video.

Figure shows Presentation Layer

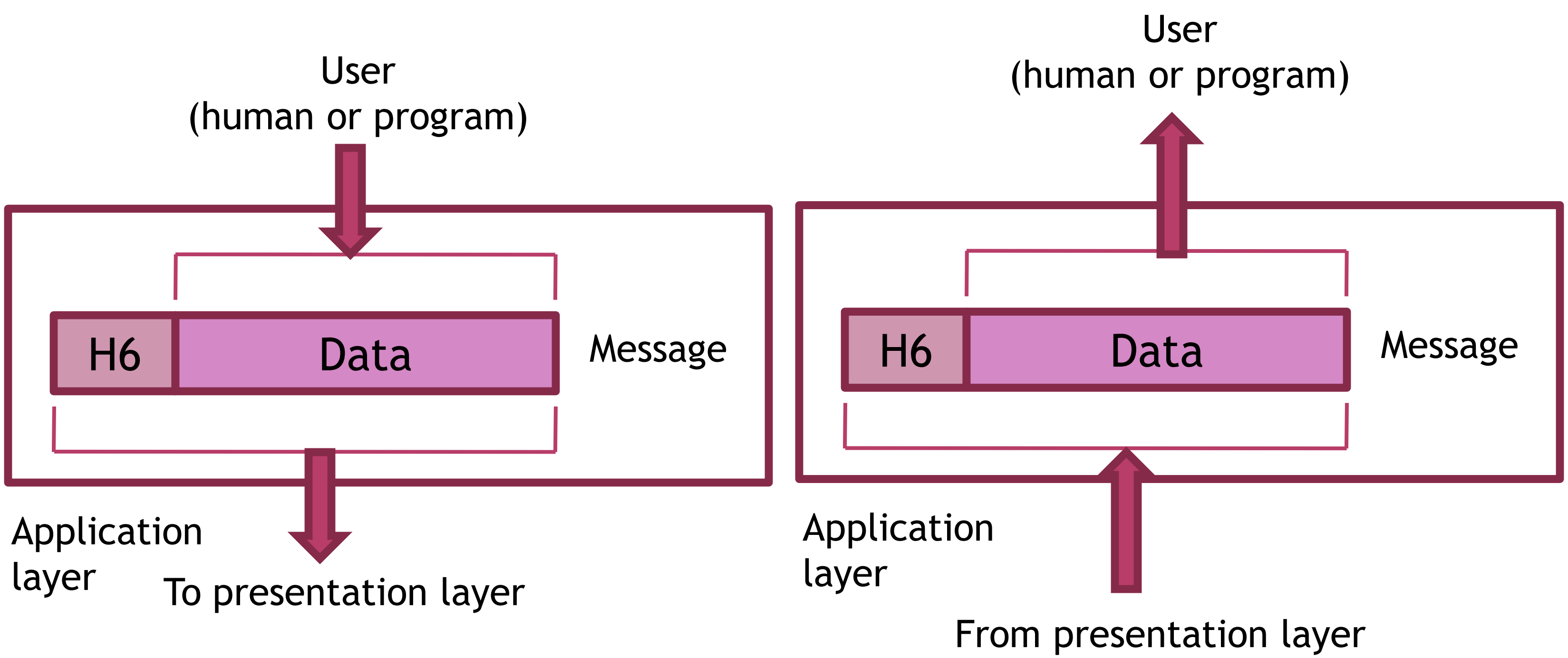


Application Layer

The application layer enables the user, whether human or software, to access the network. It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services.

The application layer is responsible for providing services to the user.

Figure shows the relationship of the application layer to the user and the presentation layer.



Services provided by the application layer are,

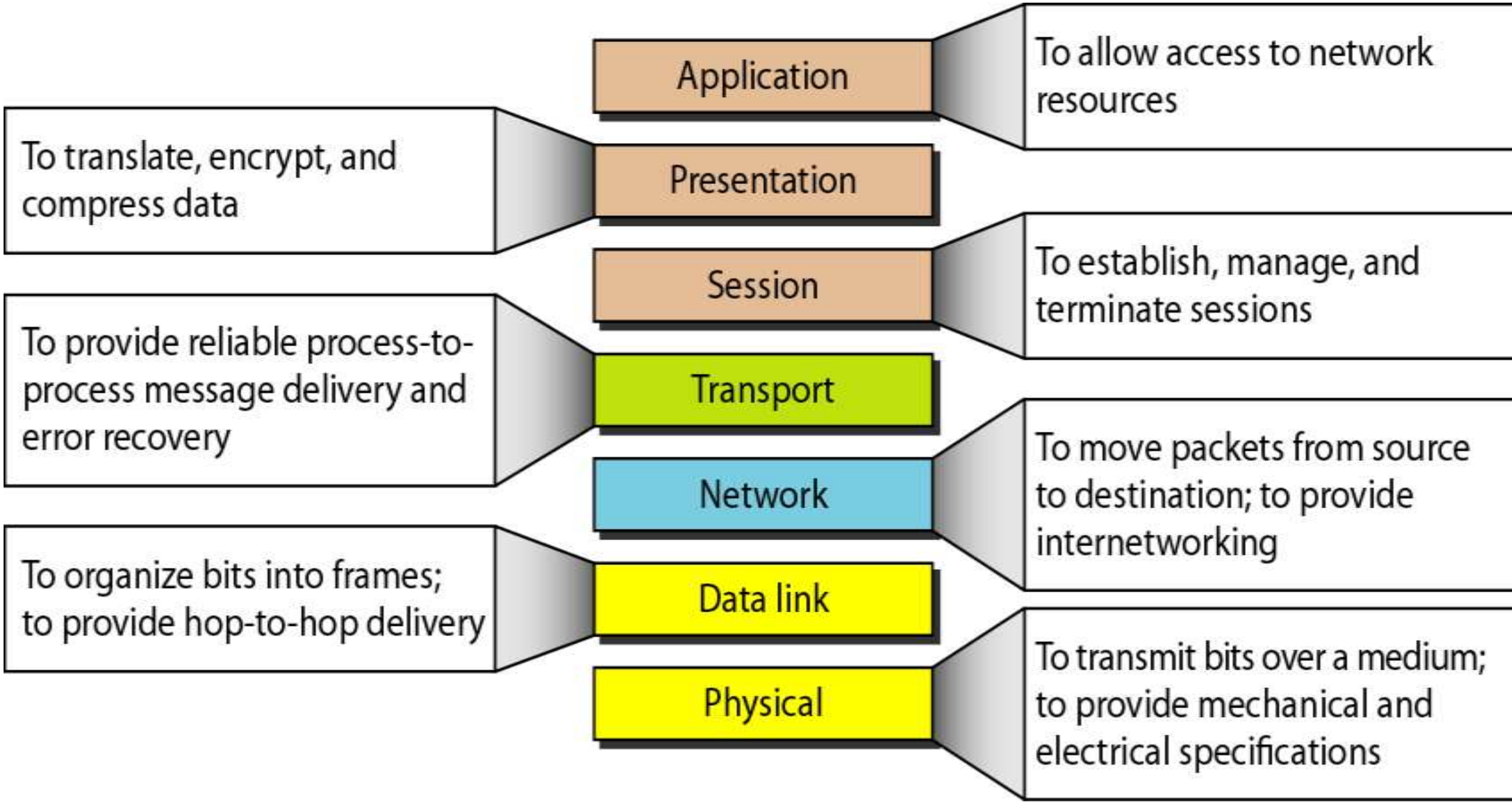
- Network virtual terminal. A network virtual terminal is a software version of a physical terminal, and it allows a user to log on to a remote host. The remote host believes it is communicating with one of its own terminals and allows the user to log on.

- File transfer, access, and management. This application allows a user to access files in a remote host, to retrieve files from a remote computer for use in the local computer, and to manage or control files in a remote computer locally.

- **Mail services**. This application provides the basis for e-mail forwarding and storage.

- **Directory services**. This application provides distributed database sources and access for global information about various objects and services.

Figure *Summary of layers*

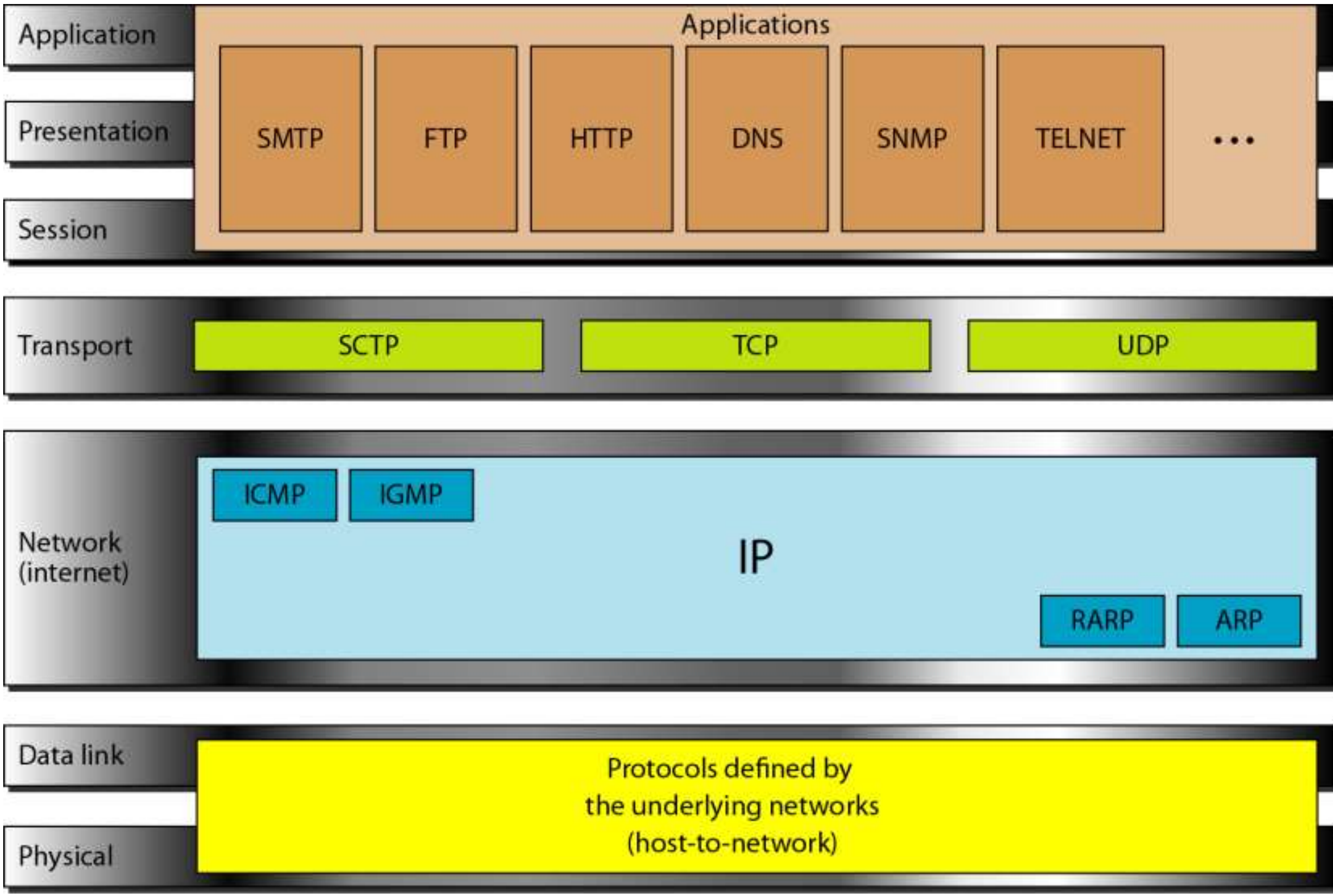


TCP/IP PROTOCOL SUITE

The layers in the TCP/IP protocol suite do not exactly match those in the OSI model. The original TCP/IP protocol suite was defined as having four layers: host-to-network, internet, transport, and application. However, when TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers: physical, data link, network, transport, and application.

TCP/IP is a hierarchical protocol made up of interactive modules, each of which provides a specific functionality.

Figure 2.16 TCP/IP and OSI model



Whereas the OSI model specifies which functions belong to each of its layers, the layers of the *TCP/IP protocol suite contain relatively independent protocols that* can be mixed and matched depending on the needs of the system.

Physical and Data Link Layers

At the physical and data link layers, *TCP/IP does not define any specific protocol*. *It* supports all the standard and proprietary protocols.

Network Layer

At the network layer (or, more accurately, the internetwork layer), *TCP/IP supports* the Internetworking Protocol. IP, in turn, uses four supporting protocols: ARP, RARP, ICMP, and IGMP.

- *Internetworking Protocol (IP)*

The Internetworking Protocol (IP) is the transmission mechanism used by the TCP/IP protocols. It is an unreliable and connectionless protocol. IP transports data in packets called *datagrams, each of which is transported separately*. Datagrams can travel along different routes and can arrive out of sequence or be duplicated.

Address Resolution Protocol

The Address Resolution Protocol (ARP) is used to associate a logical address with a physical address. each device on a link is identified by a physical or station address, usually imprinted on the network interface card (NIC). ARP is used to find the physical address of the node when its Internet address is known.

III Reverse Address Resolution Protocol

The Reverse Address Resolution Protocol (RARP) allows a host to discover its Internet address when it knows only its physical address.

IV Internet Control Message Protocol

The Internet Control Message Protocol (ICMP) is a mechanism used by hosts and gateways to send notification of datagram problems back to the sender.

Internet Group Message Protocol

The Internet Group Message Protocol (IGMP) is used to facilitate the simultaneous transmission of a message to a group of recipients.

Transport Layer

Traditionally the transport layer was represented in *TCP/IP by two protocols: TCP and* UDP. UDP and TCP are transport level protocols responsible for delivery of a message from a process to another process.

I User Datagram Protocol

It is a process-to-process protocol that adds only port addresses, checksum error control, and length information to the data from the upper layer.

II Transmission Control Protocol

The Transmission Control Protocol (TCP) provides full transport-layer services to applications. TCP is a reliable stream transport protocol. It is connection-oriented: A connection must be established between both ends of a transmission before either can transmit data.

III **Stream Control Transmission Protocol**

The Stream Control Transmission Protocol (SCTP) provides support for newer applications such as voice over the Internet.

Application Layer

The *application layer in TCP/IP is equivalent to the combined session*, *presentation*, and application layers in the OSI model. Many protocols are defined at this layer.

ADDRESSING

Four levels of addresses are used in an internet employing the *TCP/IP protocols*: physical (link) addresses, logical (IP) addresses, port addresses, and specific addresses.

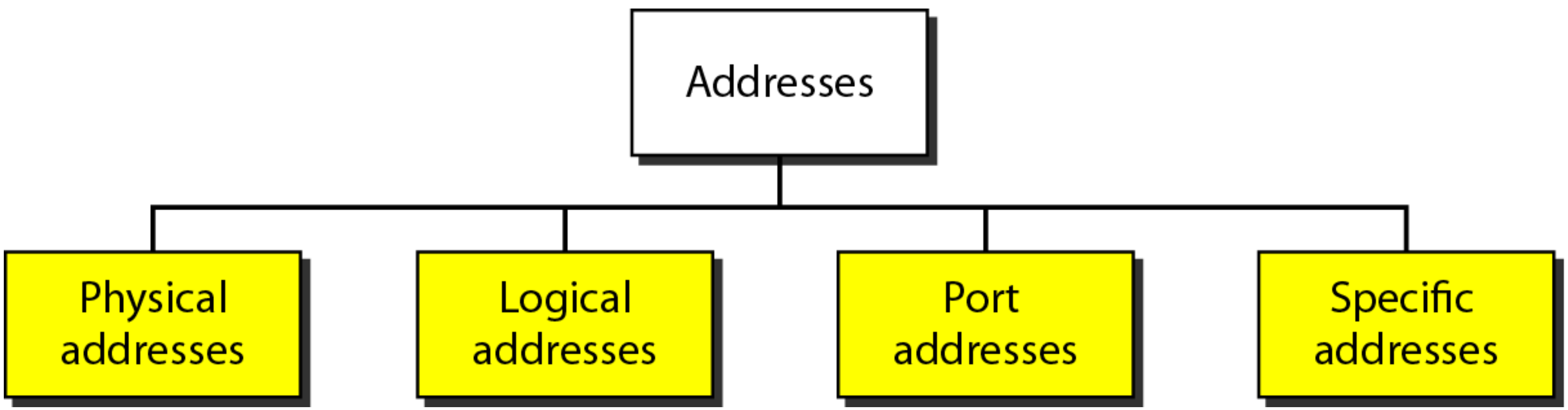
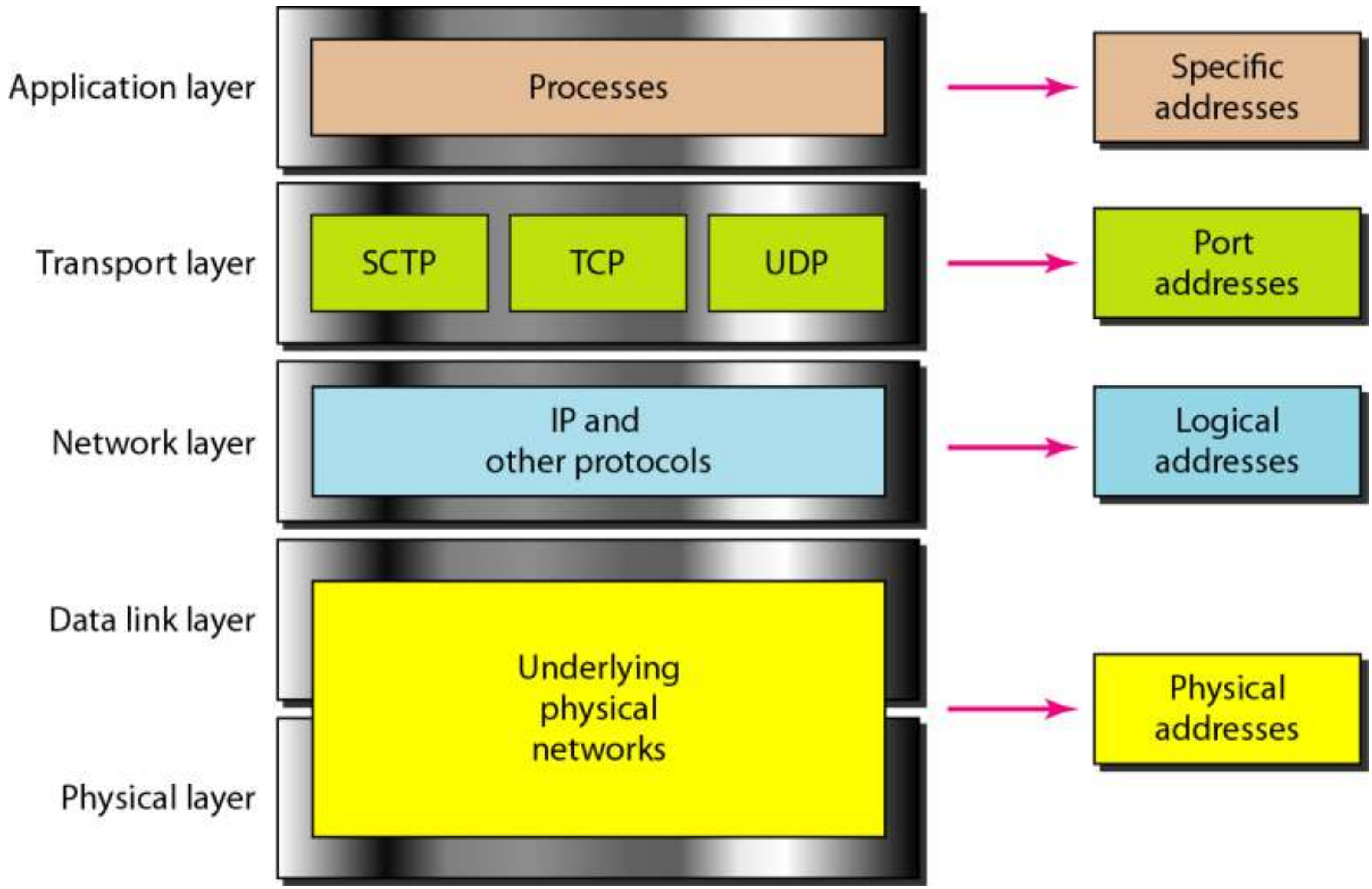


Figure *Relationship of layers and addresses in TCP/IP*



Physical Addresses

The physical address, also known as the link address, is the address of a node as defined by its LAN or WAN. It is included in the frame used by the data link layer. It is the lowest-level address.

Ethernet uses a 6-byte (48-bit) physical address that is imprinted on the network interface card (NIC).

07:01:02:01:2C:4B

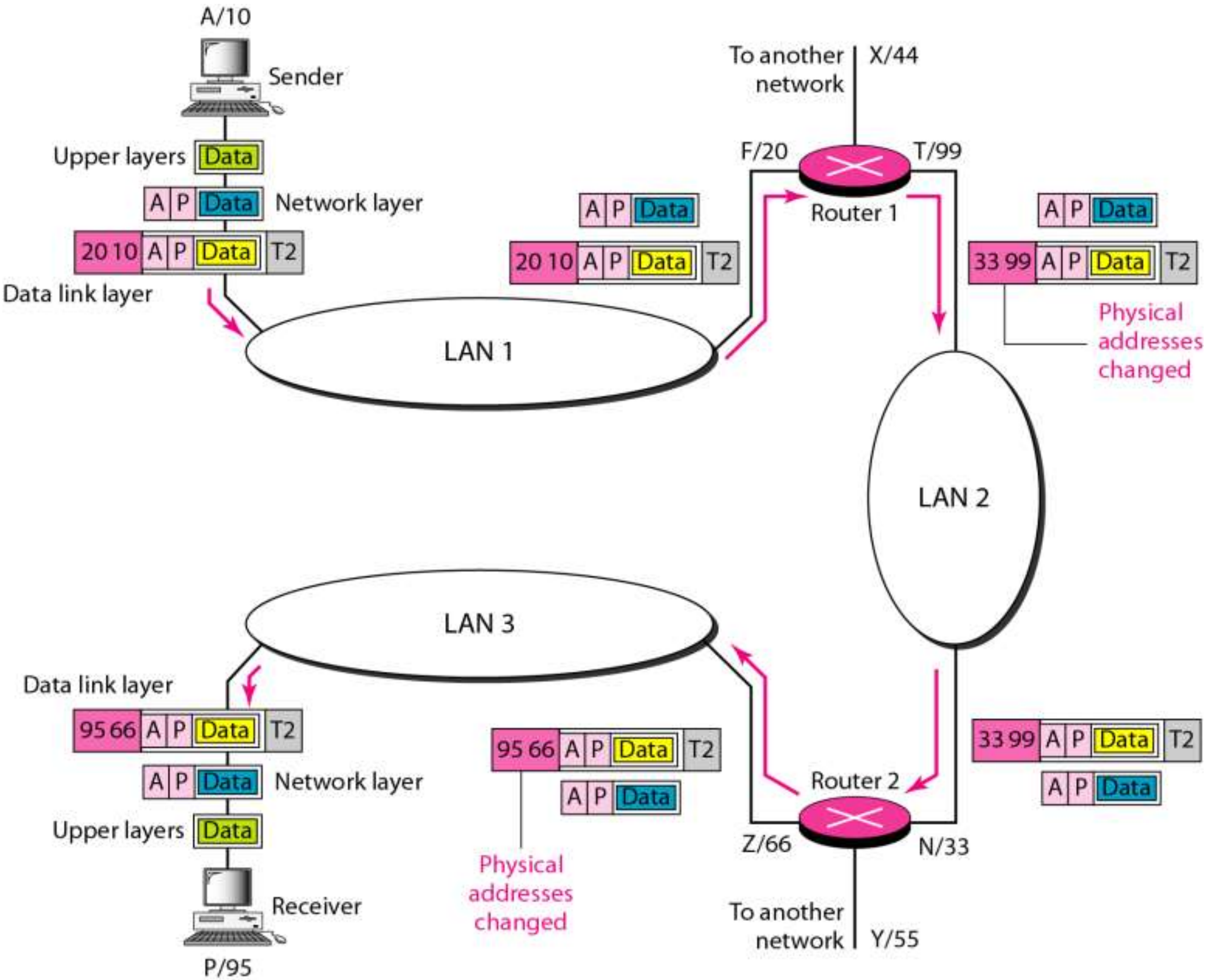
A 6-byte (12 hexadecimal digits) physical address.

Logical Addresses

Logical addresses are necessary for universal communications that are independent of underlying physical networks.

A Logical address is a 32- bit address assigned to each system in a network. This works in Layer-3 of OSI Model. This would be generally the IP address.

The physical addresses will change from hop to hop, but the logical addresses usually remain the same.



A/10
Sender
Upper layers
Data
A
P
Data
Network layer
20 10
A
P
Data
T2
Data link layer
LAN 1
To another network
X/44
F/20
T/99
Router 1
A P Data
20 10 A P Data T2
A P Data
33 99 A P Data T2
Physical addresses changed
LAN 2
LAN 3
Data link layer
95 66 A P Data T2
A P Data
Network layer
Upper layers
Data
Receiver
P/95
95 66 A P Data T2
A P Data
Physical addresses changed
Router 2
Z/66
N/33
To another network
Y/55
33 99 A P Data T2
A P Data

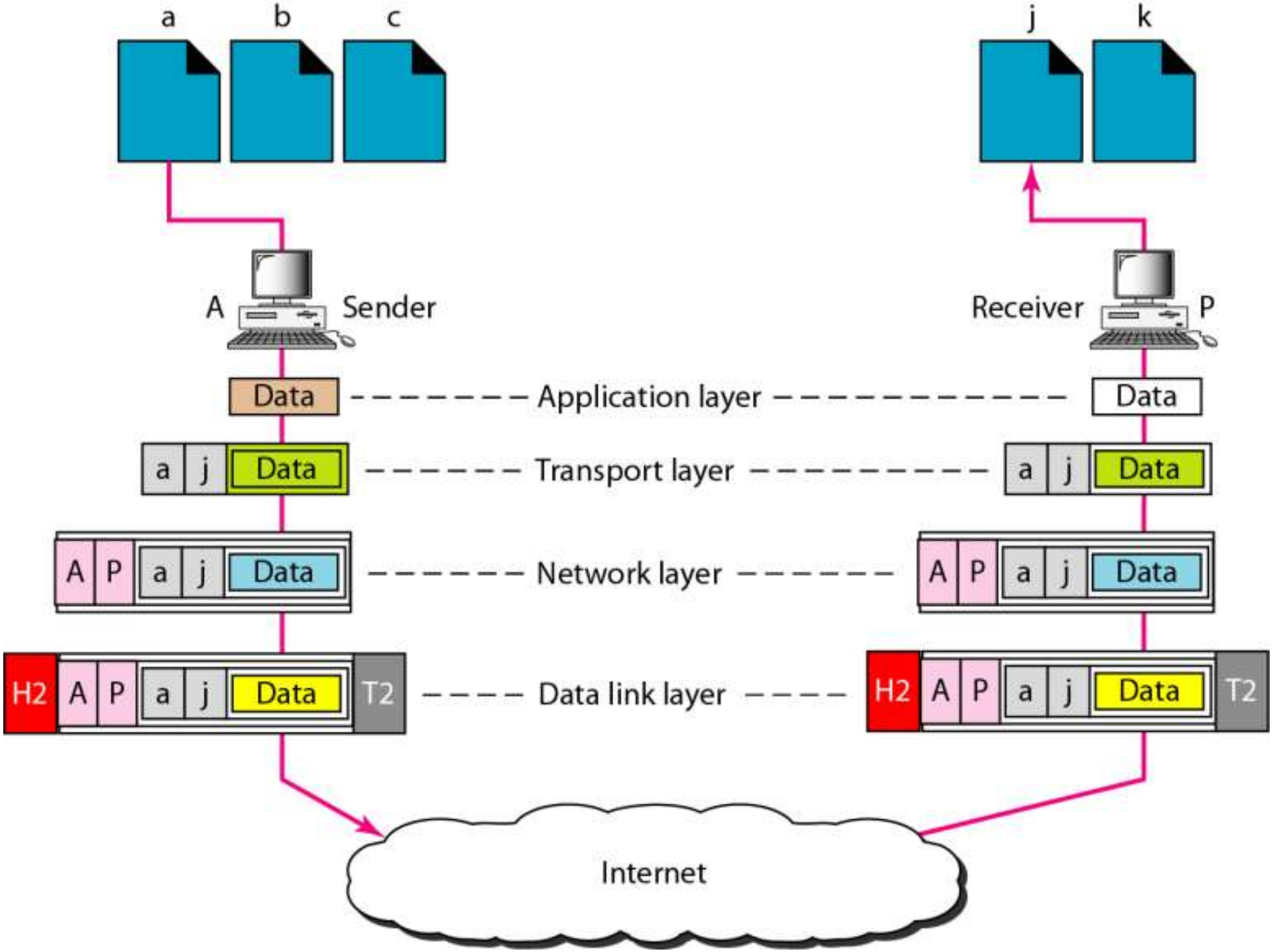
Port Addresses

The IP address and the physical address are necessary for a quantity of data to travel from a source to the destination host. Arrival at the destination host is not the final objective of data communications on the Internet.

Computers are devices that can run multiple processes at the same time. The end objective of Internet communication is a process communicating with another process.

For example, computer A can communicate with computer C by using TELNET. At the same time, computer A communicates with computer B by using the File Transfer Protocol (FTP). For these processes to receive data simultaneously, we need a method to label the different processes. In other words, they need addresses.

In the TCP/IP architecture, the label assigned to a process is called a port address. A port address in TCP/IP is 16 bits in length.



The physical addresses will change from hop to hop, but the logical addresses usually remain the same.

Specific Addresses

Some applications have user-friendly addresses that are designed for that specific address.

Examples include the e-mail address (for example, forouzan@fhda.edu) and the Universal Resource Locator (URL) (for example, www.mhhe.com).