University of Kelaniya, Sri Lanka 

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SENG 24213
Computer Networks

Final Assessment

Final Exam - 70 %

Assignments - 10%

In class Test - 10%

Attendance - 10%

Course contents

- Evolution of communication networks
- Data representation and transmission
- Voice communication networks and devices
- Data communication networks and devices
- Wired and wireless networks
- Infrastructure dependency of networks
- Categorizing networks
- Network communication technologies
- Types of network communication media
- Network addressing, network standards, network topologies, network communication types, network architectures, network protocols, common protocol stacks, network delivery types
- Configuring network devices, network troubleshooting principles and tools
- Drawing network designs and setting up computer networks

Course Materials

- Natalia Olifer and Victor Olifer, Computer Networks: Principles, Technologies and Protocols for Network Design, John Wiley, 2005.
- Douglas E. Comer, Internetworking with TCP/IP Volume One, 6th Edition, Pearson, 2013.
- William A. Shay, Understanding Data Communications and Networks, 3rd Edition, Brooks/Cole, 2004.

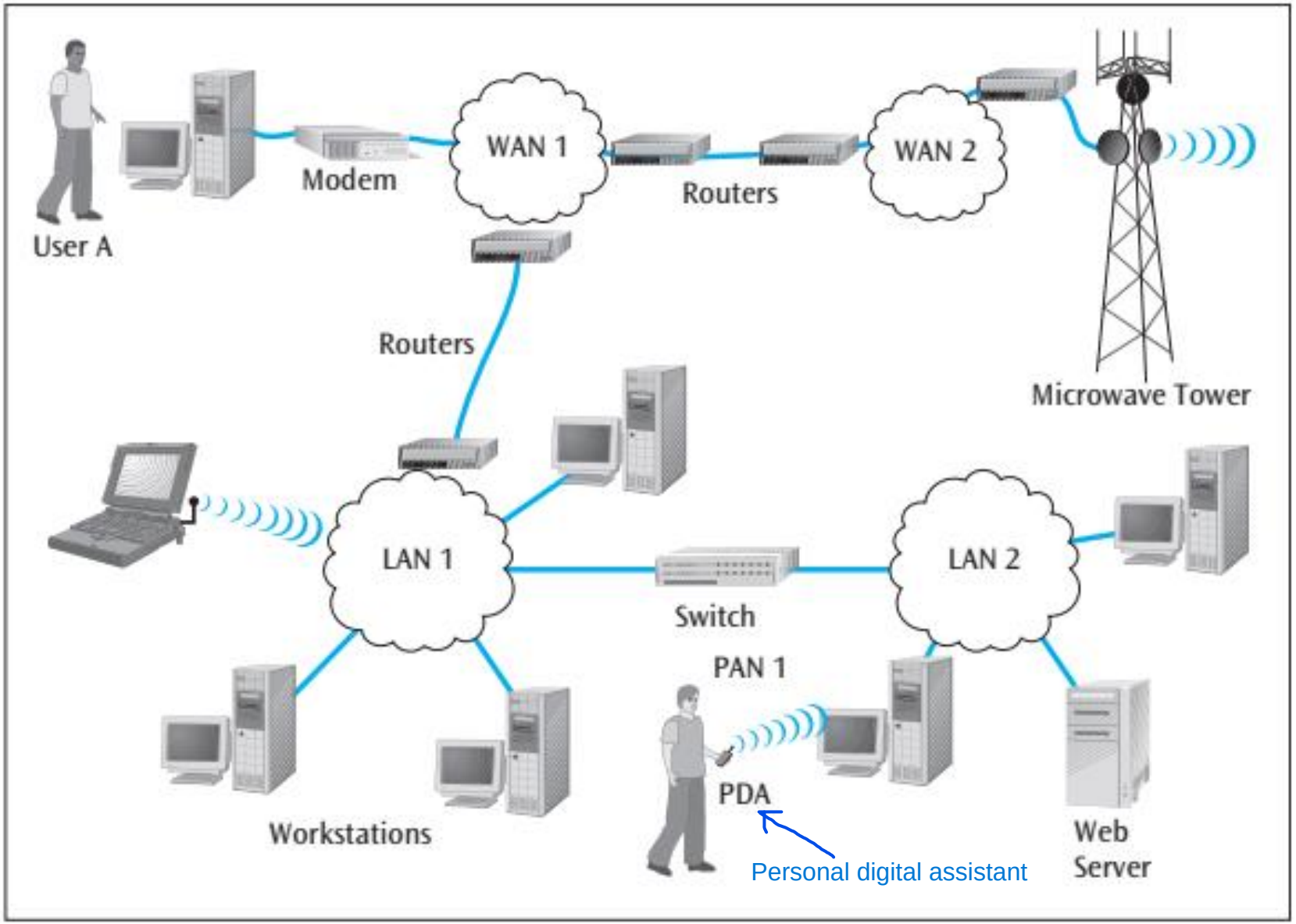
A computer network is an interconnection of computers and computing equipment using either wires or radio waves and can share data and computing resources. Computer networks that use radio waves are termed wireless and can involve broadcast radio, microwaves, or satellite transmissions. Networks spanning an area of several meters around an individual are called personal area networks (PANs). Personal area networks include devices such as laptop computers, personal digital assistants, and wireless connections. Networks that are a little larger in geographic size—spanning a room, a floor within a building, a building, or a campus—are local area networks (LANs). Networks that serve an area up to roughly 50 km—approximately the area of a typical city— are called metropolitan area networks (MANs). Metropolitan area networks are high-speed networks that interconnect businesses with other businesses and the Internet. Large networks encompassing parts of states, multiple states, countries, and the world are wide area networks (WANs).

The study of computer networks usually begins with the introduction of two important building blocks: data and signals. Data is information that has been translated into a form more conducive to storage, transmission, and calculation. A signal is used to transmit data. We define data communications as the transfer of digital or analog data using digital or analog signals. Once created, these analog and digital signals then are transmitted over conducted media or wireless media.

Connecting devices to a computer, or a computer to a network, requires interfacing. Because sending only one signal over a medium at one time can be an inefficient way to use the transmission medium, many systems perform multiplexing. Multiplexing is the transmission of multiple signals on one medium. For a medium to transmit multiple signals simultaneously, the signals must be altered so that they do not interfere with one another. Compression is another technique that can maximize the amount of data sent over a medium. Compression involves squeezing data into a smaller package, thus reducing the amount of time (as well as storage space) needed to transmit the data.

wenas wenna one

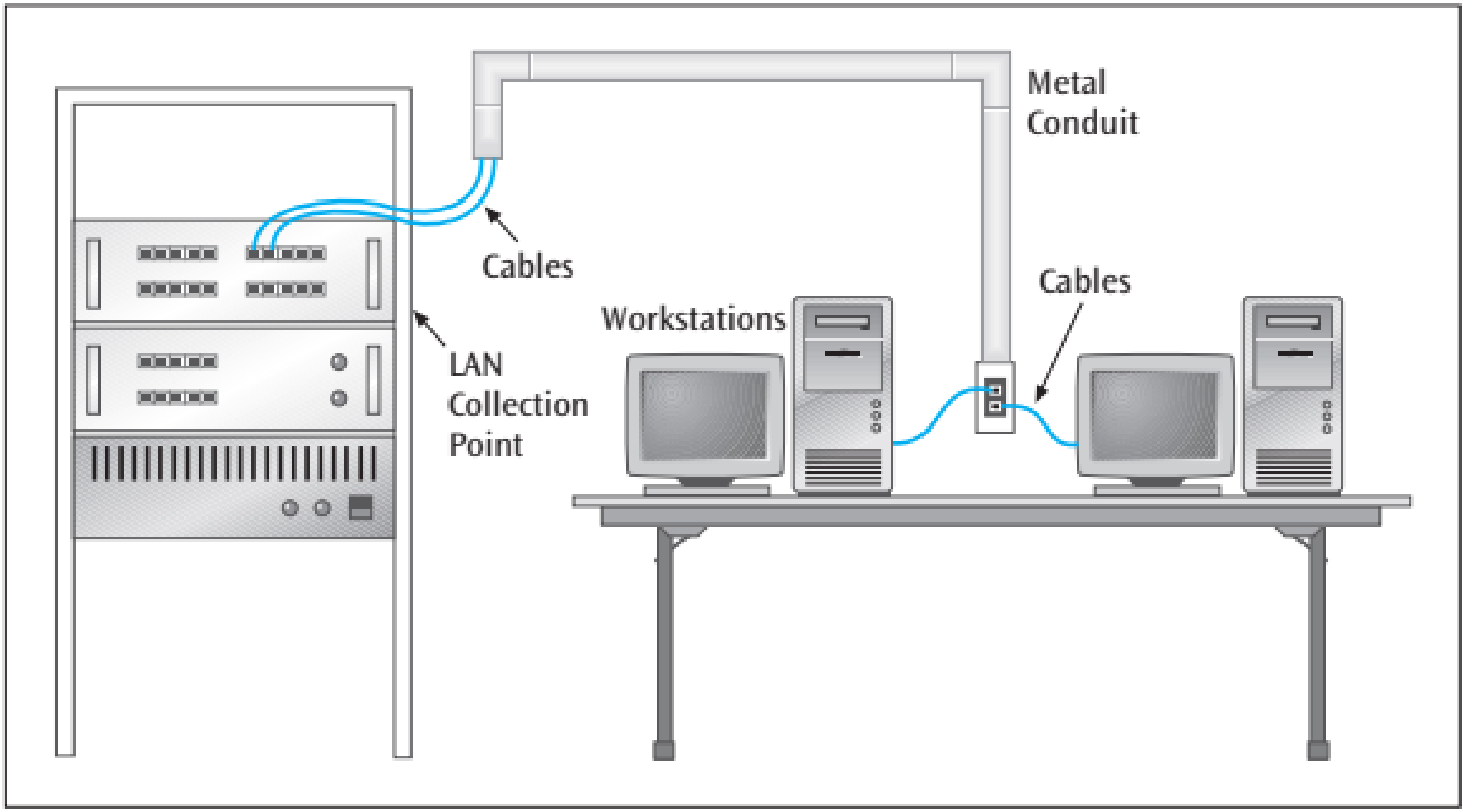
When the signals transmitted between computing devices are corrupted and errors result, error detection and error control are necessary. Once upon a time, a voice network transmitted telephone signals, and a data network transmitted computer data. Eventually, however, the differences between voice networks and data networks disappeared. The merging of voice and data networks is one example of convergence. Computer security is a growing concern of both professional computer support personnel and home computer users with Internet connections. Network management is the design, installation, and support of a network and its hardware and software. Also there are many of the basic concepts necessary to support properly the design and improvement of network hardware and software, as well as the more common management techniques used to support a network.


User A
Modem
WAN 1
Routers
WAN 2
Microwave Tower
Routers
LAN 1
Switch
LAN 2
PAN 1
PDA
Personal digital assistant
Workstations
Web
Server

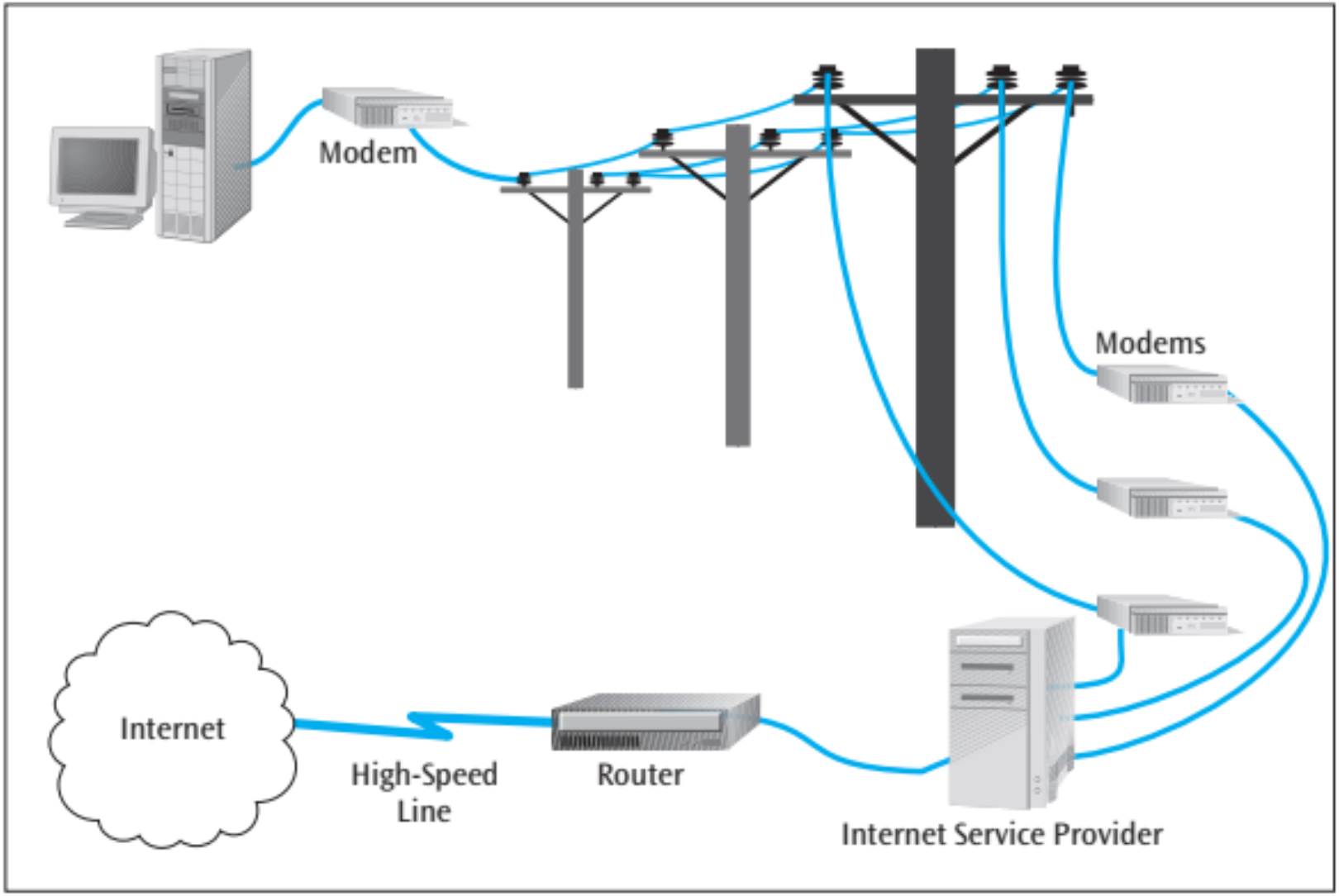
COMMUNICATIONS NETWORKS—BASIC LAYOUTS

- Microcomputer-to-local area network
- Microcomputer-to-Internet
- Local area network-to-local area network
- Personal area network-to-workstation
- Local area network-to-metropolitan area network
- Local area network-to-wide area network
- Wide area network-to-wide area network
- Sensor-to-local area network
- Satellite and microwave
- Cell phones
- Terminal/microcomputer-to-mainframe computer

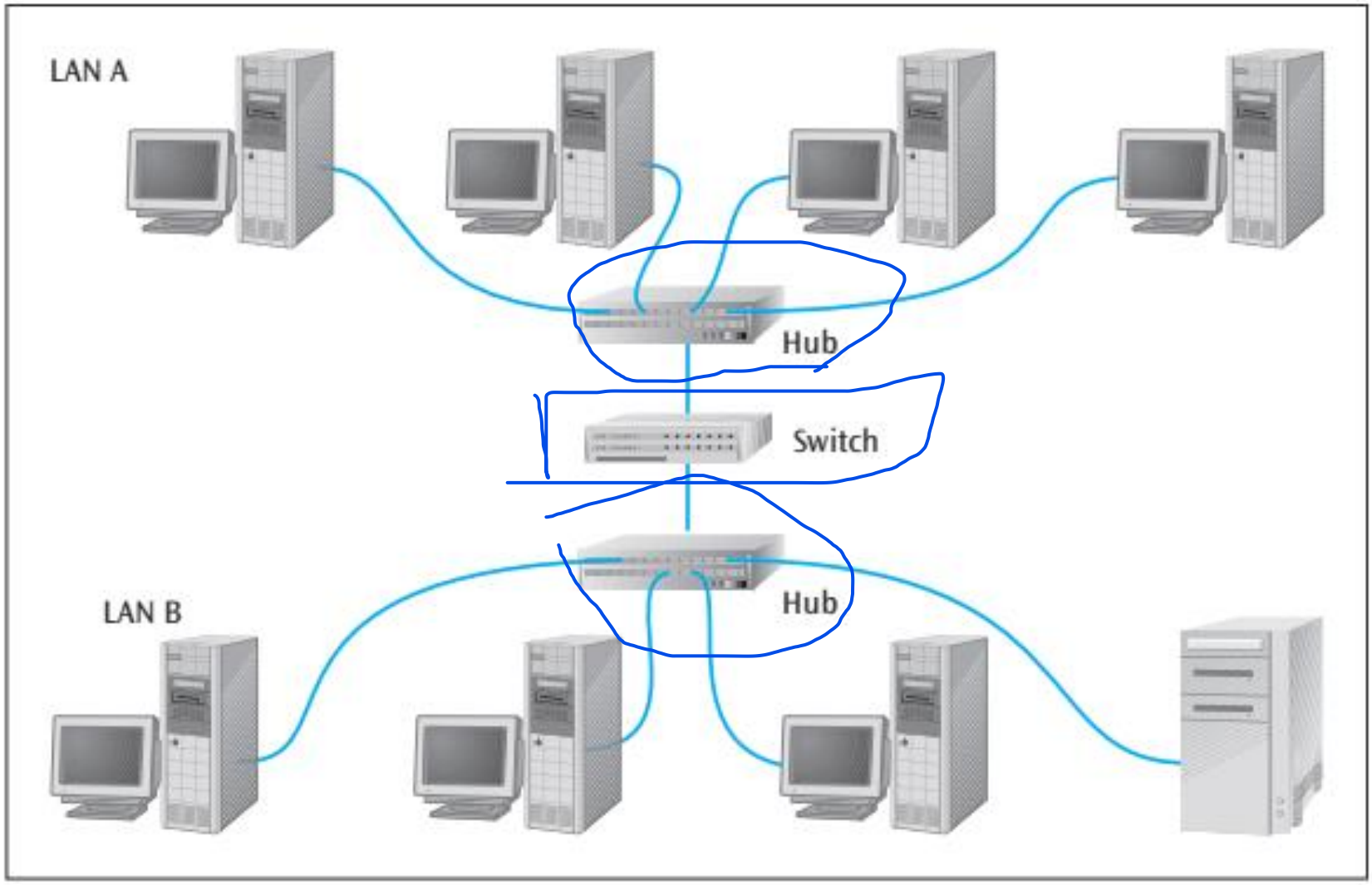
Microcomputer-to-local area network layouts



Microcomputer-to-Internet layouts

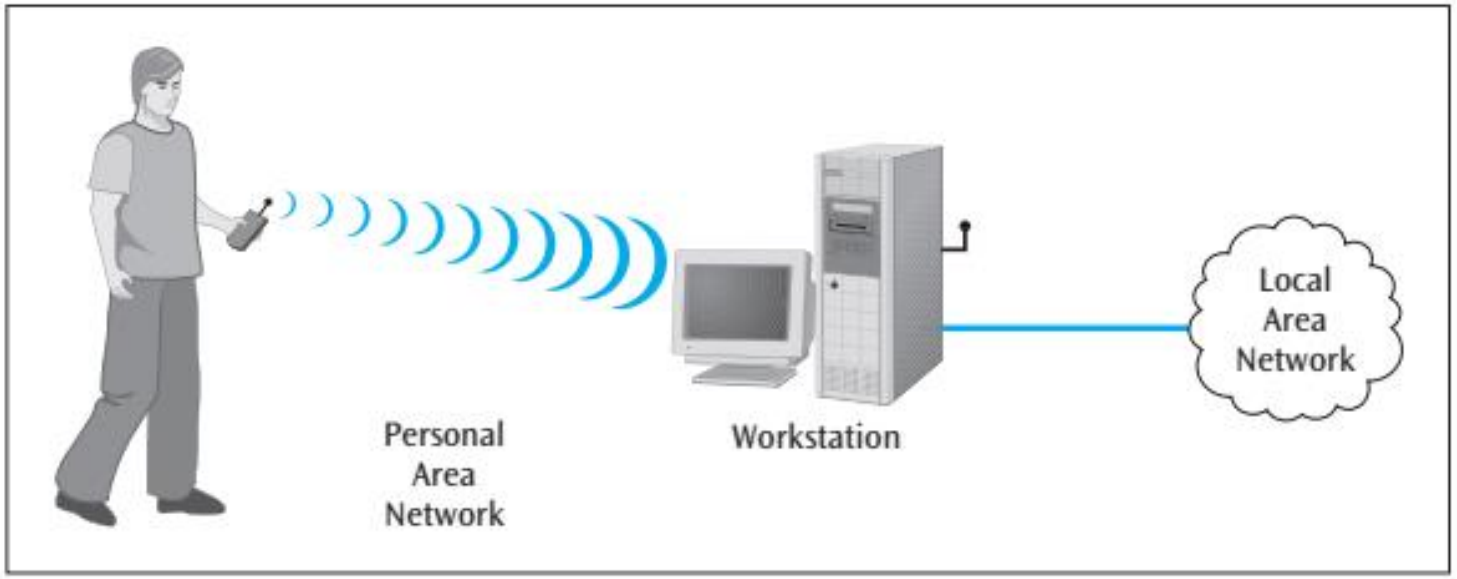


Local area network –to- Local area network layouts



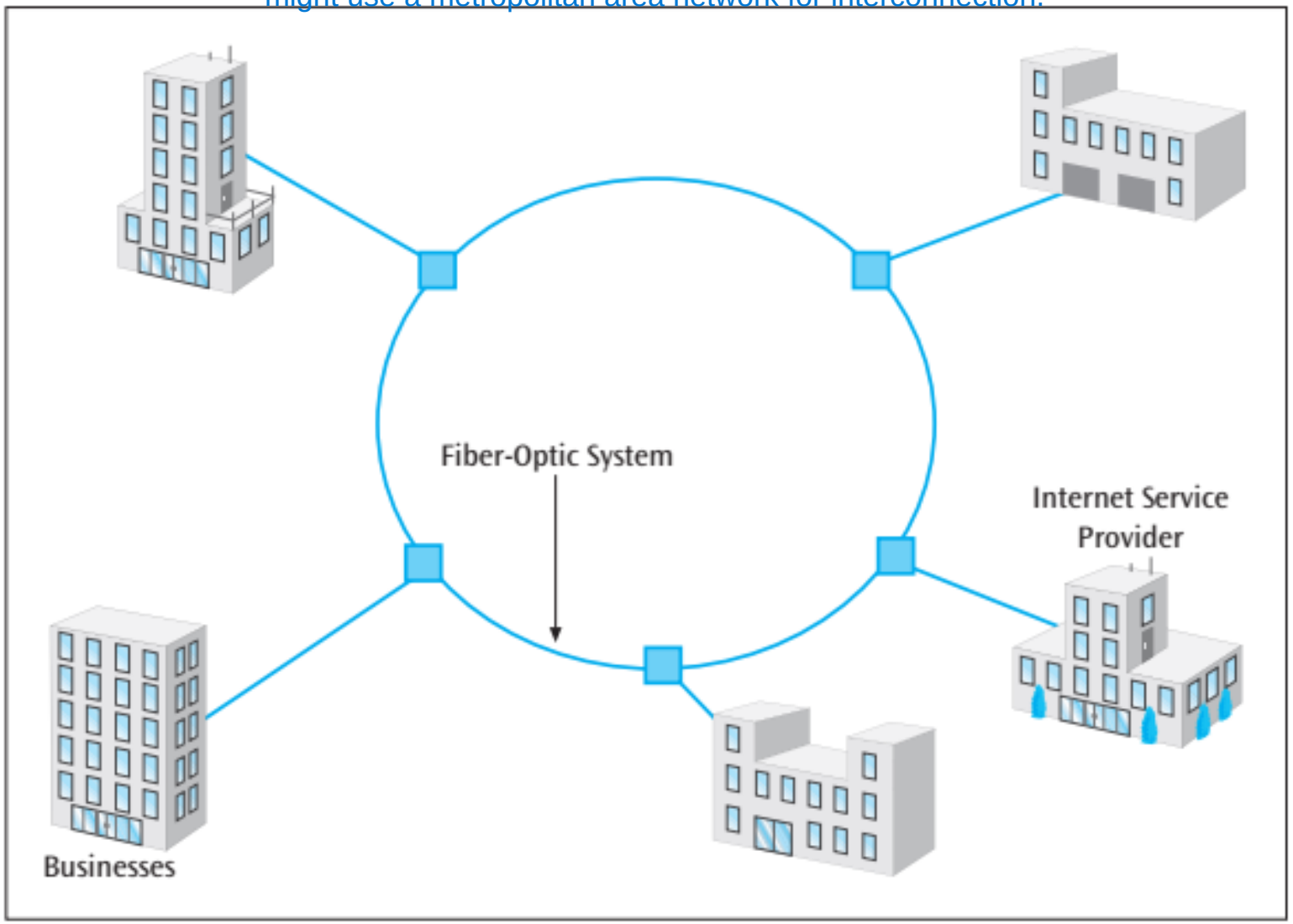
Personal area network –to- workstation layouts

1. Short range bluetooth network.
2.Transferring files via bluetooth.

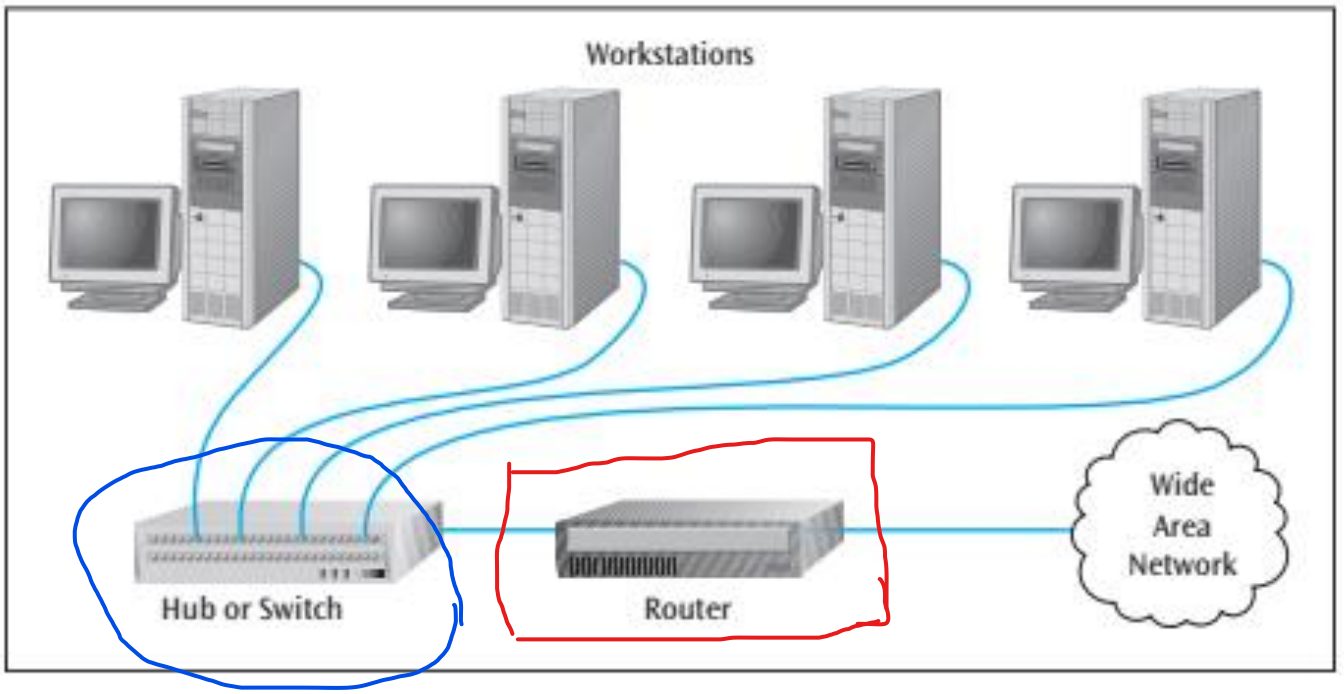


Local area network –to- metropolitan area network layouts

businesses that require a high-speed connection to their Internet service providers might use a metropolitan area network for interconnection.



Local area network –to- Wide area network layouts



Commonly used on workstations where in all computers are connected on to one server that is connected to a wide area network.

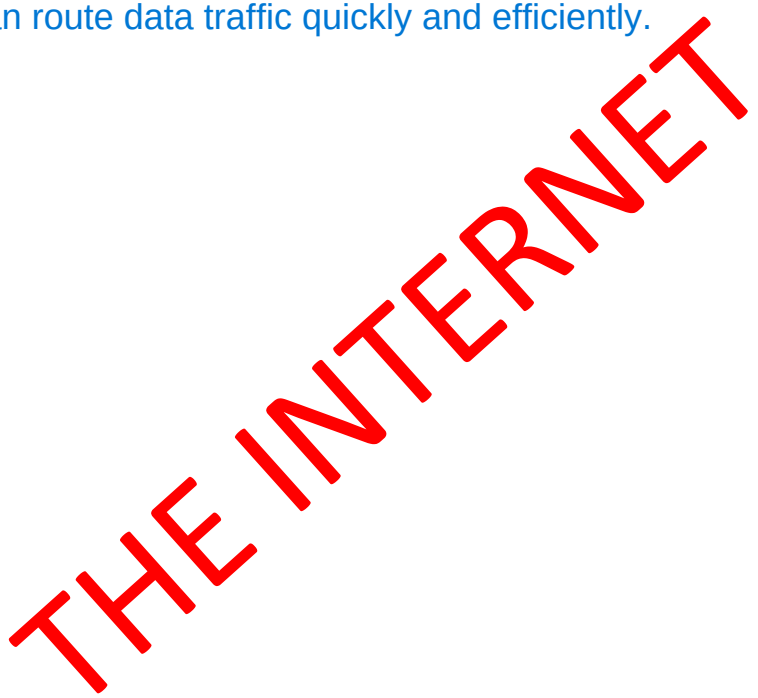
A router is used to connect all these computers using a local area network.

Ex: -Internet cafes nowadays, because all their computers are connected to one main server.

Wide area network–to- Wide area network layouts

In order to travel any distance across the Internet, a data packet undoubtedly will pass through multiple wide area networks.

-requires a highspeed router that can route data traffic quickly and efficiently.



Internet - Internet with a capital "I" refers to the entire Internet (meaning the biggest collection of networks on the planet).

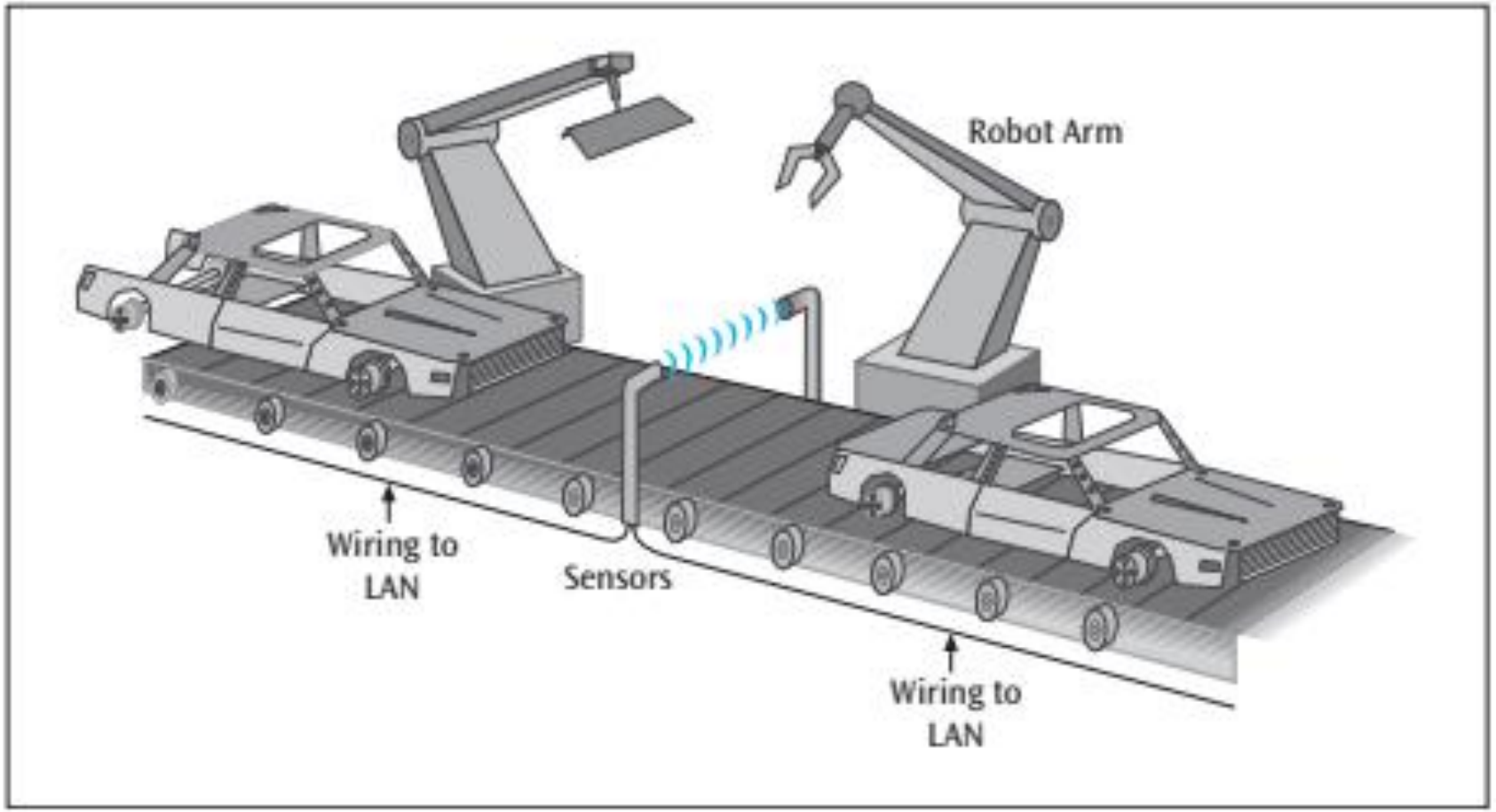
internet - Internet with a lowercase "i" refers to any group of networks that are connected together.

Internet = The internet

Intranet = a single inter-connected network within one organization that uses HTTP/Web technologies for the sharing of information internally.

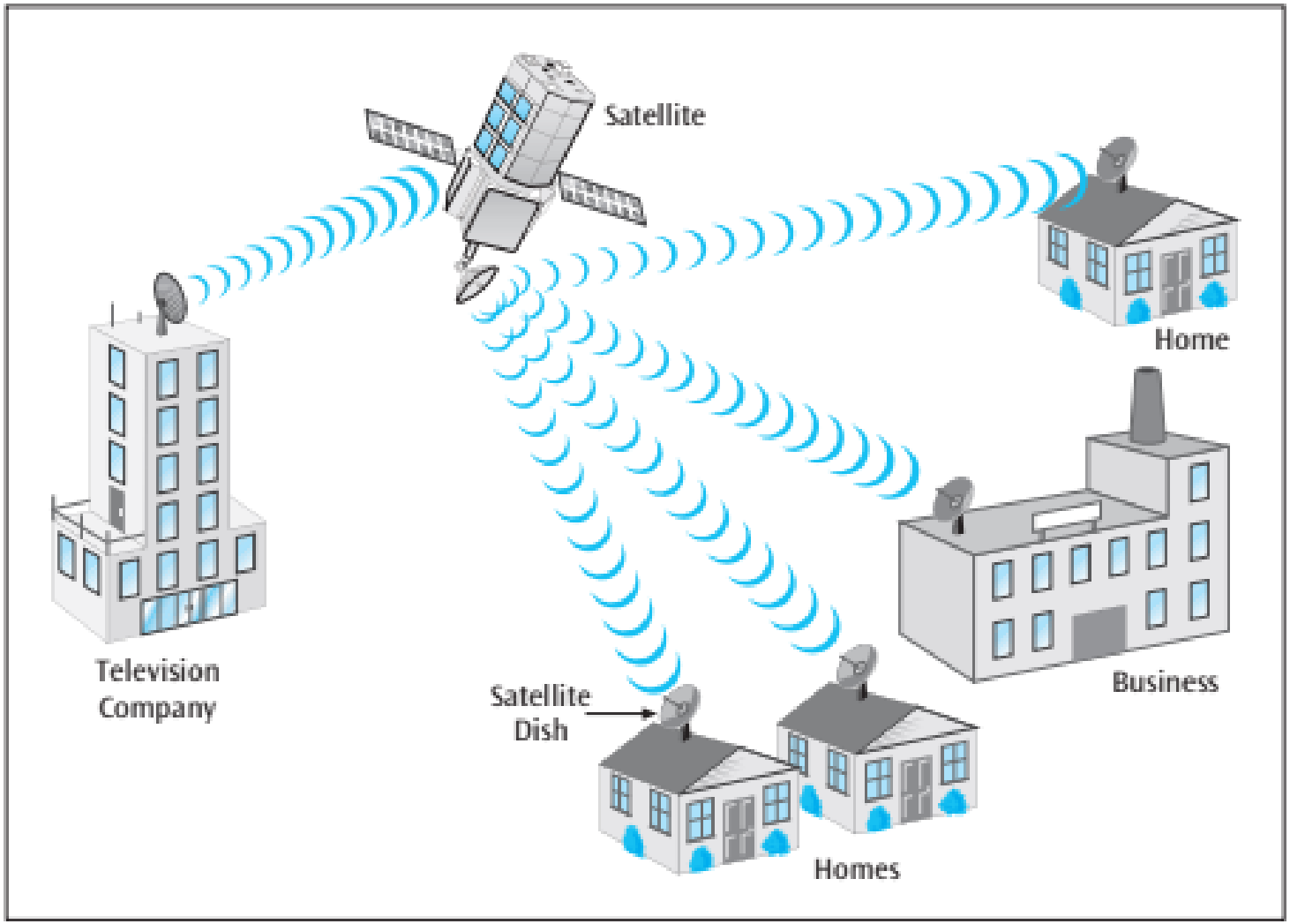
Sensor – to -Local area network layouts

Assembly lines, robotic control devices, oven temperature controls, and chemical analysis equipment often use sensors connected to data-gathering computers that control movements and operations, sound alarms, and compute experimental or quality control results.

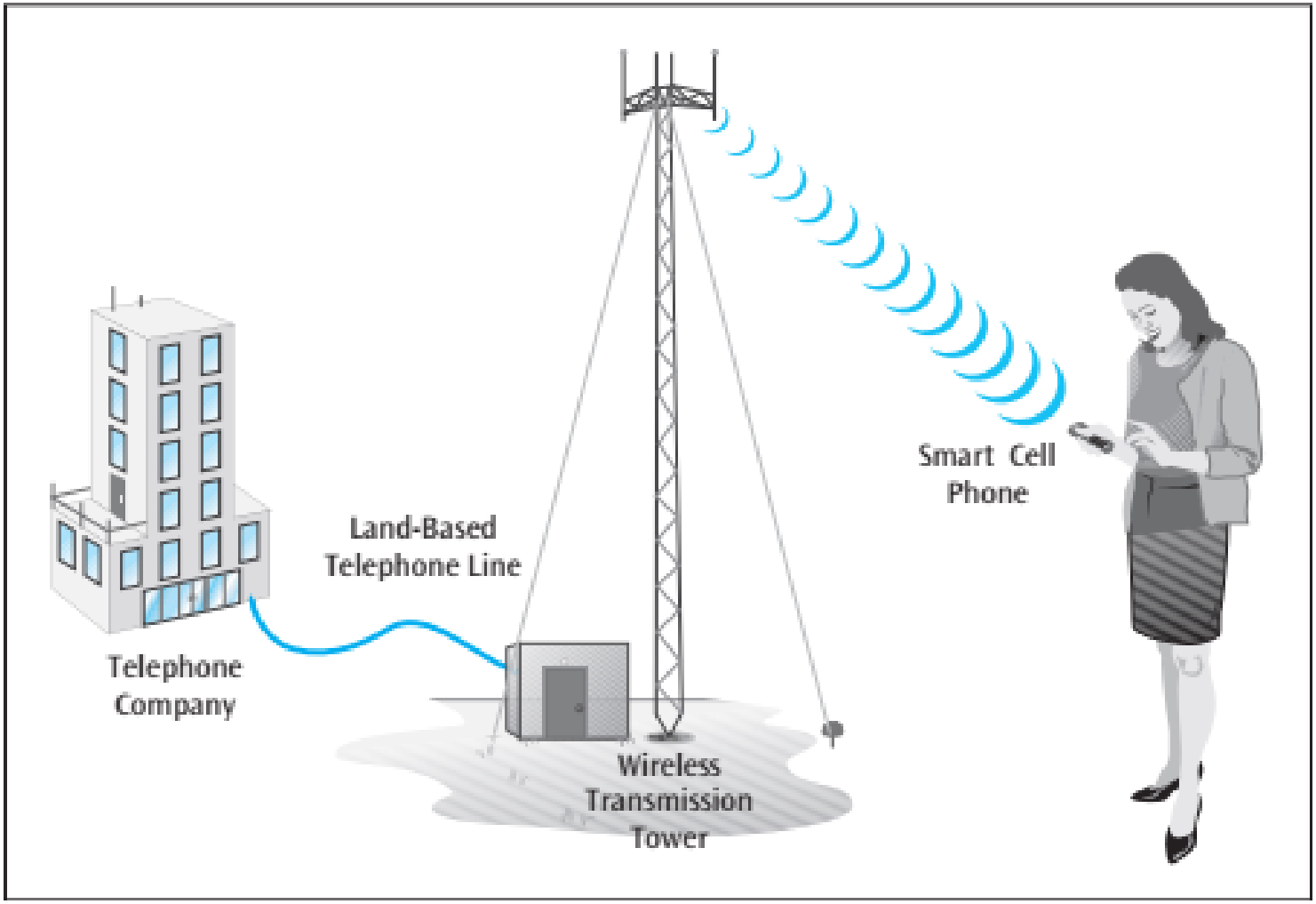


Satellite and microwave layouts

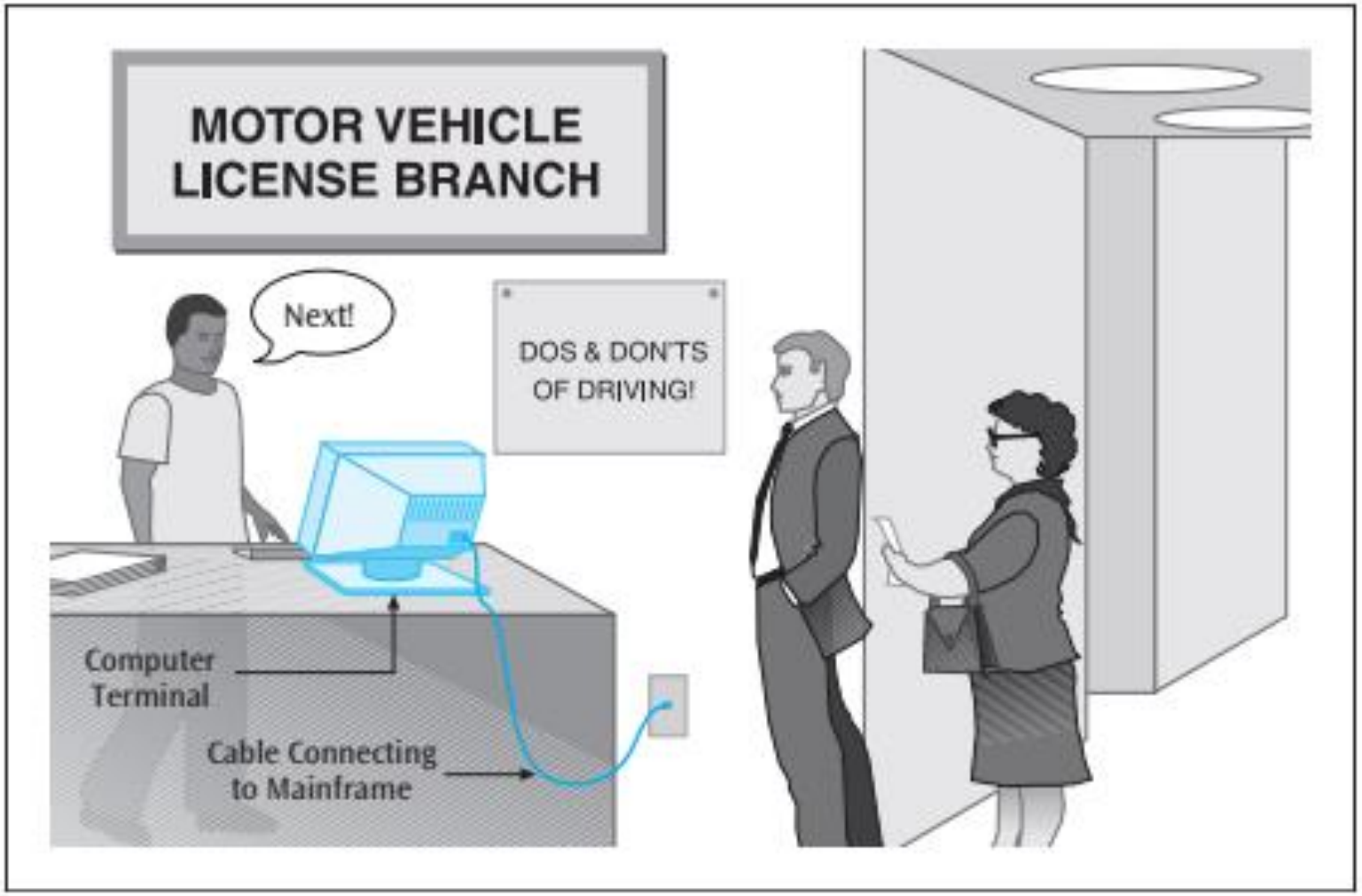
An example of this is are digital satellite TV's, radios, GPS, emails, telephone signals, and etc.



Cell phone layouts



Terminal/microcomputer-to-mainframe computer layouts



Server is a computer program or a device that provides service/information to other program or a device.

Clients

Fundamentals of Data & Signal

Data

- Data is entities that convey meaning within a computer or computer system.
  - A computer file of names and addresses stored on a hard disk drive
  - The bits or individual elements of a movie stored on a DVD
  - The binary 1s and 0s of music stored on a CD or inside an iPod
  - The dots (pixels) of a photograph that has been digitized by a digital camera and stored on a memory stick
  - The digits 0 through 9, which might represent some kind of sales figures for a business

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Information has been electronically captured and stored on some type of storage device

Signal

- Signals are the electric or electromagnetic impulses used to encode and transmit data.
  - A transmission of a telephone conversation over a telephone line
  - A live television news interview from USA transmitted over a satellite system
  - A transmission of a term paper over the printer cable between a computer and a printer
  - The downloading of a Web page as it is transferred over the telephone line between your Internet service provider and your home computer

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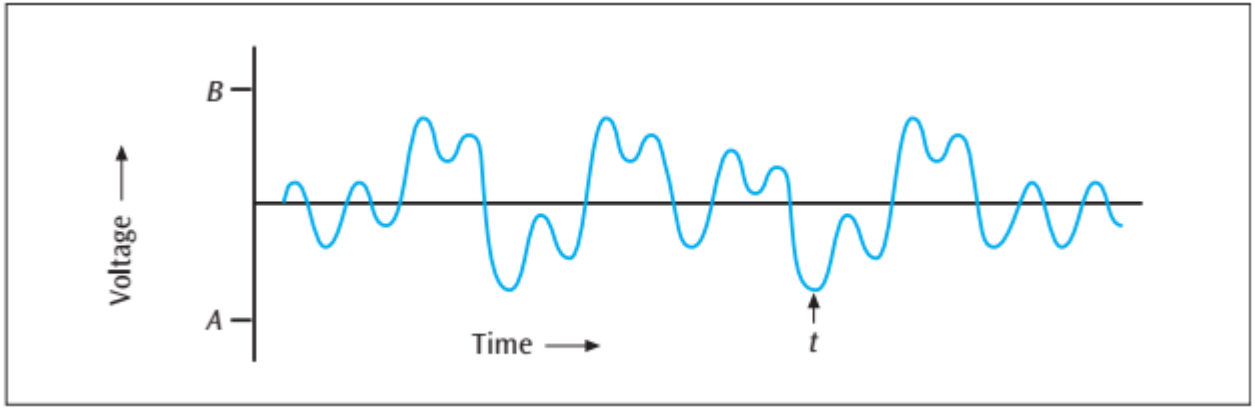
- Data, the static entity or tangible item, is transmitted over a wire or an airwave in the form of a signal which is the dynamic entity or intangible item.
- Some type of hardware device is necessary to convert the static data into a dynamic signal ready for transmission and then convert the signal back to data at the receiving destination.

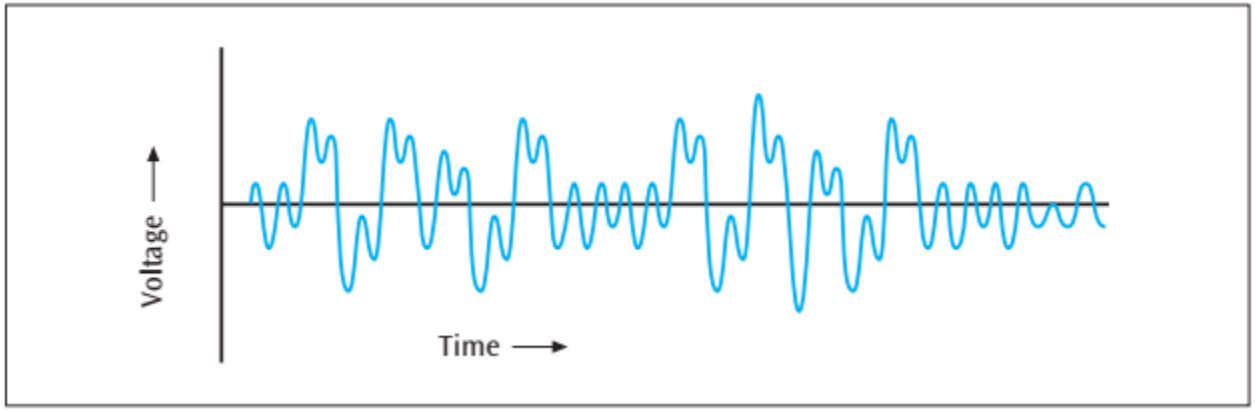
Analog Vs Digital

- Data and signals can exist in either analog or digital form.
- Analog data and analog signals are represented as continuous waveforms that can be at an infinite number of points between some given minimum and maximum.



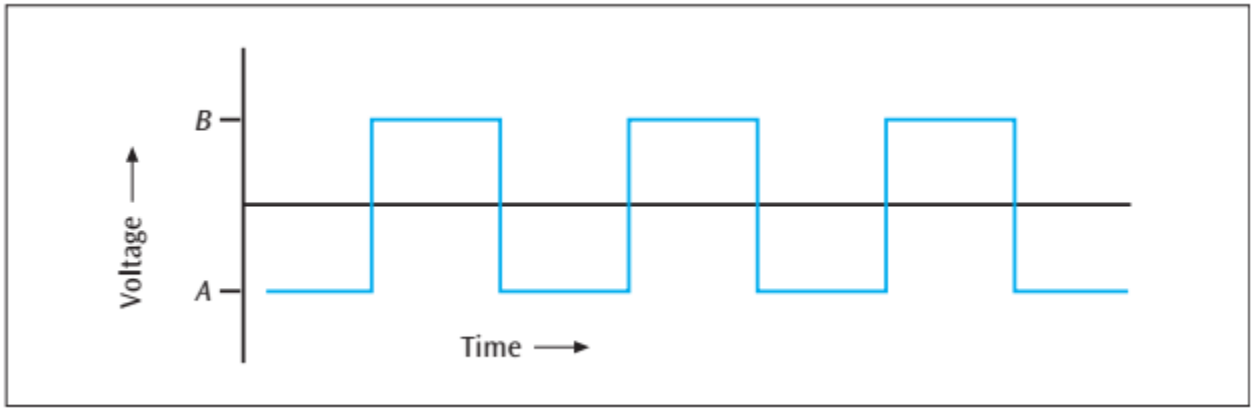
Analog Vs Digital

- One of the primary shortcomings of analog data and analog signals is how difficult it is to separate noise from the original waveform.
- Noise is unwanted electrical or electromagnetic energy that degrades the quality of signals and data



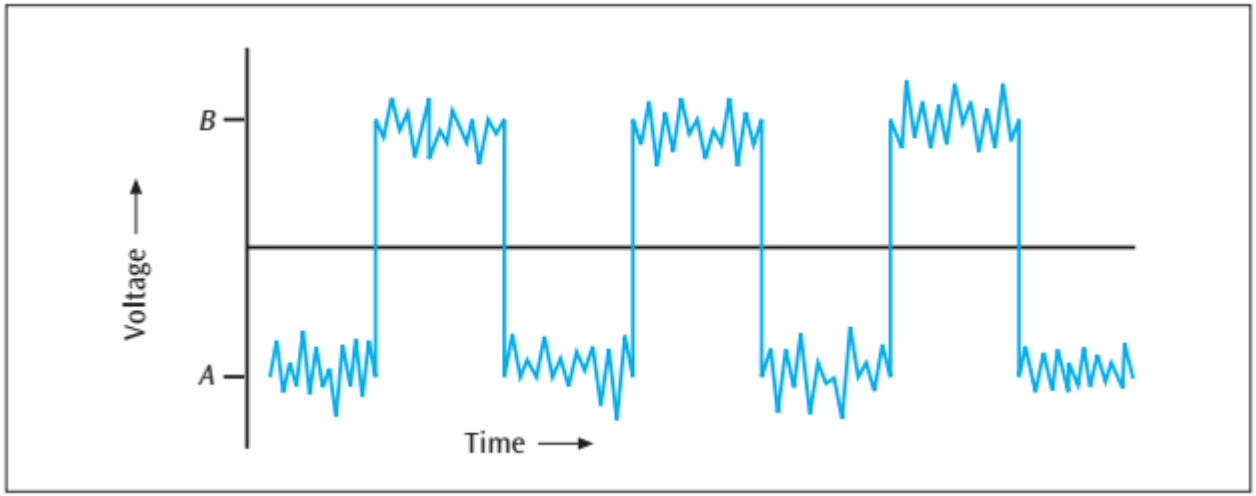
Analog Vs Digital

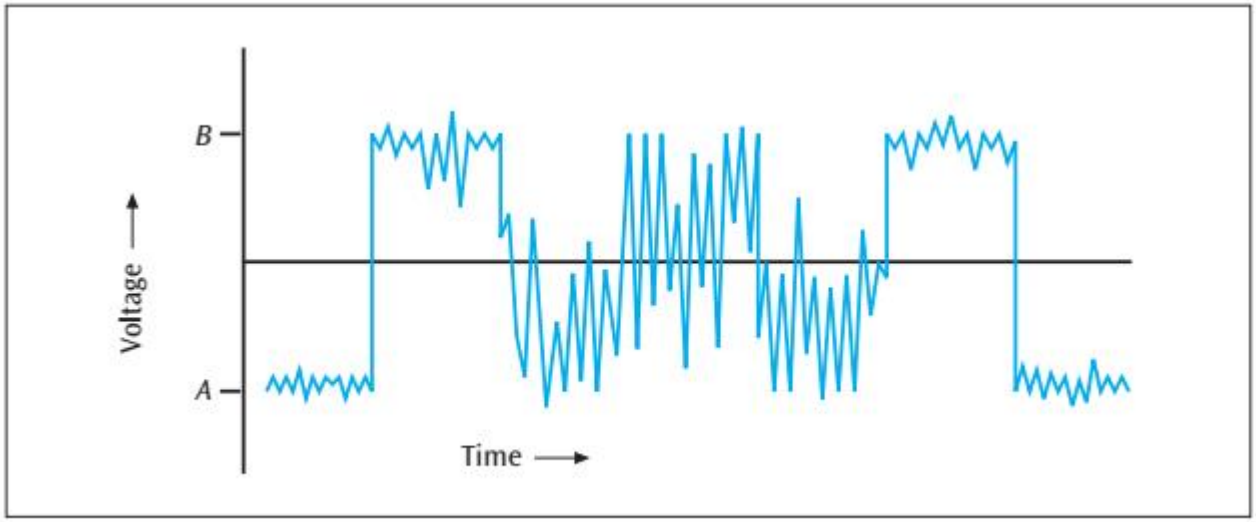
- Digital data and digital signals are composed of a discrete or fixed number of values, rather than a continuous or infinite number of values.
- Digital data takes on the form of binary 1s and 0s.



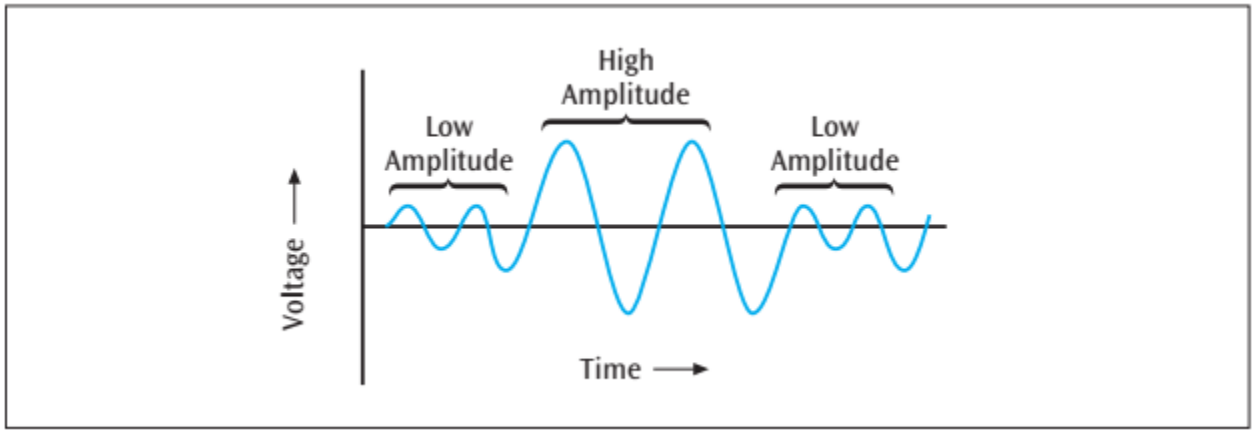
square wave

Analog Vs Digital

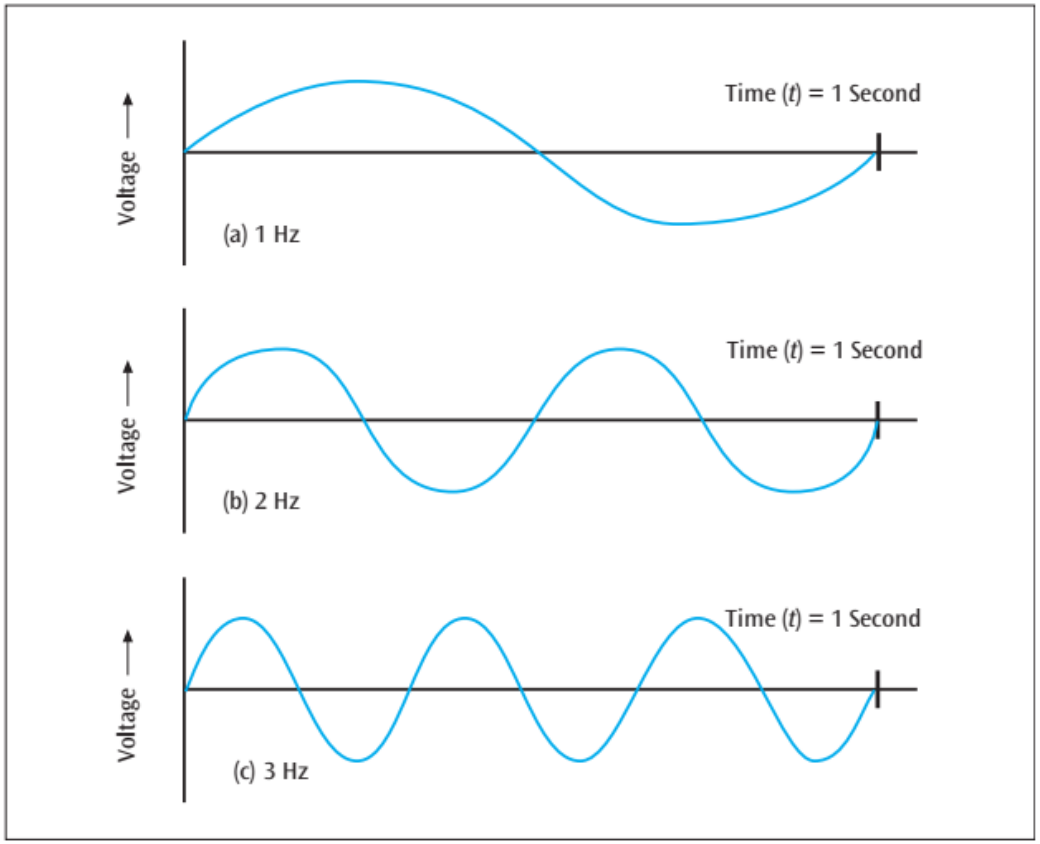




- **Amplitude** of a signal is the height of the wave above (or below) a given reference point.
- This height often denotes the voltage level of the signal (measured in volts), but it also can denote the current level of the signal (measured in amps) or the power level of the signal (measured in watts).

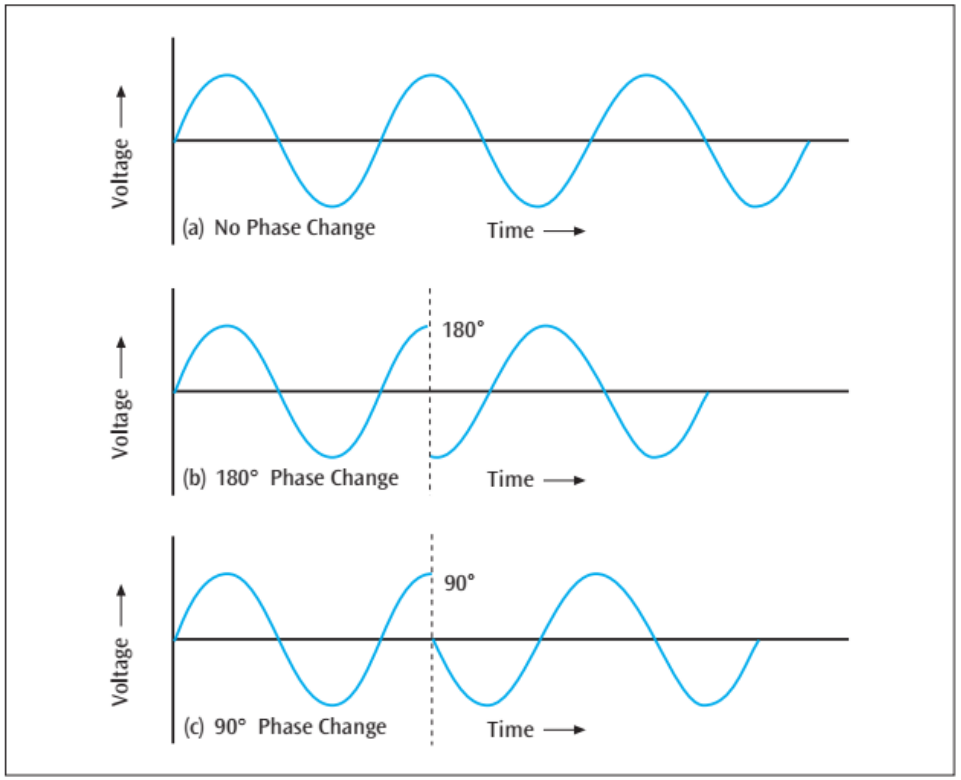


- **Frequency** of a signal is the number of times a signal makes a complete cycle within a given time frame.[represented by hertz (Hz)]
- The length, or time interval, of one cycle is called its **period**.



- The range of frequencies that a signal spans from minimum to maximum is called the **spectrum**. The spectrum of our telephone example is simply 300 Hz to 3400 Hz.
- The **bandwidth** of a signal is the absolute value of the difference between the lowest and highest frequencies.
- Noise degrades original signals, an electronic device usually has an **effective bandwidth** that is less than its bandwidth.

- **Phase** of a signal is the position of the waveform relative to a given moment of time, or relative to time zero.
- A phase change (or phase shift) involves jumping forward (or backward) in the waveform at a given moment of time.



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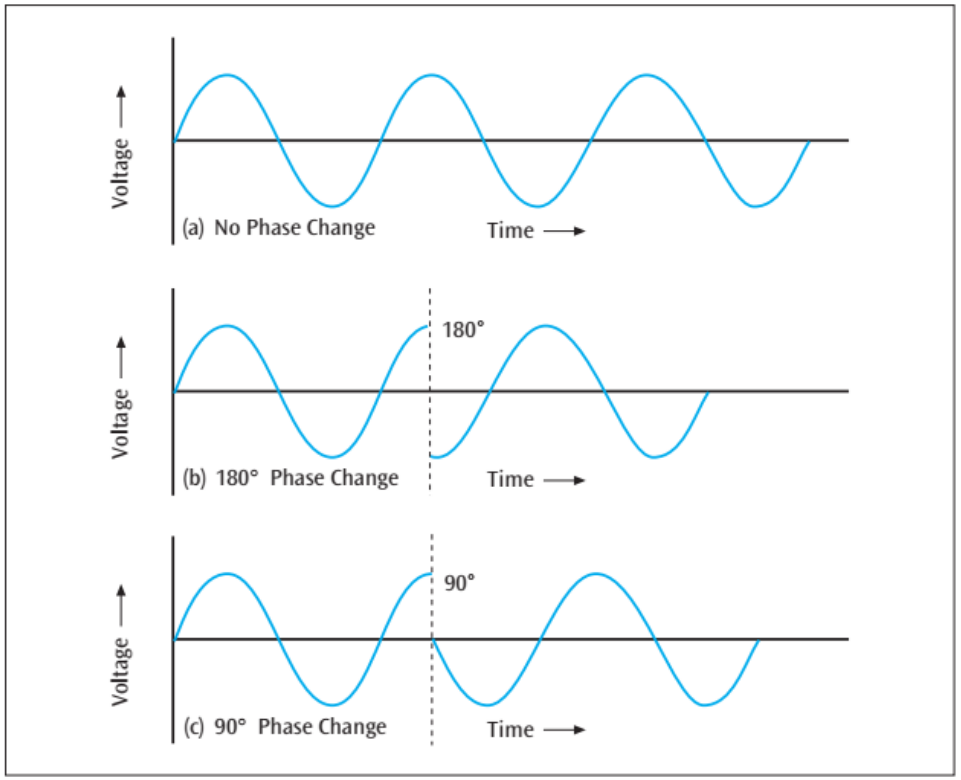


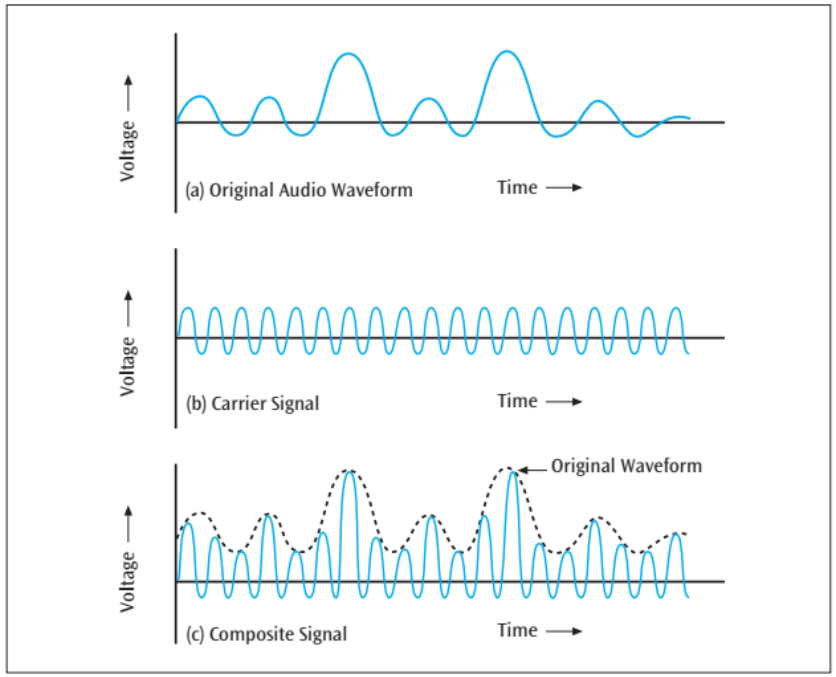
- When traveling through any type of medium, a signal always experiences some loss of its power due to friction. This loss of power, or loss of signal strength, is called **attenuation**.
- **Decibel (dB)** is a relative measure of signal loss or gain.
- **Amplification** is the opposite of attenuation. When a signal is amplified by an amplifier, the signal gains in decibels.

Converting Data into Signals

- Analog data transmitted using analog signals
- Digital data transmitted using digital signal
- Digital data transmitted using discrete analog signals
- Analog data transmitted using digital signals

Analog data transmitted using analog signals

- The data is an analog waveform that is simply being transformed to another analog waveform, the signal, for transmission. The basic operation performed is **modulation**.

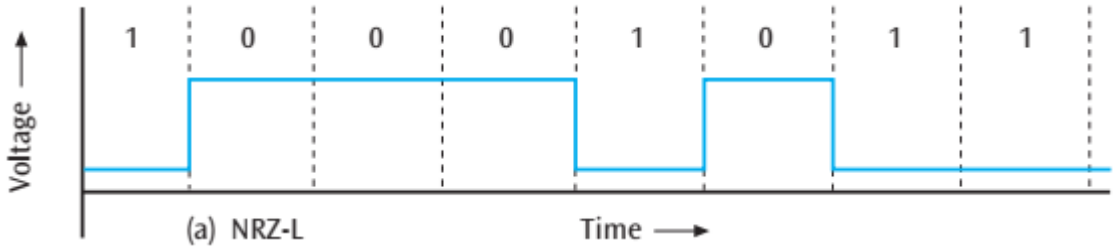


Digital data transmitted using digital signal

- The 1s and 0s of the digital data must be converted to the proper physical form that can be transmitted over a wire or an airwave.
- To transmit a data value of 1-> transmitting a positive voltage on the medium.
- To transmit a data value of 0-> transmit a zero voltage.
- OR the opposite scheme
- Most digital encoding schemes: NRZ-L, NRZI, Manchester, bipolar-AMI,and 4B/5B.

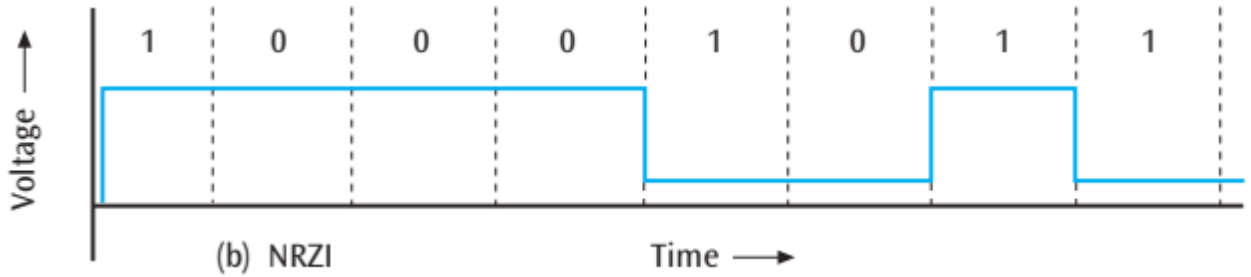
Digital data transmitted using digital signal

- nonreturn to zero-level (**NRZ-L**) digital encoding scheme transmits 1s as zero voltages and 0s as positive voltages.



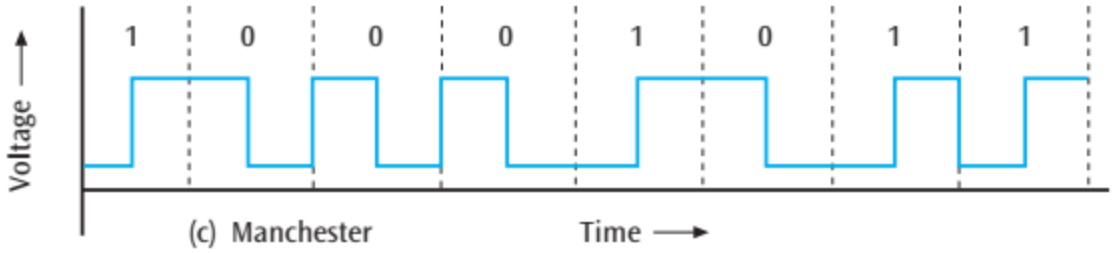
Digital data transmitted using digital signal

- Nonreturn to zero inverted (**NRZI**) has a voltage change at the beginning of a 1 and no voltage change at the beginning of a 0.



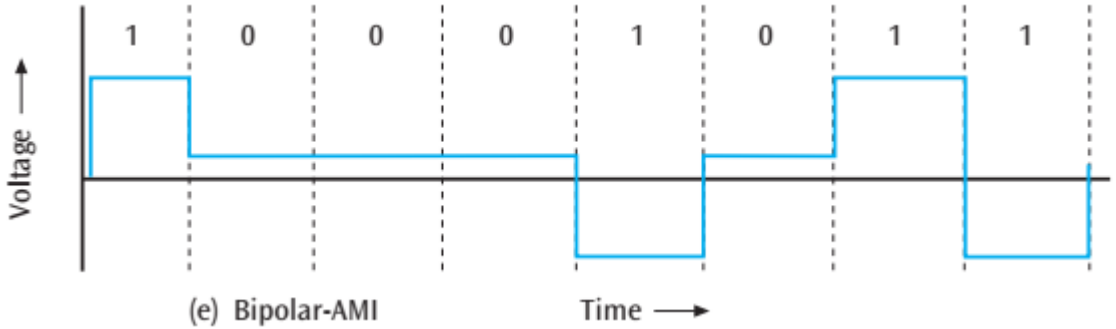
Digital data transmitted using digital signal

- **Manchester** encoding scheme has the following properties: To transmit a 1, the signal changes from low to high in the middle of the interval, and to transmit a 0, the signal changes from high to low in the middle of the interval.



Digital data transmitted using digital signal

- Bipolar-AMI encoding scheme is unique among all the encoding schemes seen thus far because it uses three voltage levels.
- When a device transmits a binary 0, a zero voltage is transmitted.
- When the device transmits a binary 1, either a positive voltage or a negative voltage is transmitted.
- Which of these is transmitted depends on the binary 1 value that was last transmitted.
- For example, if the last binary 1 transmitted a positive voltage, then the next binary 1 will transmit a negative voltage. Likewise, if the last binary 1 transmitted a negative voltage, then the next binary 1 will transmit a positive voltage



Digital data transmitted using digital signal

- The 4B/5B encoding scheme takes 4 bits of data, converts the 4 bits into a unique 5-bit sequence, and encodes the 5 bits using NRZI.

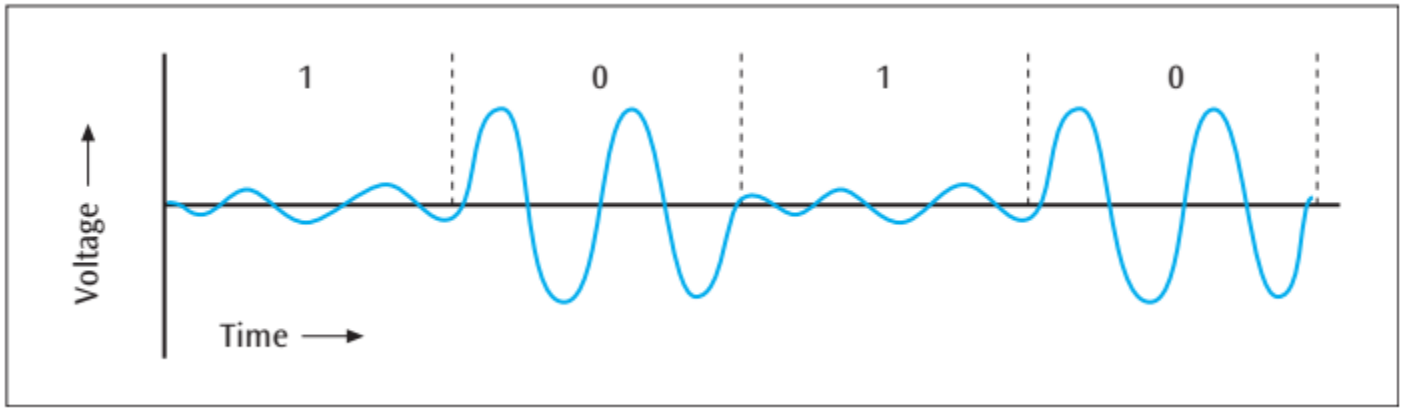
Valid Data Symbols

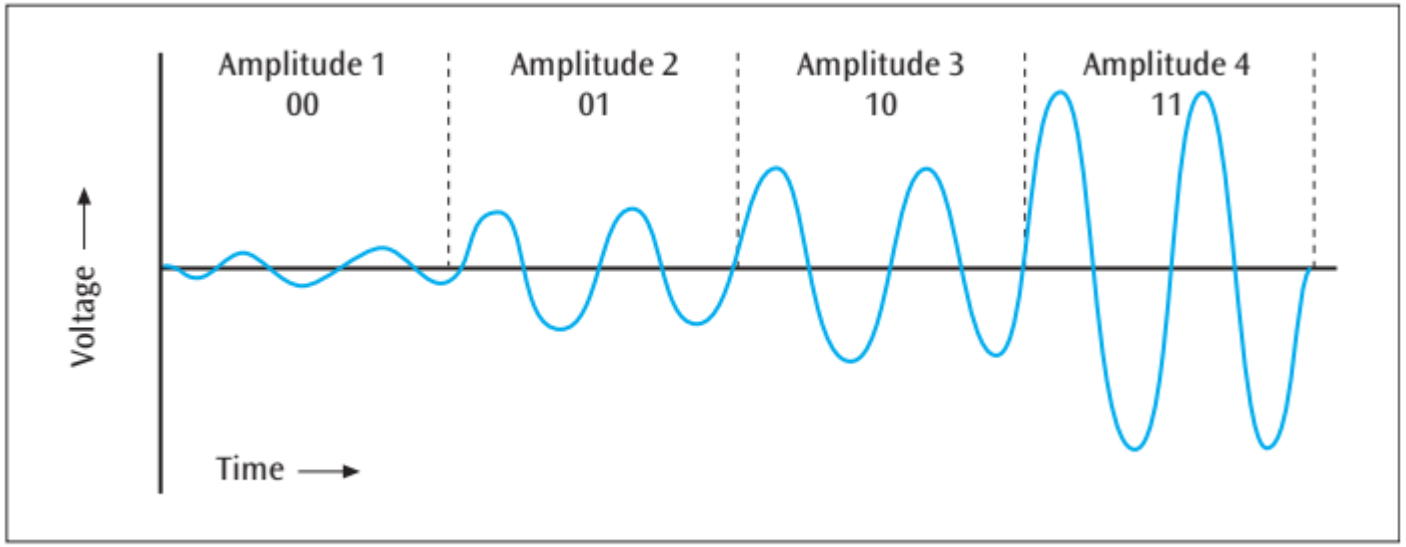
Original 4-bit data	New 5-bit code
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

Invalid codes
00001
00010
00011
01000
10000

Digital data transmitted using discrete analog signals

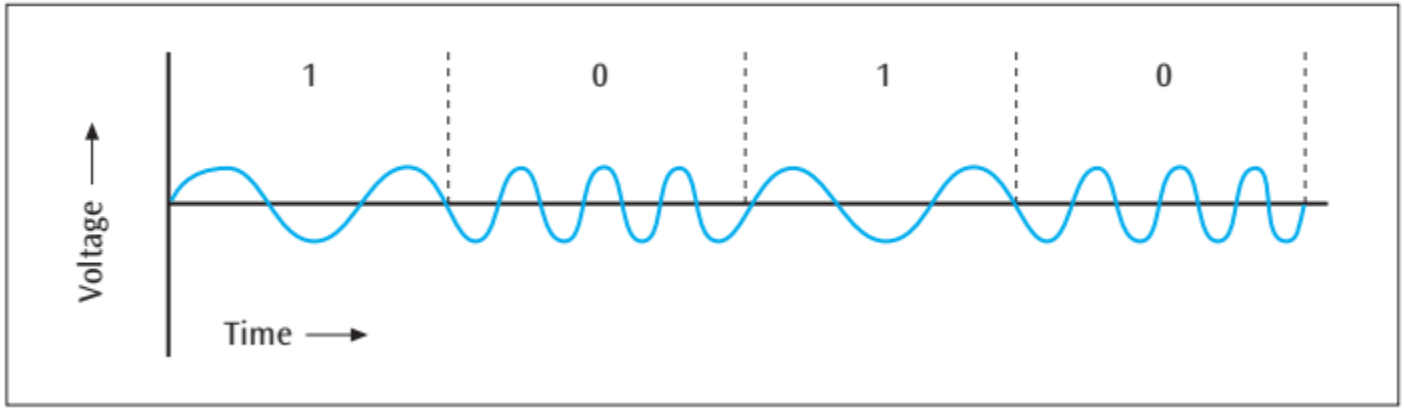
- The simplest modulation technique is **amplitude shift keying**.
- Data value of 1 and a data value of 0 are represented by two different amplitudes of a signal.
- For example, the higher amplitude could represent a 1, while the lower amplitude (or zero amplitude) could represent a 0.




Amplitude 1
00
Amplitude 2
01
Amplitude 3
10
Amplitude 4
11
Voltage
Time

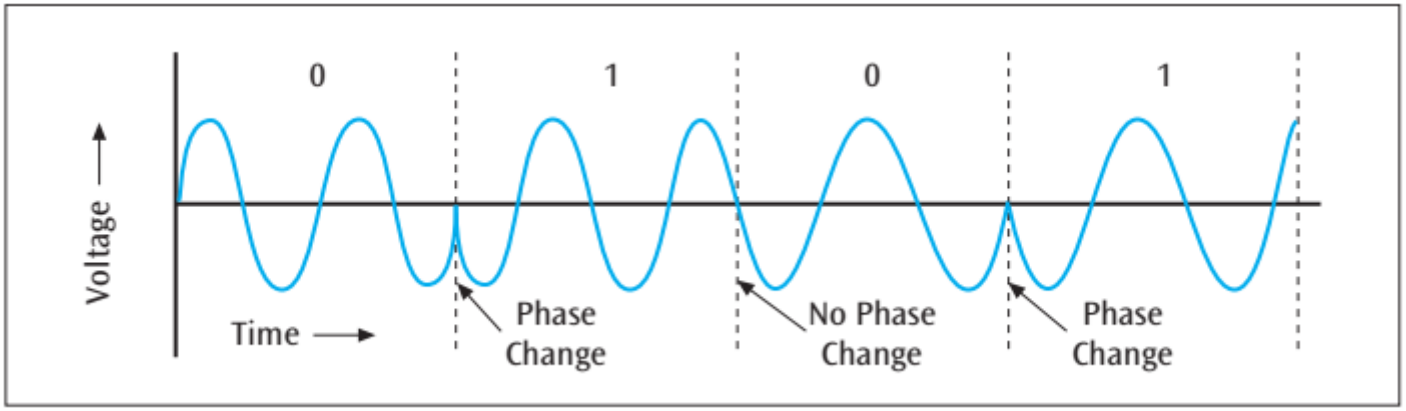
Digital data transmitted using discrete analog signals

- **Frequency shift keying** uses two different frequency ranges to represent data values of 0 and 1
- The lower frequency signal might represent a 1, while the higher frequency signal might represent a 0.



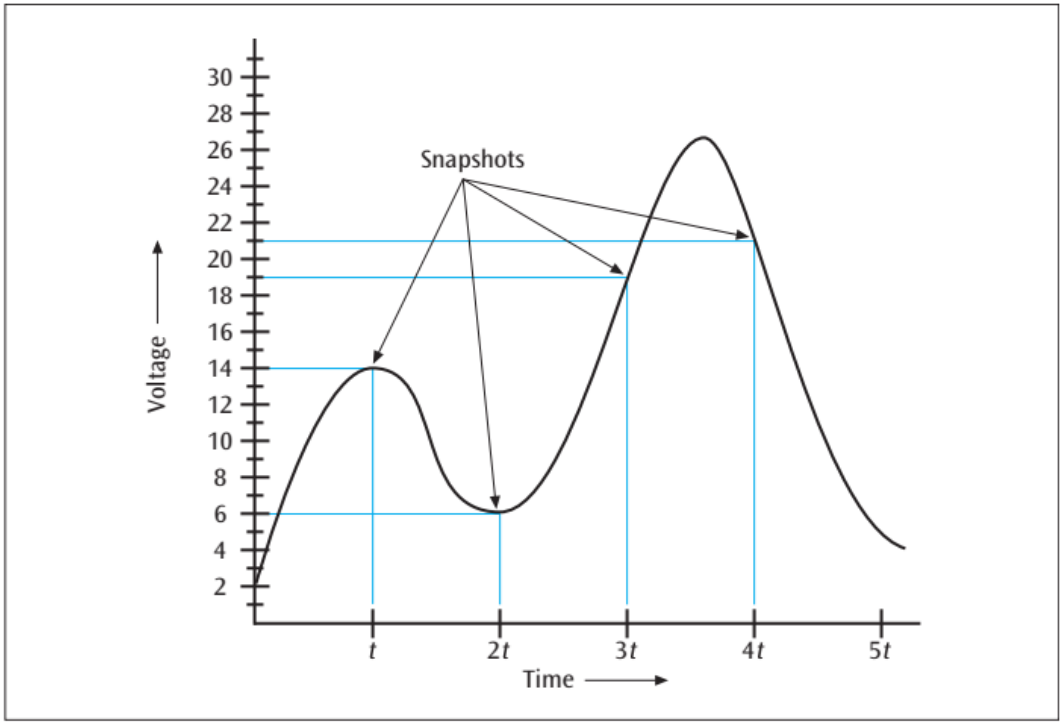
Digital data transmitted using discrete analog signals

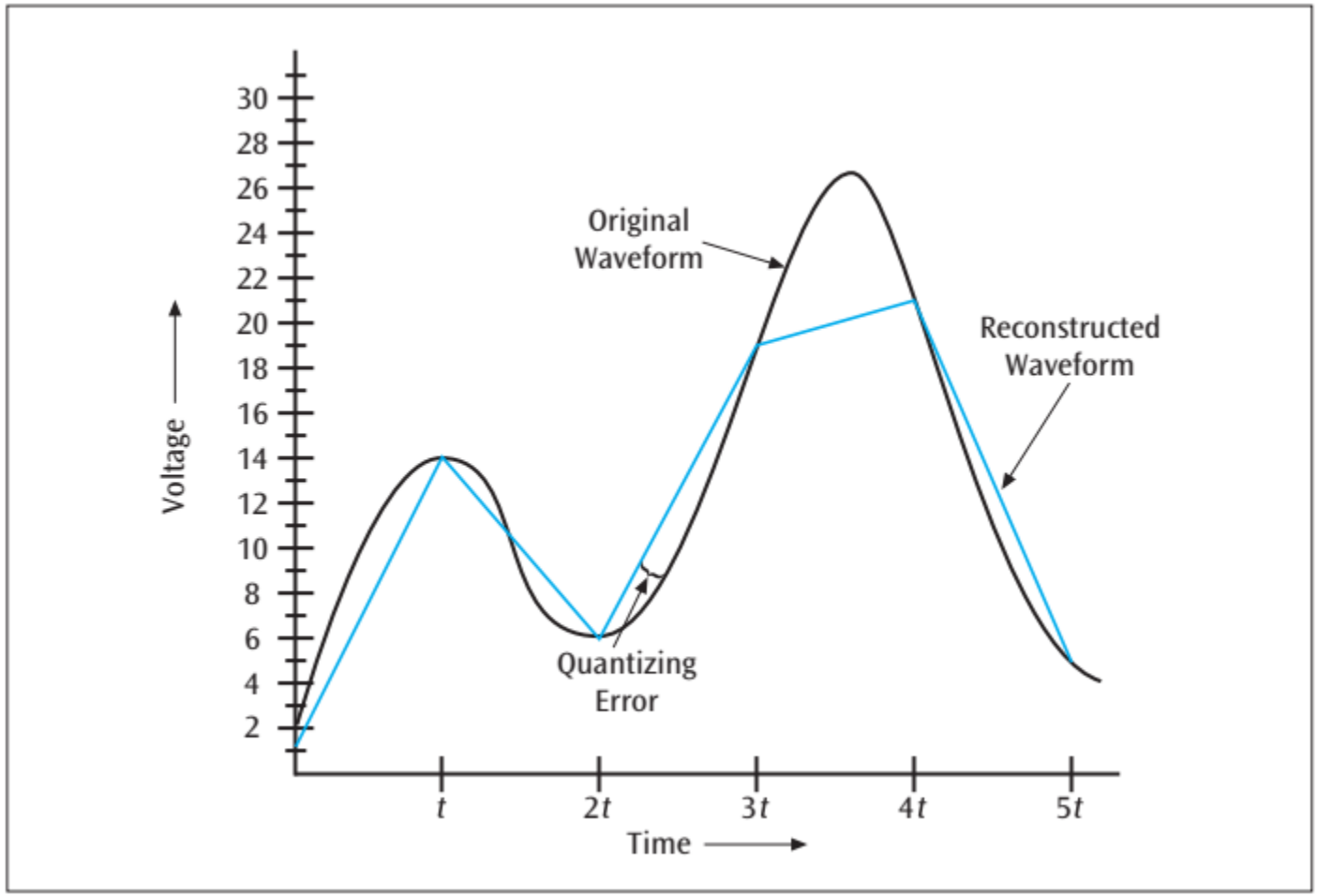
- **Phase shift keying** represents 0s and 1s by different changes in the phase of a waveform.
- For example, a 0 could be no phase change, while a 1 could be a phase change of 180 degrees



Analog data transmitted using digital signals

- Tracking an analog waveform and converting it to pulses that represent the wave's height above (or below) a threshold is termed **pulse amplitude modulation (PAM).**




30
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Waveform
Quantizing
Error
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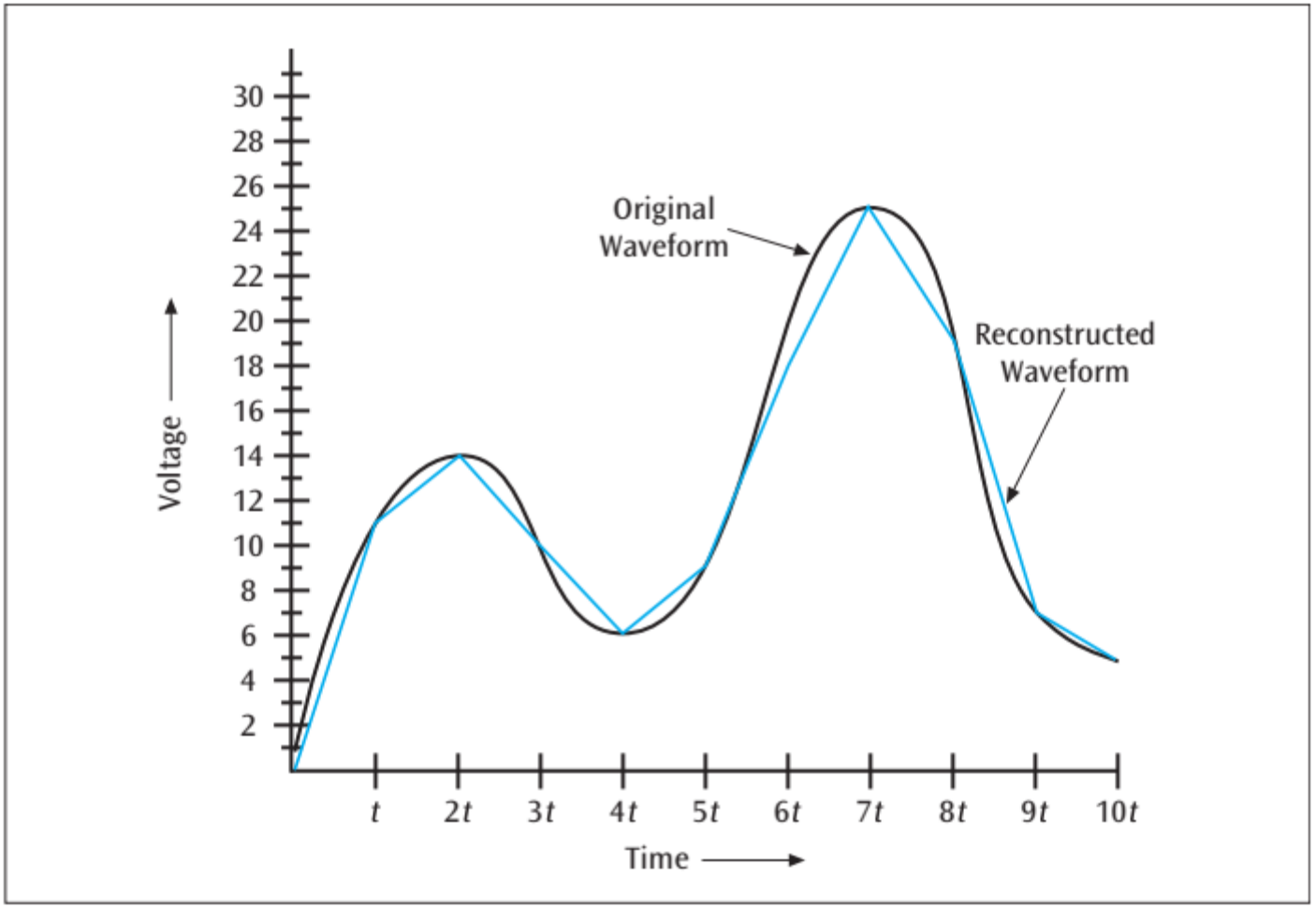
4t
5t
Time


30
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6
4
2
Voltage
Original
Waveform
Reconstructed
Waveform
t
2t
3t
4t
5t
6t
7t
8t
9t
10t
Time

Analog data transmitted using digital signals

- With **delta modulation**, a codec tracks the incoming analog data by assessing up or down "steps."
- During each time period, the codec determines whether the waveform has risen one delta step or dropped one delta step. If the waveform rises one delta step, a 1 is transmitted.
- If the waveform drops one delta step, a 0 is transmitted.