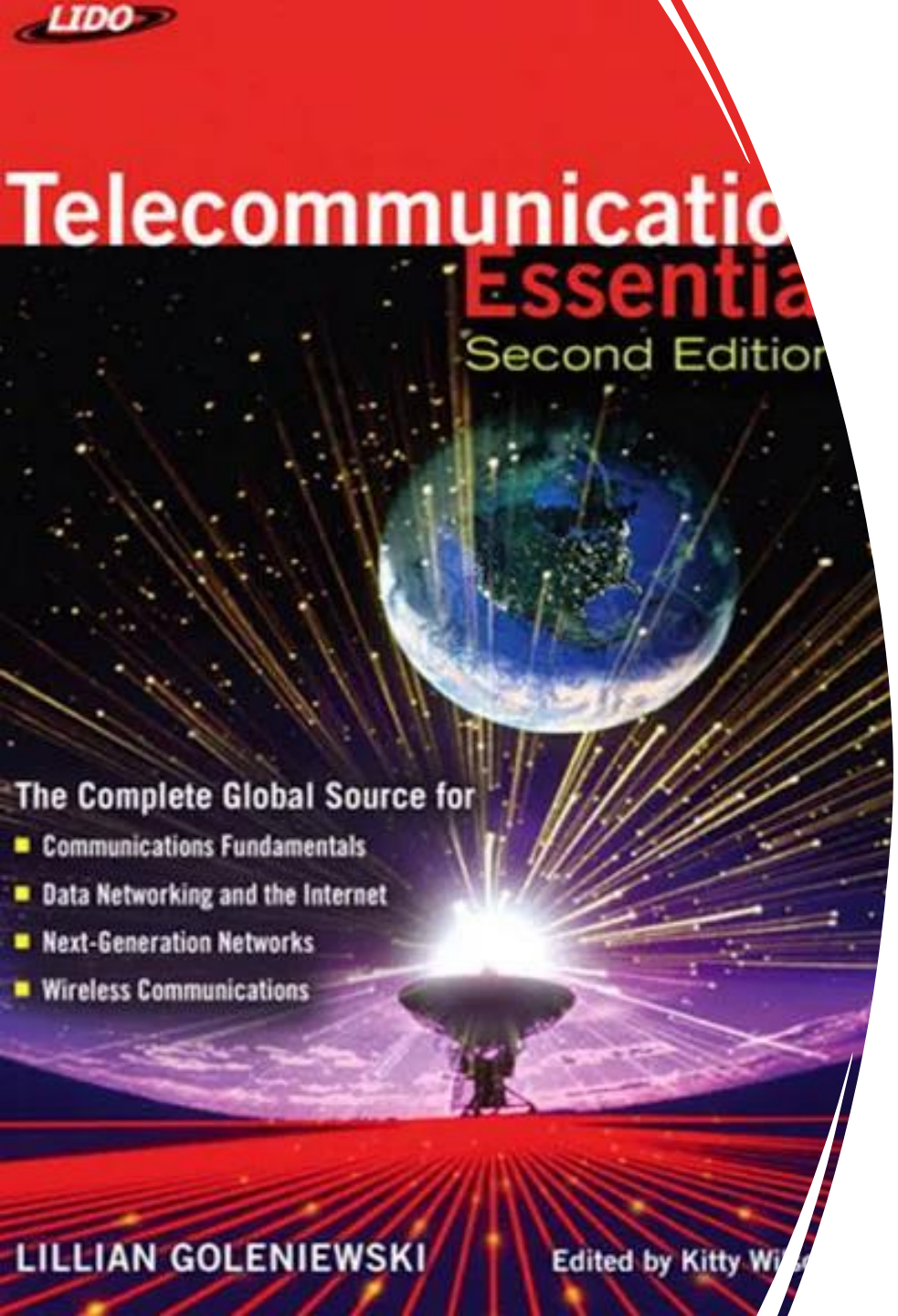


1. Communications Fundamentals

1.1 Transmission Lines

1.2 Types of Network Connections

1.3 The Electromagnetic Spectrum

1.4 Analog and Digital Transmission

1.5 Multiplexing

1.6 Traditional Transmission Media

1.7 Establishing Channels

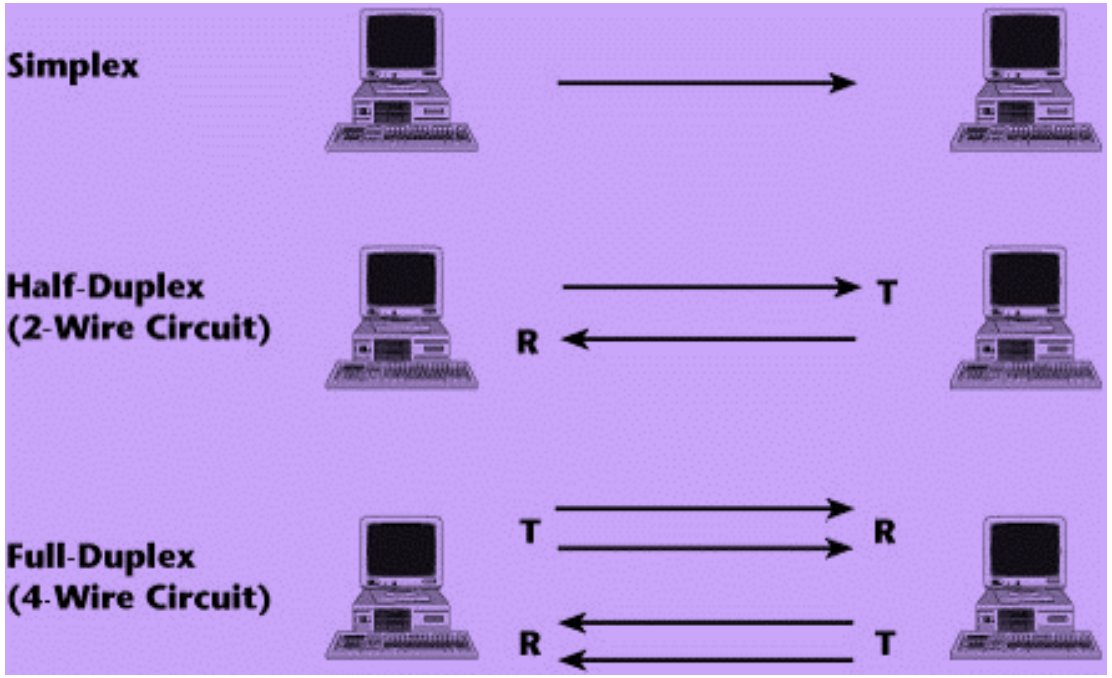
1.8 Political and Regulatory Forces

1.1 Transmission Lines

- Two prerequisites must be satisfied to have successful communication.
- The first prerequisite is understandability. The transmitter and receiver must speak the same language.
- The second prerequisite is the capability to detect errors as they occur and to have some procedure for resolving those errors.
- If these two prerequisites understandability and error control are met, then communication can occur. We communicate by using data devices over what is generically termed a *transmission line*. There are five main types of transmission lines: *circuits*, *channels*, *lines*, *trunks*, and *virtual circuit*.

1.1 Transmission Lines

- A *circuit* is the physical path that runs between two or more points. It terminates on a *port* , and that port can be in a host computer, on a multiplexer, on a switch, or in another device.

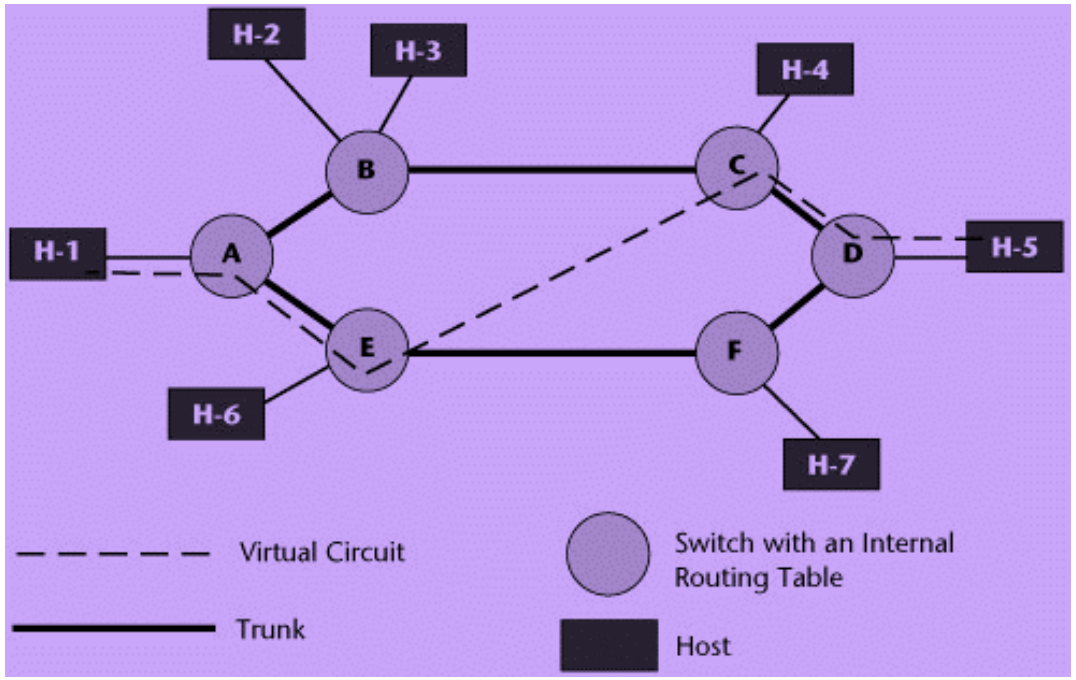


1.1 Transmission Lines

- A *channel* defines a logical conversation path. It is the frequency band, time slot, or wavelength (also referred to as lambda, λ) allocated to a single conversation. In the context of telecommunications, a channel is a child of the digital age because digital facilities enable multiple channels, greatly increasing the carrying capacity of an individual circuit. Because we are becoming more digitalized all the time, people often refer to the number of channels rather than the number of circuits.
- *Lines* and *trunks* are basically the same thing, but they're used in different situations. A *line* is a connection configured to support a normal calling load generated by one individual. A *trunk* is a circuit configured to support the calling loads generated by a group of users; it is the transmission facility that ties together switching systems. A switching system is a device that connects two transmission lines.

1.1 Transmission Lines

- Because of the great interest in and increased use of packet switching, most networks use *virtual circuits*. Unlike a *physical circuit*, which terminates on specific physical ports, a virtual circuit is a series of logical connections between sending and receiving devices.



1.2 Types of Network Connections

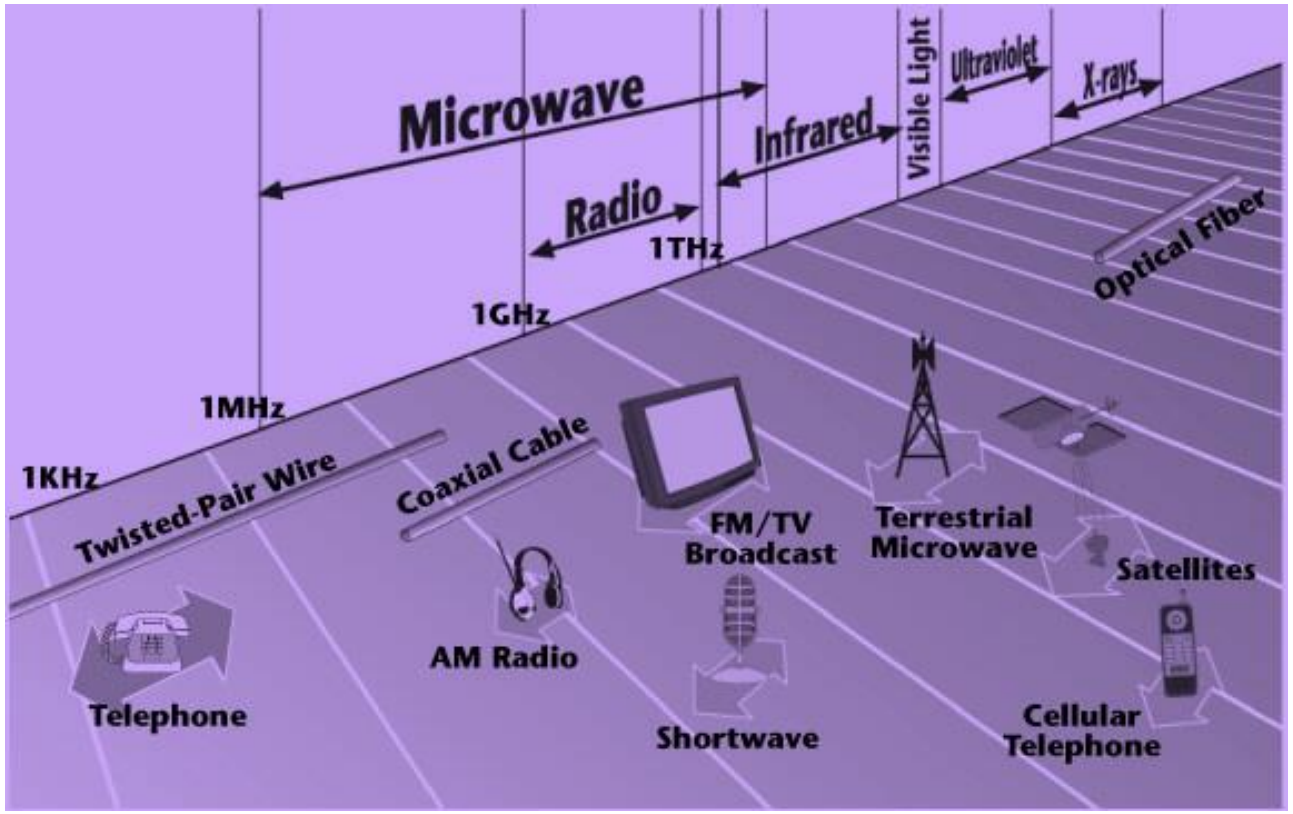
- *Switched network connections* : A switched connection is referred to as a dialup connection. This implies that it uses a series of network switches to establish the connection between the parties.
- *Leased-line network connections* : A leased line is also referred to as a private line. With a leased line, the same locations or the same devices are always connected, and transmission between those locations or devices always occurs on the same path.
- *Dedicated network connections* : In essence, a dedicated line works exactly like a leased line. It is always connected, and it always uses the same path for transmission. However, the end user may own the transmission facility (rather than lease it) such that it is exclusive to that user.

1.3 The Electromagnetic Spectrum

- When electrons move, they create electromagnetic waves that can propagate through free space. *James Maxwell* first predicted the existence of this phenomenon in 1865, and *Heinrich Hertz* first produced and observed it in 1887. All modern communication depends on manipulating and controlling signals within the electromagnetic spectrum.
- The electromagnetic spectrum ranges from extremely low-frequency radio waves of 30Hz, with wavelengths nearly double the earth's diameter, to high-frequency cosmic rays of more than 10 million trillion Hz, with wavelengths smaller than the nucleus of an atom.
- The electromagnetic spectrum is depicted as a logarithmic progression: The scale increases by multiples of 10, so the higher regions encompass a greater span of frequencies than do the lower regions.

1.3 The Electromagnetic Spectrum

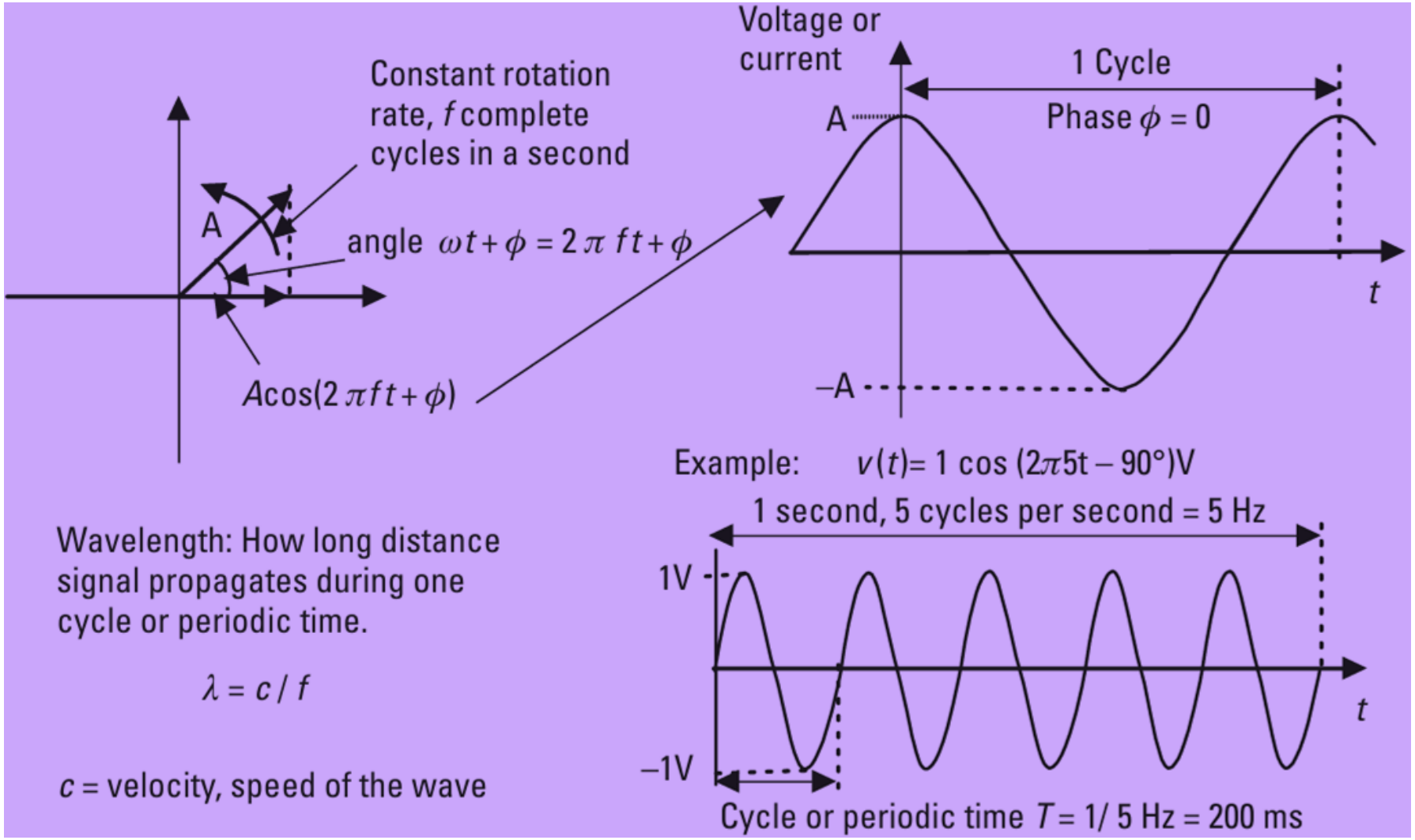
Transmission Media	ITU-Defined Band	Frequency	
	Gamma Rays	10^{22}	
		10^{19}	
	X-rays	10^{16}	
	Ultraviolet		
Fiber Optics	Visible Light	10^{14}	
	Infrared		
Microwave	THF	10^{12}	1THz
↑	EHF		
PCS Microwave	SHF		
FM TV, Cellular Radio	UHF	10^{9}	1GHz
TV, Coax	VHF		
AM ↑			
↑ Coax	High	10^{6}	1MHz
Twisted Pair	Medium		
Audio Frequencies	Low		
	Very Low	10^{3}	1KHz
	Extremely Low		
		10^{0}	1Hz



1.3 The Electromagnetic Spectrum

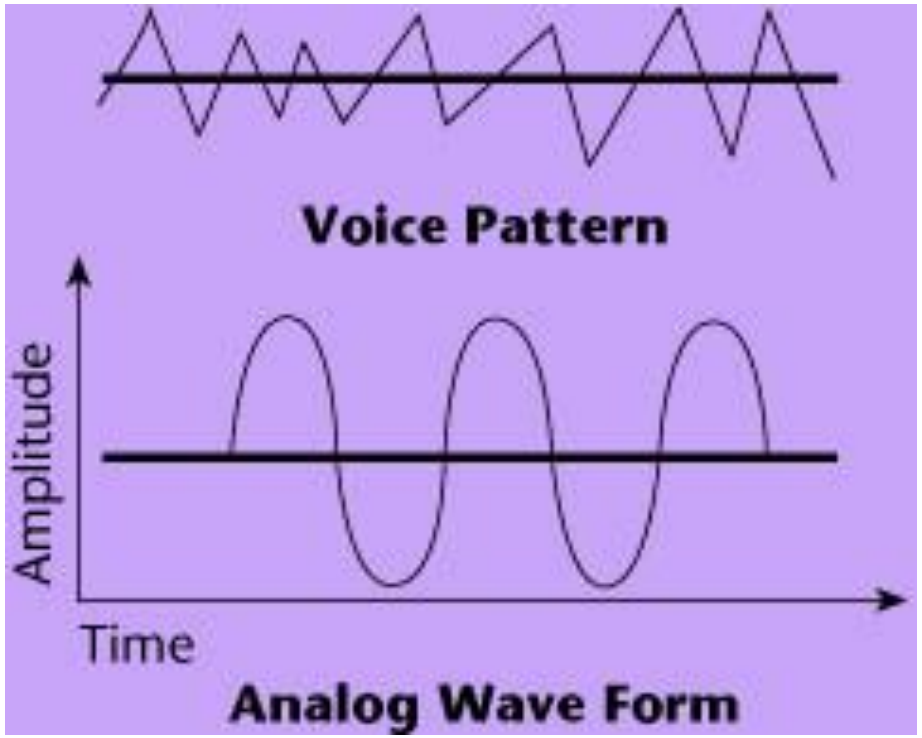
- *Frequency* : The number of oscillations per second of an electromagnetic wave.
- *Hertz* : Frequency is measured in Hertz (Hz).
- *Wavelength* : The distance between two consecutive maxima or minima of the waveform.
- *Amplitude* : The height of the wave, which indicates the strength, or power, of the signal.
- *Phase* : The phase of a wave refers to the angle of the waveform at any given moment; more specifically, it defines the offset of the wave from a reference point.
- Bandwidth : The range of frequencies (i.e., the difference between the lowest and highest frequencies carried).

1.3 The Electromagnetic Spectrum



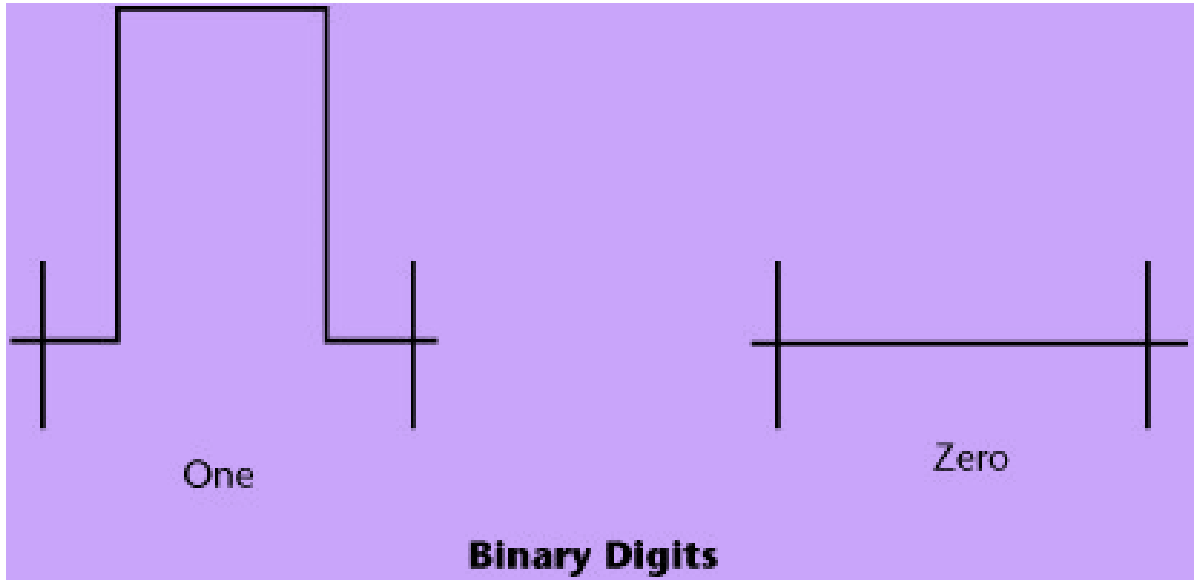
1.4 Analog and Digital Transmission

- *Analog Transmission* : An analog waveform (or signal) is characterized by being continuously variable along amplitude and frequency.

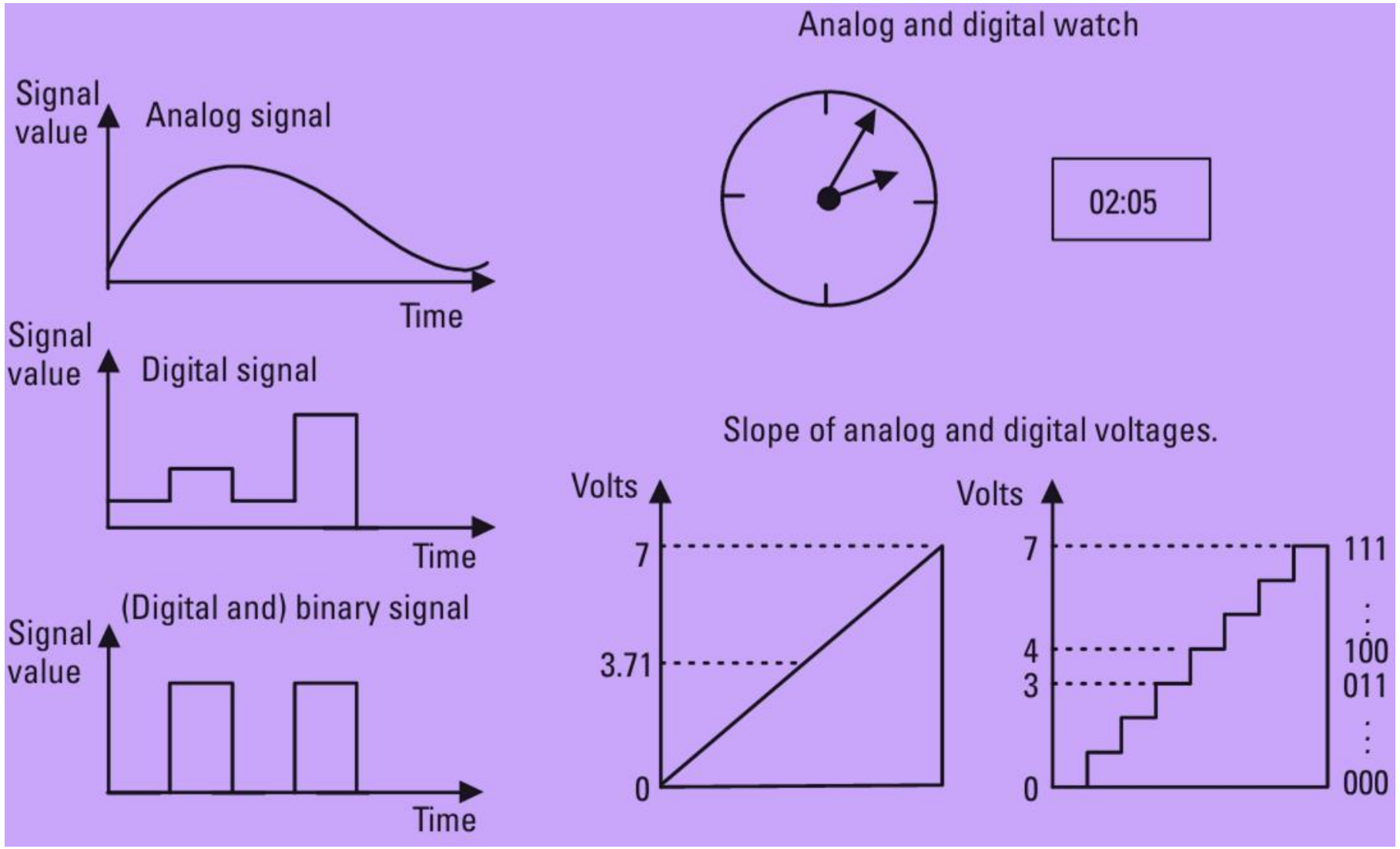


1.4 Analog and Digital Transmission

- *Digital Transmission* : It is a series of discrete pulses, representing one bits and zero bits. In electrical networks, one bits are represented as high voltage, and zero bits are represented as null, or low voltage.

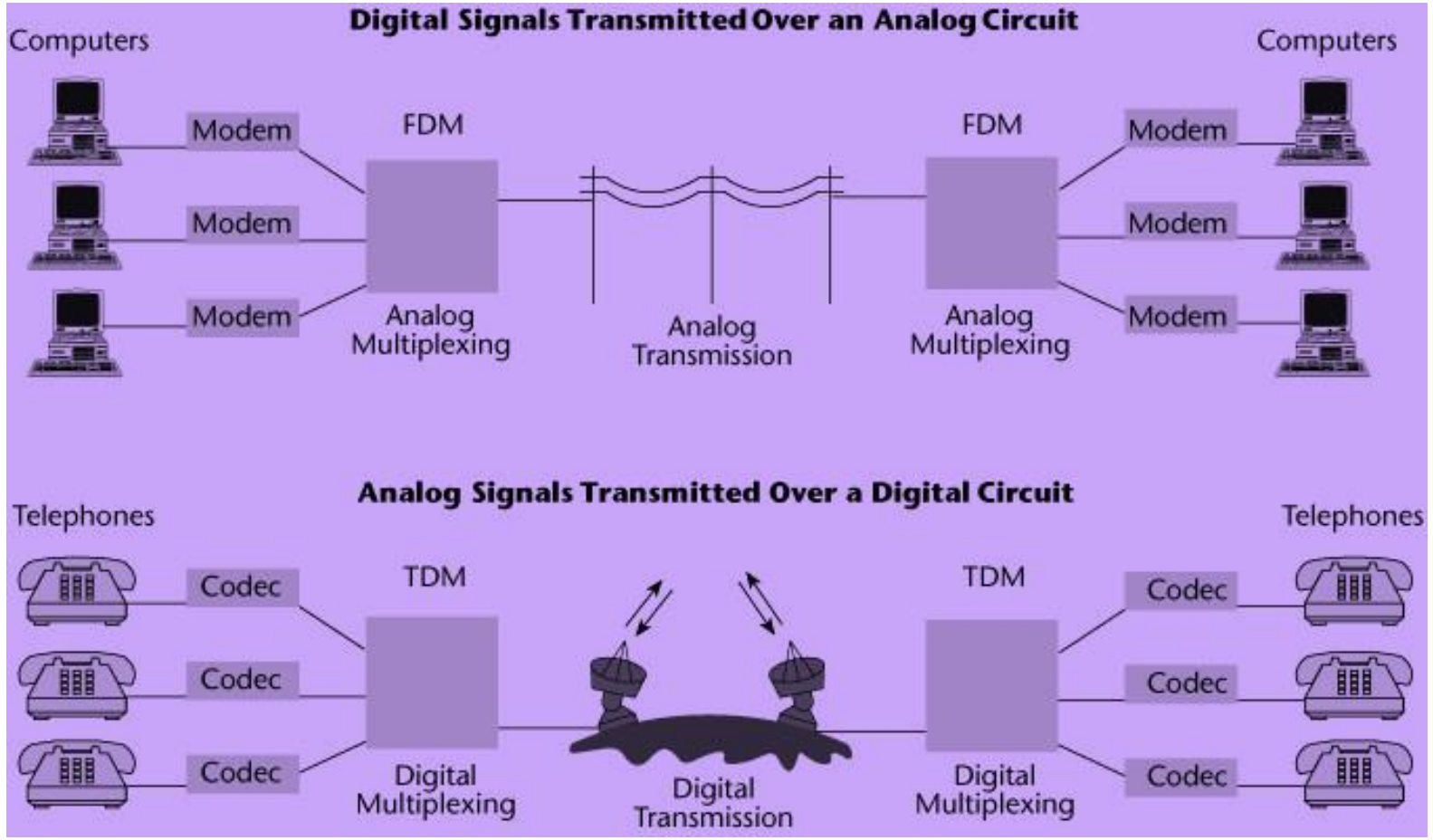


1.4 Analog and Digital Transmission



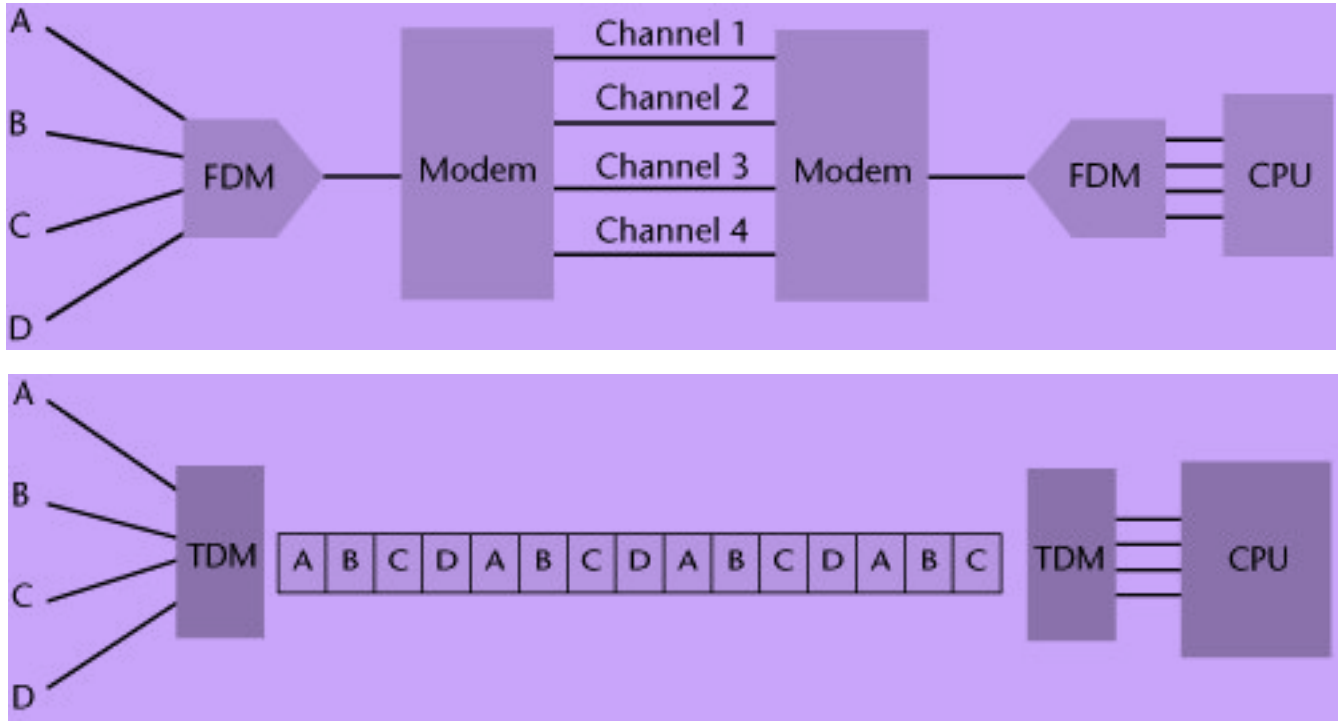
1.4 Analog and Digital Transmission

- Conversion: *Codecs* and *Modems*



1.5 Multiplexing

- *Multiplexers*, often called muxes, are extremely important to communication system. Their main reason for being is to reduce network costs by minimizing the number of communications links needed between two points.



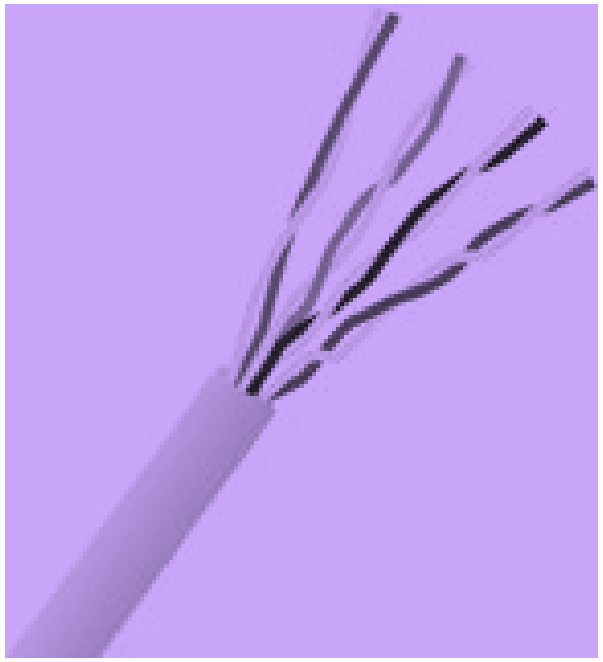
1.6 Traditional Transmission Media

- *Twisted-Pair* - There are two types of twisted-pair: UTP and STP. In STP, a metallic shield around the wire pairs minimizes the impact of outside interference. Most implementations today use UTP.
- The primary applications of twisted-pair are in premises distribution systems, telephony, private branch exchanges (PBXs) between telephone sets and switching cabinets, LANs, and local loops, including both analog telephone lines and broadband DSL.
- Twisted-pair is used in traditional analog subscriber lines, also known as the telephony channel or 4KHz channel. Digital twisted-pair takes the form of Integrated Services Digital Network (ISDN) and the new-generation family of DSL standards, collectively referred to as xDSL

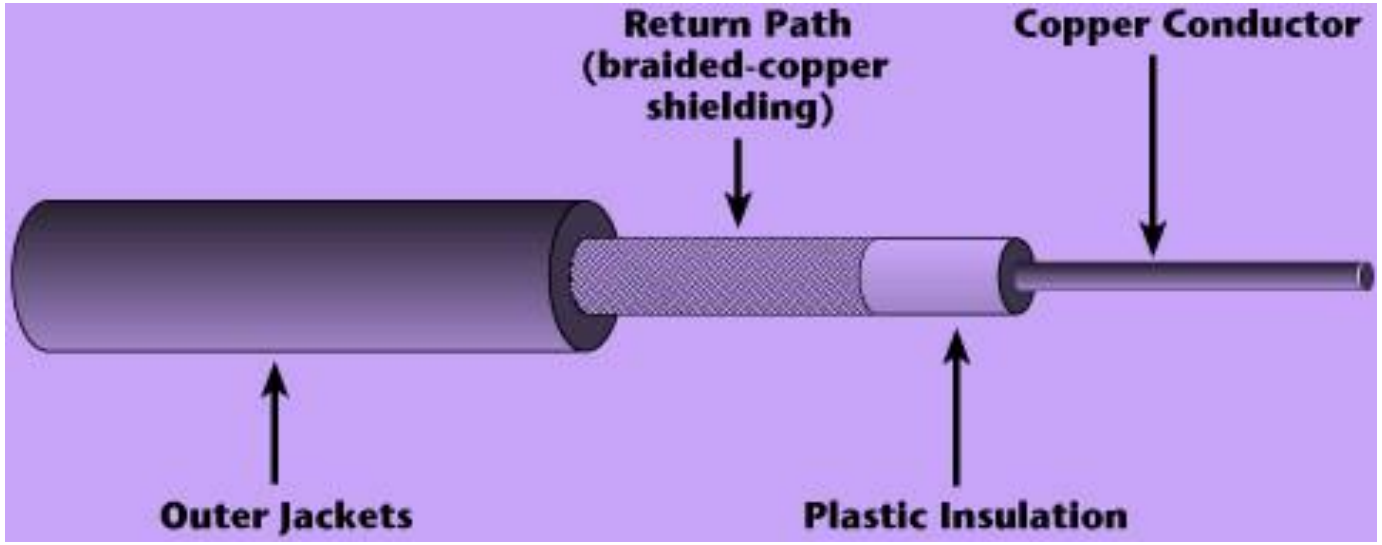
1.6 Traditional Transmission Media

- *Coaxial Cable* - In the mid-1920s, coax was applied to telephony networks as interoffice trunks.
- The next major use of coax in telecommunications occurred in the 1950s, when it was deployed as submarine cable to carry international traffic.
- It was then introduced into the data-processing realm in the mid- to late 1960s. Early computer architectures required coax as the media type from the terminal to the host.
- LANs were predominantly based on coax from 1980 to about 1987.
- Coax has been used in cable TV and in the local loop, in the form of HFC architectures.

1.6 Traditional Transmission Media



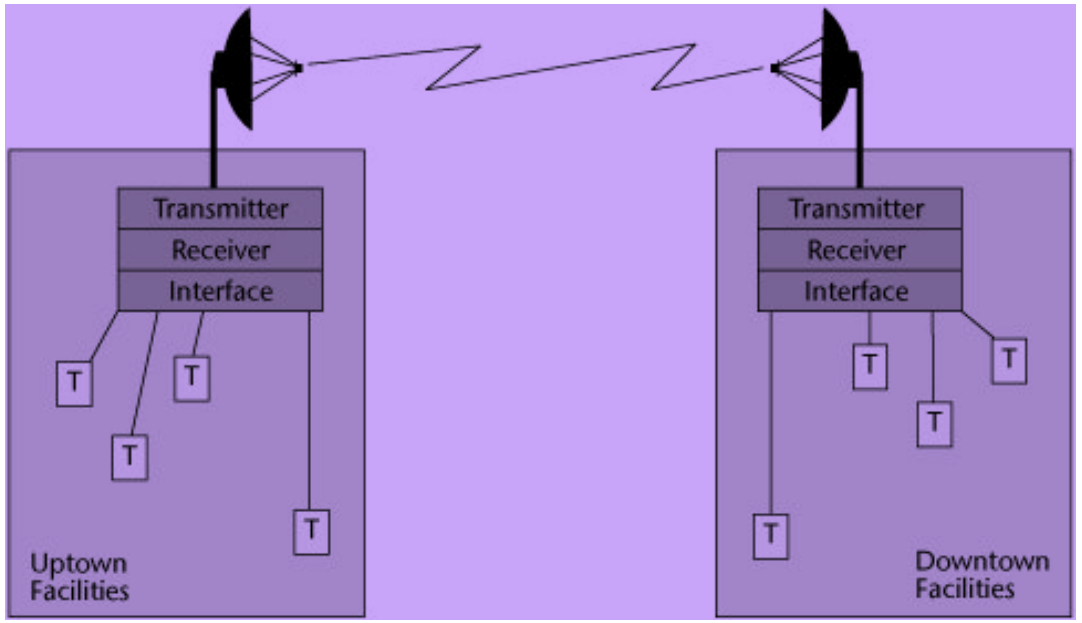
Twisted-Pair



Coaxial Cable

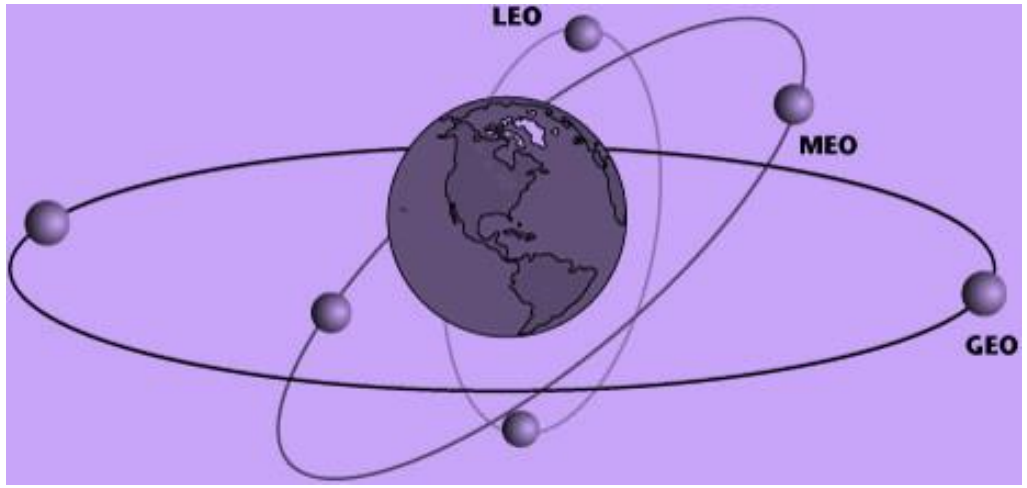
1.6 Traditional Transmission Media

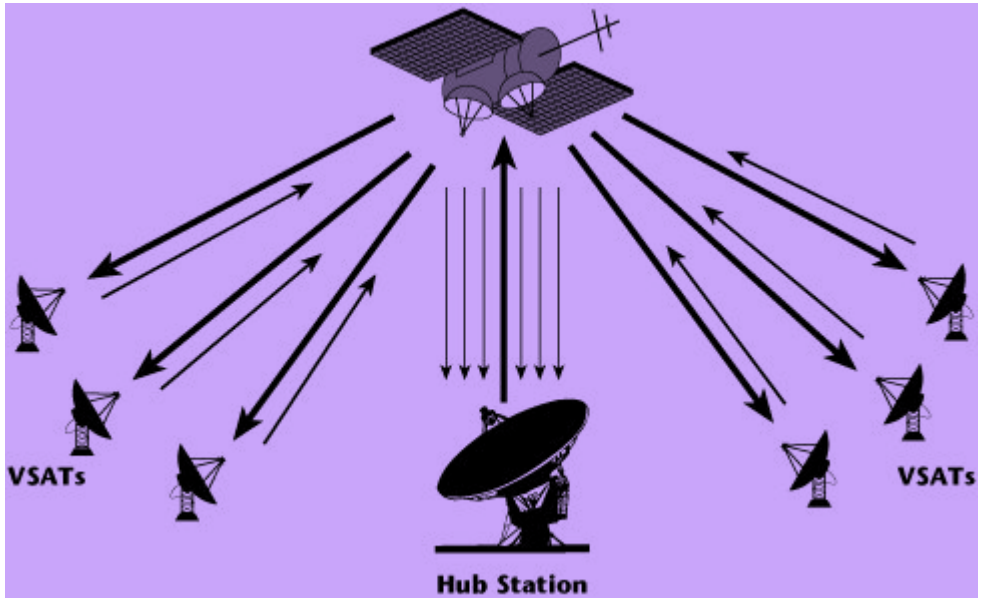
- twisted-pair and coax both face limitations because of the frequency spectrum.
- *microwave* promises to have a much brighter future than twisted-pair or coax.
- Many locations cannot be cost-effectively cabled by using wires and this is where microwave can shine.
- In addition, the microwave spectrum is the workhorse of the wireless world.



1.6 Traditional Transmission Media

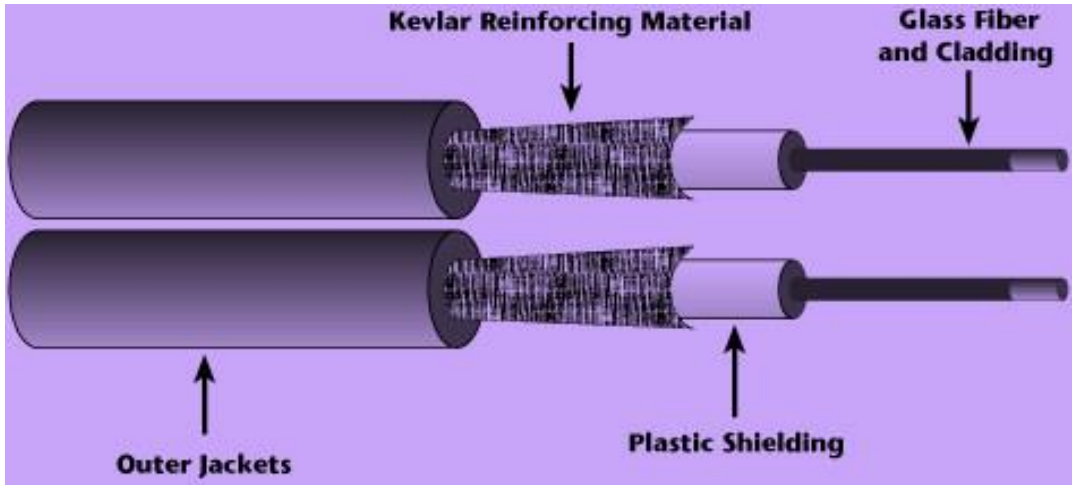
- *Satellite* - In descriptions of satellite services, three abbreviations relate to the applications that are supported: FSS Fixed satellite services, BSS Broadcast satellite services and MSS Mobile satellite services

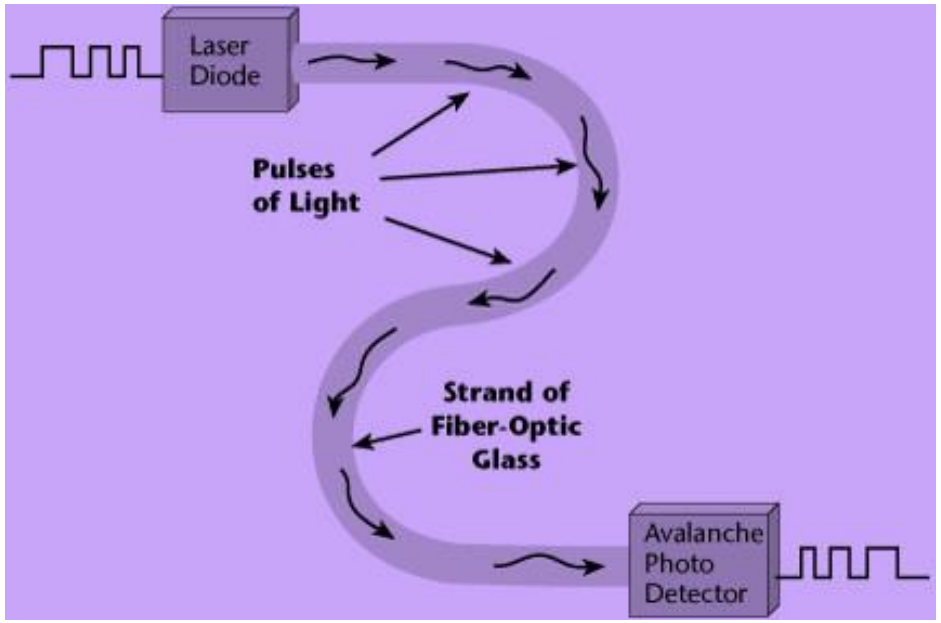




1.6 Traditional Transmission Media

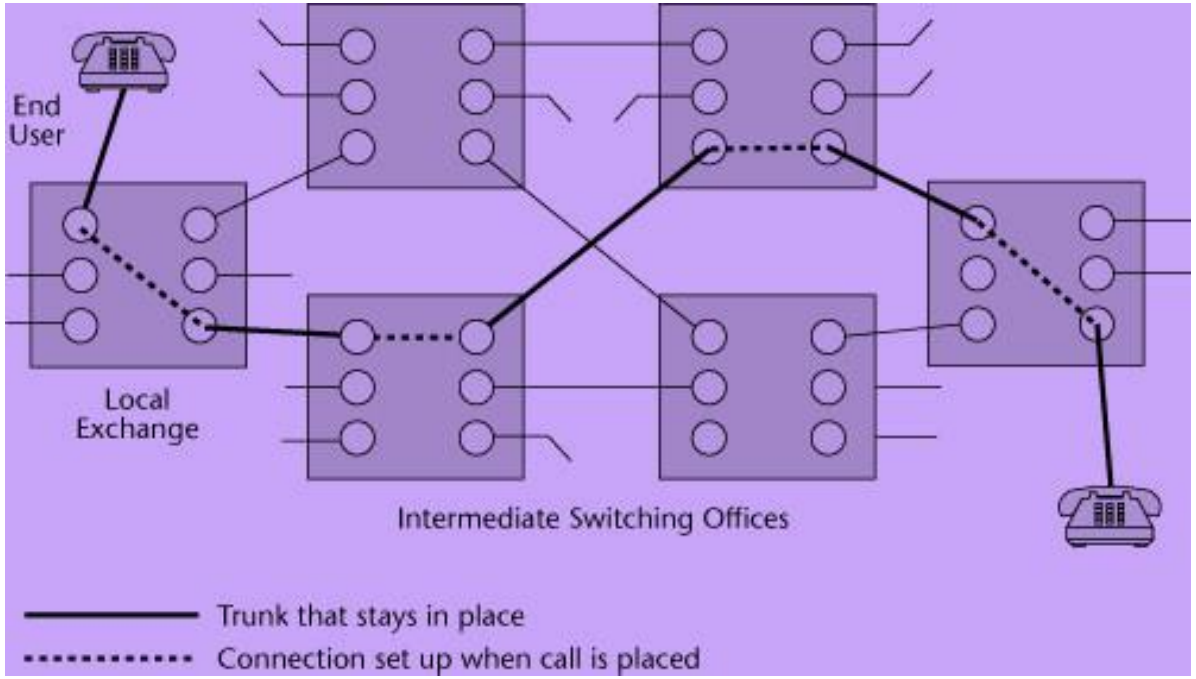
- *Fiber Optics* - Fiber optics operates in the visible light spectrum. Wavelength is a measure of the width of the waves being transmitted. Different fiber-optic materials are optimized for different wavelengths. The EIA/TIA standards currently support three wavelengths for fiber-optic transmission: 850, 1,300, and 1,550 nanometers (nm).





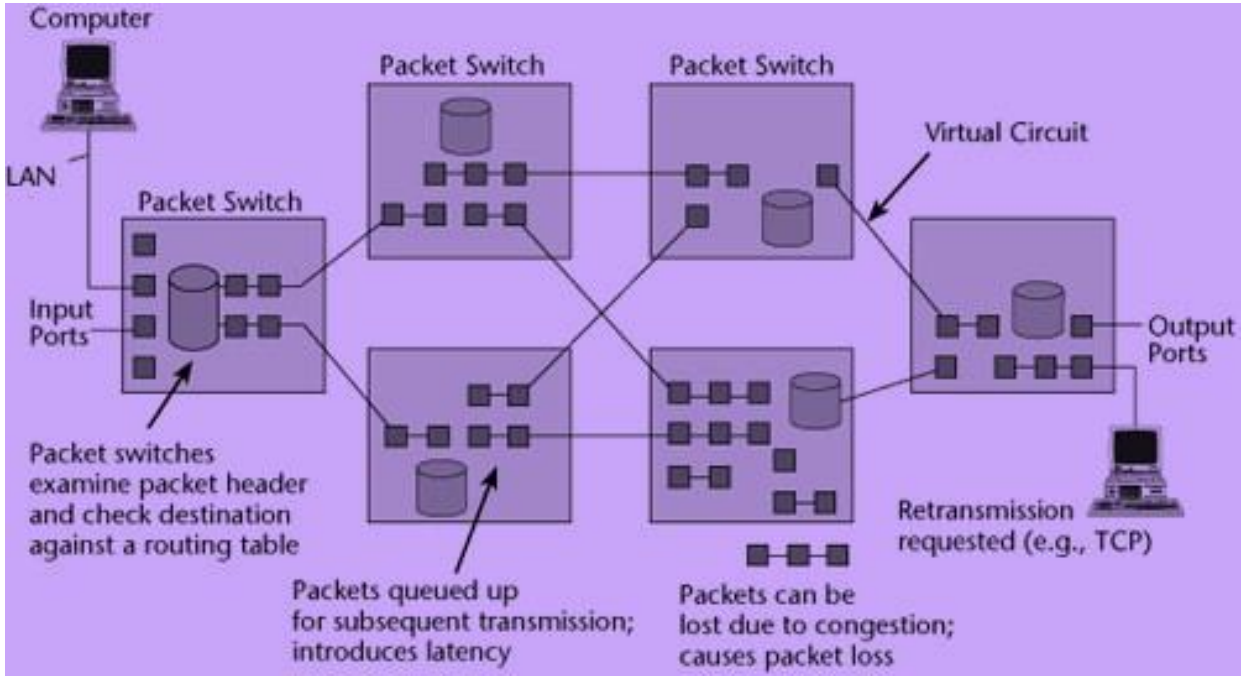
1.7 Establishing Channels

- There are two switching modes: circuit switching and packet switching.
- *Circuit switching* has been the basis of voice networks worldwide for many years. You can apply three terms to the nature of a circuit-switched call to help remember what it is: continuous, exclusive, and temporary.



1.7 Establishing Channels

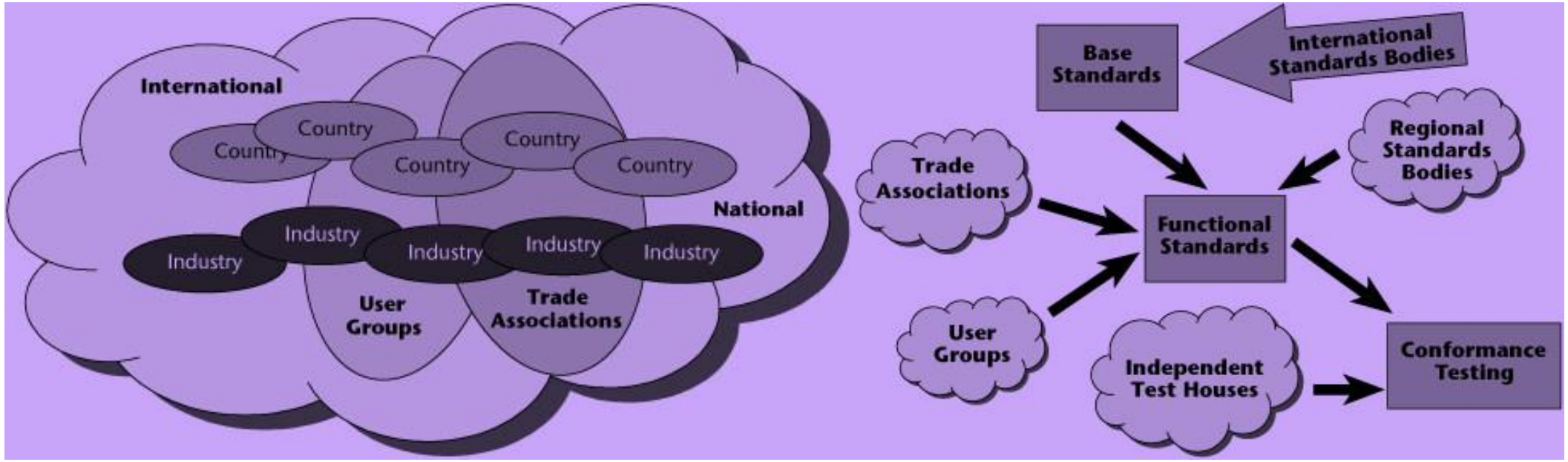
- *Packet switching* has its origin in data communications. In fact, packet switching was developed specifically as a solution for the communications implications of a form of data processing called interactive processing.



1.7 Establishing Channels

Characteristic	Circuit Switching	Packet Switching
Origin	Voice telephony	Data networking
Connectionless or connection oriented	Connection oriented	Both
Key applications	Real-time voice, streaming media, videoconferencing, video-on-demand, and other delay- and loss-sensitive traffic applications	Bursty data traffic that has long connect times but low data volumes; applications that are delay and loss tolerant
Latency/delay/jitter	Low latency and minimal delays	Subject to latency, delay, and jitter because of its store-and-forward nature
Network intelligence	Centralized	Decentralized
Bandwidth efficiency	Low	High
Packet loss	Low	Low to high, depending on the network

1.8 Political and Regulatory Forces



Standards-making groups & The standards-making process

1.8 Political and Regulatory Forces

Region	Standards Organizations
International	ITU, ITU-T, ITU-R, ITU-D, IEC, ISO
Australia	ACA, ACC, AIIA, ATUG
Europe	AFNOR (France), CEN and CENLEC, CEPT, DIN (Germany), DTI (UK), ETSI, European Community (EU)
Japan	JISC, TTC
New Zealand	ITANZ
North America	ANSI (USA), EIA, FCC (USA), IEEE, NIST, SCC (Canada)