UNIT 1

Bandwidth

Some of the definitions of bandwidth in the context of Information Technology (IT) are :

1) In computer networks, bandwidth is used as a synonym for data transfer rate, the amount of data that can be carried from one point to another in a given time period (usually a second). Network bandwidth is usually expressed in bits per second (bps); modern networks typically have speeds measured in the millions of bits per second (megabits per second, or Mbps) or billions of bits per second (gigabits per second, or Gbps).

Note that bandwidth is not the only factor that affects network performance: There is also packet loss, latency and jitter, all of which degrade network throughput and make a link perform like one with lower bandwidth. A network path usually consists of a succession of links, each with its own bandwidth, so the end-to-end bandwidth is limited to the bandwidth of the lowest speed link (the bottleneck).

Different applications require different bandwidths. An instant messaging conversation might take less than 1,000 bits per second (bps); a voice over IP (VoIP) conversation requires 56 kilobits per second (Kbps) to sound smooth and clear. Standard definition video (480p) works at 1 megabit per second (Mbps), but HD video (720p) wants around 4 Mbps, and HDX (1080p), more than 7 Mbps.

Effective bandwidth -- the highest reliable transmission rate a path can provide -- is measured with a bandwidth test. This rate can be determined by repeatedly measuring the time required for a specific file to leave its point of origin and successfully download at its destination.

2) Bandwidth is the range of frequencies -- the difference between the highest-frequency signal component and the lowest-frequency signal component -- an electronic signal uses on a given transmission medium. Like the frequency of a signal, bandwidth is measured in hertz (cycles per second). This is the original meaning of bandwidth, although it is now used primarily in discussions about cellular networks and the spectrum of frequencies that operators license from various governments for use in mobile services.

Example: If a periodic signal is decomposed into five sine waves with frequencies of 100, 300, 500, 700, and 900 Hz, what is its bandwidth?

Sol: Let fh be the highest frequency, fl the lowest frequency, and B the bandwidth.

Then B =fh -fl = 900 -100 = 800 Hz

Bit Rate

Most digital signals are nonperiodic, and thus period and frequency are not appropriate characteristics. Another term-bit rate (instead ofjrequency)-is used to describe digital signals. The bit rate is the number of bits sent in Is, expressed in bits per second (bps).

Example: Assume we need to download text documents at the rate of 100 pages per minute. What is the required bit rate of the channel?

Sol:A page is an average of 24 lines with 80 characters in each line. If we assume that one character requires 8 bits, the bit rate is 100 x 24 x 80 x 8 =1,636,000 bps =1.636 Mbps

Bit Length

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

Bit length =propagation speed x bit duration

DATA RATE LIMITS

A very important consideration in data communications is how fast we can send data, in bits per second. over a channel. Data rate depends on three factors:

1. The bandwidth available
2. The level of the signals we use
3. The quality of the channel (the level of noise)

Two theoretical formulas were developed to calculate the data rate: one by Nyquist for a noiseless channel. another by Shannon for a noisy channel.

Data Transmission Concepts

Data transmission occurs between transmitter and receiver over some transmission medium. Transmission media may be classified as guided or unguided. In both cases, communication is in the form of electromagnetic waves. With guided media, the waves are guided along a physical path; examples of guided media are twisted pair, coaxial cable, and optical fiber. Unguided media, also called wireless, provide a means for transmitting electromagnetic waves but do not guide them; examples are propagation through air, vacuum, and seawater. The term direct link is used to refer to the transmission path between two devices in which signals propagate directly from transmitter to receiver with no intermediate devices, other than amplifiers or repeaters used to increase signal strength. Note that this term can apply to both guided and unguided media. A guided transmission medium is point to point if it provides a direct link between two devices and those are the only two devices sharing the medium. In a multipoint guided configuration, more than two devices share the same medium. A transmission may be simplex, half duplex, or full duplex. In simplex transmission, signals are transmitted in only one direction; one station is transmitter and the other is receiver. In half-duplex operation, both stations may transmit, but only one at a time. In full-duplex operation, both stations may transmit simultaneously. In the latter case, the medium is carrying signals in both directions at the same time. How this can be is explained in due course. We should note that the definitions just given are the ones in common use in the United States (ANSI definitions). Elsewhere (ITU-T definitions), the term simplex is used to correspond to half duplex as defined previously, and duplex is used to correspond to full duplex as just defined.

Analog and Digital Transmission

Both analog and digital signals may be transmitted on suitable transmission media. The way these signals are treated is a function of the transmission system. Table 3.1 summarizes the methods of data transmission. Analog transmission is a means of transmitting analog signals without regard to their content; the signals may represent analog data (e.g., voice) or digital data (e.g., binary data that pass through a modem). In either case, the analog signal will become weaker (attenuate) after a certain distance. To achieve longer distances, the analog transmission system includes amplifiers that boost the energy in the signal. Unfortunately, the amplifier also boosts the noise components. With amplifiers cascaded to achieve long distances, the signal becomes more and more distorted.

Table 3.1 Analog and Digital Transmission

(a) Data and Signals

	Analog Signal	Digital Signal
Analog Data	Two alternatives: (1) signal occupies the same spectrum as the analog data; (2) analog data are encoded to occupy a different portion of spectrum.	Analog data are encoded using a codec to produce a digital bit stream.
Digital Data	Digital data are encoded using a modem to produce analog signal.	Two alternatives: (1) signal consists of two voltage levels to represent the two binary values; (2) digital data are encoded to produce a digital signal with desir ed properties.

(b) Treatment of Signals

	Analog Transmission	Digital Transmission
Analog Signal	Is propagated through amplifiers; same treatment whether signal is used to represent analog data or digital data.	Assumes that the analog signal represents digital data. Signal is propagated through repeaters; at each repeater, digital data are recovered from inbound signal and used to generate a new analog outbound signal.
Digital Signal	Not used	Digital signal represents a stream of 1s and 0s, which may represent digital data or may be an encoding of analog data. Signal is propagated through repeaters; at each repeater, stream of 1s and 0s is recovered from inbound signal and used to generate a new digital outbound signal.

For analog data, such as voice, quite a bit of distortion can be tolerated and the data remain intelligible. However, for digital data, cascaded amplifiers will introduce errors.

Digital transmission, in contrast, assumes a binary content to the signal. A digital signal can be transmitted only a limited distance before attenuation, noise, and other impairments endanger the integrity of the data. To achieve greater distances, repeaters are used. A repeater receives the digital signal, recovers the pattern of 1s and 0s, and retransmits a new signal. Thus the attenuation is overcome. The same technique may be used with an analog signal if it is assumed that the signal carries digital data. At appropriately spaced points, the transmission system has repeaters rather than amplifiers. The repeater recovers the digital data from the analog signal and generates a new, clean analog signal. Thus noise is not cumulative. The question naturally arises as to which is the preferred method of transmission. The answer being supplied by the telecommunications industry and its customers is digital. Both long-haul telecommunications facilities and intrabuilding services have moved to digital transmission and, where possible, digital signaling techniques. The most important reasons are as follows:

Digital technology: The advent of large-scale integration (LSI) and very-large-scale integration (VLSI) technology has caused a continuing drop in the cost and size of digital circuitry. Analog equipment has not shown a similar drop.

• *Data integrity*: With the use of repeaters rather than amplifiers, the effects of noise and other signal impairments are not cumulative. Thus it is possible to transmit data longer distances and over lower quality lines by digital means while maintaining the integrity of the data.

• *Capacity utilization*: It has become economical to build transmission links of very high bandwidth, including satellite channels and optical fiber. A high degree of multiplexing is needed to utilize such capacity effectively, and this is more easily and cheaply achieved with digital (time division) rather than analog (frequency division) techniques.

• *Security and privacy*: Encryption techniques can be readily applied to digital data and to analog data that have been digitized.

• *Integration*: By treating both analog and digital data digitally, all signals have the same form and can be treated similarly. Thus economies of scale and convenience can be achieved by integrating voice, video, and digital data.

ANALOG AND DIGITAL

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. For example, an analog clock that has hour, minute, and second hands gives information in a continuous form; the movements of the hands are continuous. On the other hand, a digital clock that reports the hours and the minutes will change suddenly from 8:05 to 8:06. Analog data, such as the sounds made by a human voice, take on continuous values. When someone speaks, an analog wave is created in the air. 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 Os 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

Like the data they represent, signals can be either analog or digital. An analog signal has infinitely many levels of intensity over a period of time. 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, on the other hand, can have only a limited number of defined values. Although each value can be any number, it is often as simple as 1 and O.

Periodic and Nonperiodic Signals

Both analog and digital signals can take one of two forms: periodic or nonperiodic (sometimes refer to as aperiodic, because the prefix a in Greek means "non"). 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. Both analog and digital signals can be periodic or nonperiodic. In data communications, we commonly use periodic analog signals (because they need less bandwidth,) and nonperiodic digital signals (because they can represent variation in data)

PERIODIC ANALOG SIGNALS

Periodic analog signals can be classified as simple or composite. A simple periodic analog signal, a sine wave, cannot be decomposed into simpler signals. A composite periodic analog signal is composed of multiple sine waves.

Sine Wave

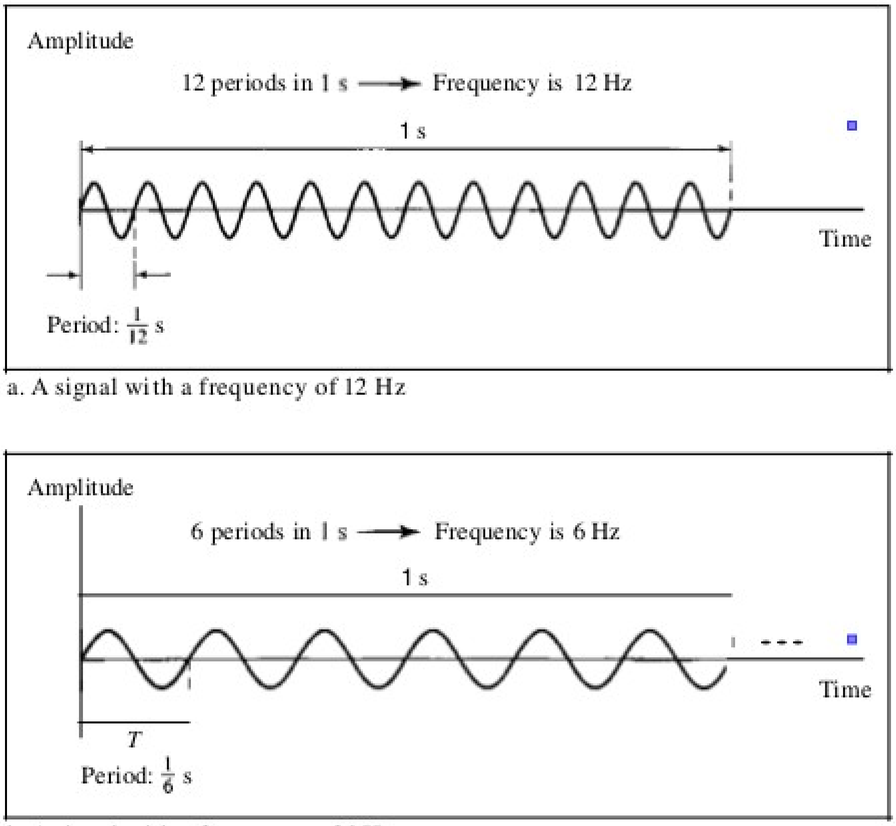
The sine wave is the most fundamental form of a periodic analog signal. When we visualize it as a simple oscillating curve, its change over the course of a cycle is smooth and consistent, a continuous, rolling flow. A sine wave can be represented by three parameters: the peak amplitude, the frequency, and the phase. These three parameters fully describe a sine wave.

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. Note that period and frequency are just one characteristic defined in two ways. Period is the inverse of frequency, and frequency is the inverse of period, as the following formulas show.

$$f = 1/T \text{ and } T = 1/f$$

Figure 3.4 *Two signals with the same amplitude andphase, but differentfrequencies*



a. A signal with a frequency of 12 Hz

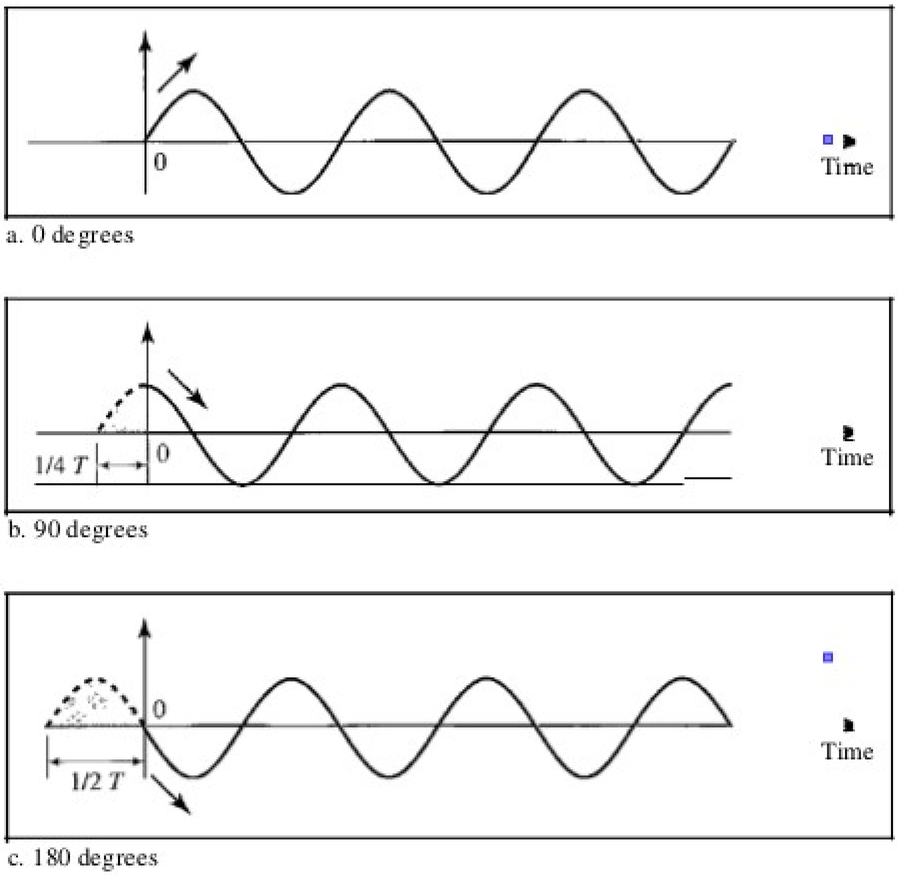
b. A signal with a frequency of6 Hz

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

Phase

The term phase describes the position of the waveform relative to time O. If we think of the wave as something that can be shifted backward or forward along the time axis, phase describes the amount of that shift. It indicates the status of the first cycle.

Figure 3.5 *Three sine waves with the same amplitude andfrequency, but different phases*



Phase is measured in degrees or radians [360° is 2n rad; 1° is 2n/360 rad, and 1 rad is 360/(2n)]. 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; and a phase shift of 90° corresponds to a shift of one-quarter of a period (see Figure 3.5).

Wavelength

Wavelength is another characteristic of a signal traveling through a transmission medium. 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. Wavelength is a property of any type of signal. In data communications, we often use wavelength to describe the transmission of light in an optical fiber. The wavelength is the distance a simple signal can travel in one period.

Noiseless Channel: Nyquist Bit Rate

For a noiseless channel, the Nyquist bit rate formula defines the theoretical maximum bit rate. BitRate = 2 x bandwidth x log2 L

In this formula, bandwidth is the bandwidth of the channel, L is the number of signal levels used to represent data, and BitRate is the bit rate in bits per second. According to the formula, we might think that, given a specific bandwidth, we can have any bit rate we want by increasing the number of signa11eve1s. Although the idea is theoretically correct, practically there is a limit. When we increase the number of signal leve1s, we impose a burden on the receiver. If the number of levels in a signal is just 2, the receiver can easily distinguish between a 0 and a 1. If the level of a signal is 64, the receiver must be very sophisticated to distinguish between 64 different levels. In other words, increasing the levels of a signal reduces the reliability of the system.

Example: Consider the same noiseless channel transmitting a signal with four signal levels (for each level, we send 2 bits). The maximum bit rate can be calculated as BitRate =2 x 3000 X log2 4 = 12,000 bps

Example: We need to send 265 kbps over a noiseless channel with a bandwidth of 20 kHz. How many signal levels do we need?

Sol We can use the Nyquist formula as shown:

265,000 =2 X 20,000 X logz L

log2 L = 6.625

L =2 6.625 = 98.7 levels

Since this result is not a power of 2, we need to either increase the number of levels or reduce the bit rate. If we have 128 levels, the bit rate is 280 kbps. If we have 64 levels, the bit rate is 240 kbps.

Noisy Channel: Shannon Capacity

In reality, we cannot have a noiseless channel; the channel is always noisy. In 1944, Claude Shannon introduced a formula, called the Shannon capacity, to determine the theoretical highest data rate for a noisy channel: Capacity = bandwidth X log2 (1 + SNR)

In this formula, bandwidth is the bandwidth of the channel, SNR is the signal-to-noise ratio, and capacity is the capacity of the channel in bits per second. Note that in the Shannon formula there is no indication of the signal level, which means that no matter how many levels we have, we cannot achieve a data rate higher than the capacity of the channel. In other words, the formula defines a characteristic of the channel, not the method of transmission.

Example

We can calculate the theoretical highest bit rate of a regular telephone line. A telephone line normally has a bandwidth of 3000 Hz (300 to 3300 Hz) assigned for data communications. The signal-to-noise ratio is usually 3162. For this channel the capacity is calculated as

C = B log2 (1+ SNR) =3000 log2 (l + 3162) =3000 log2 3163

= 3000 x 11.62 = 34,860 bps

This means that the highest bit rate for a telephone line is 34.860 kbps. If we want to send data faster than this, we can either increase the bandwidth of the line or improve the signal-to- noise ratio.

Signal-to-Noise Ratio

In analog and digital communications, signal-to-noise ratio, often written S/N or SNR, is a measure of signal strength relative to background noise. The ratio is usually measured in decibels (dB) using a signal-to-noise ratio formula. If the incoming signal strength in microvolts is V_s, and the noise level, also in microvolts, is V_n, then the signal-to-noise ratio, S/N, in decibels is given by the formula: $S/N = 20 \log_{10}(V_s/V_n)$

If $V_s = V_n$, then S/N = 0. In this situation, the signal borders on unreadable, because the noise level severely competes with it. In digital communications, this will probably cause a reduction in data speed because of frequent errors that require the source (transmitting) computer or terminal to resend some packets of data.

Ideally, V_s is greater than V_n, so a high signal-to-noise ratio is positive. As an example, suppose that V_s = 10.0 microvolts and V_n = 1.00 microvolt. Then:

$$S/N = 20 \log_{10}(10.0) = 20.0 \text{ dB}$$

This results in the signal being clearly readable. If the signal is much weaker but still above the noise -- say, 1.30 microvolts -- then:

$$S/N = 20 \log_{10}(1.30) = 2.28 \text{ dB}$$

This is a marginal situation. There might be some reduction in data speed under these conditions.

If V_s is less than V_n, then S/N is negative, representing a low signal-to-noise ratio. In this type of situation, reliable communication is generally not possible unless steps are taken to increase the signal level and/or decrease the noise level at the destination (receiving) computer or terminal.

Communications engineers always strive to maximize the S/N ratio. Traditionally, this has been done by using the narrowest possible receiving-system bandwidth consistent with the data speed desired. However, there are other methods. In some cases, spread spectrum techniques can improve system performance. The S/N ratio can be increased by providing the source with a higher level of signal output power if necessary. In some high-level systems such as radio telescopes, internal noise is minimized by lowering the temperature of the receiving circuitry to near absolute zero (-273 degrees Celsius or -459 degrees Fahrenheit). In wireless systems, it is always important to optimize the performance of the transmitting and receiving antennas.

Local Area Network (LAN)

Local area network (LAN) is a computer network that is designed for a limited geographic area such as a building or a campus. Although a LAN can be used as an isolated network to connect computers in an organization for the sole purpose of sharing resources, most LANs today are also linked to a wide area network (WAN) or the Internet. The LAN market has seen several technologies such as Ethernet, Token Ring, Token Bus, FDDI, and ATM LAN. Some of these technologies survived for a while, but Ethernet is by far the dominant technology.

Backbone LANs

The increasing use of distributed processing applications and personal computers has led to a need for a flexible strategy for local networking. Support of premises-wide data communications requires a networking service that is capable of spanning the distances involved and that interconnects equipment in a single (perhaps large) building or a cluster of buildings. Although it is possible to develop a single LAN to interconnect all the data processing equipment of a premises, this is probably not a practical alternative in most cases. There are several drawbacks to a single-LAN strategy:

• Reliability: With a single LAN, a service interruption, even of short duration, could result in a major disruption for users.

• Capacity: A single LAN could be saturated as the number of devices attached to the network grows over time.

• Cost: A single LAN technology is not optimized for the diverse requirements of interconnection and communication. The presence of large numbers of lowcost microcomputers dictates that network support for these devices be provided at low cost. LANs that support very low-cost attachment will not be suitable for meeting the overall requirement.A more attractive alternative is to employ lower-cost, lower-capacity LANs within buildings or departments and to interconnect these networks with a higher-capacity LAN.This latter network is referred to as a backbone LAN. If confined to a single building or cluster of buildings, a high-capacity LAN can perform the backbone function.

TOPOLOGIES AND TRANSMISSION MEDIA

The key elements of a LAN are

1. Topology
2. Transmission medium
3. Wiring layout
4. Medium access control

Together, these elements determine not only the cost and capacity of the LAN, but also the type of data that may be transmitted, the speed and efficiency of communications, and even the kinds of applications that can be supported.

Topologies

In the context of a communication network, the term topology refers to the way in which the end points, or stations, attached to the network are interconnected. The common topologies for LANs are bus, tree, ring, and star (Figure 15.2). The bus is a special case of the tree, with only one trunk and no branches.

Bus and Tree Topologies Both bus and tree topologies are characterized by the use of a multipoint medium. For the bus, all stations attach, through appropriate hardware interfacing known as a tap, directly to a linear transmission medium, or bus. Full-duplex operation between the station and the tap allows data to be transmitted onto the bus and received from the bus.

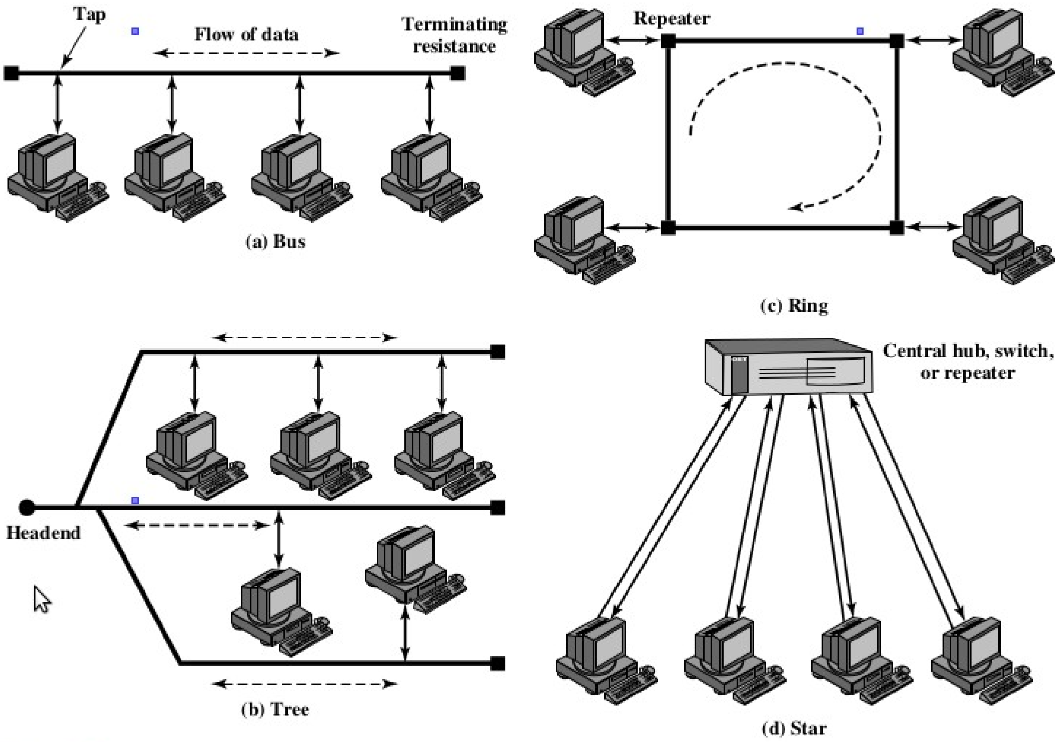


Figure 15.2 LAN Topologies

A transmission from any station propagates the length of the medium in both directions and can be received by all other stations. At each end of the bus is a terminator, which absorbs any signal, removing it from the bus. The tree topology is a generalization of the bus topology. The transmission medium is a branching cable with no closed loops. The tree layout begins at a point known as the headend. One or more cables start at the headend, and each of these may have branches. The branches in turn may have additional branches to allow quite complex layouts. Again, a transmission from any station propagates throughout the medium and can be received by all other stations.

Two problems present themselves in this arrangement. First, because a transmission from any one station can be received by all other stations, there needs to be some way of indicating for whom the transmission is intended. Second, a mechanism is needed to regulate transmission.

Ring Topology In the ring topology, the network consists of a set of repeaters joined by point-to-point links in a closed loop. The repeater is a comparatively simple device, capable of receiving data on one link and transmitting them, bit by bit, on the other link as fast as they are received. The links are unidirectional; that is, data are transmitted in one direction only, so that data circulate around the ring in one direction (clockwise or counterclockwise). Each station attaches to the network at a repeater and can transmit data onto the network through the repeater. As with the bus and tree, data are transmitted in frames. As a frame circulates past all the other stations, the destination station recognizes its address and copies the frame into a local buffer as it goes by. The frame continues to circulate until it returns to the source station, where it is removed. Because multiple stations share the ring, medium access control is needed to determine at what time each station may insert frames.

Star Topology In the star LAN topology, each station is directly connected to a common central node. Typically, each station attaches to a central node via two point-to-point links, one for transmission and one for reception. In general, there are two alternatives for the operation of the central node. One approach is for the central node to operate in a broadcast fashion. A transmission of a frame from one station to the node is retransmitted on all of the outgoing links. In this case, although the arrangement is physically a star, it is logically a bus: A transmission from any station is received by all other stations, and only one station at a time may successfully transmit. In this case, the central element is referred to as a hub. Another approach is for the central node to act as a frame switching device. An incoming frame is buffered in the node and then retransmitted on an outgoing link to the destination station.

Choice of Topology The choice of topology depends on a variety of factors, including reliability, expandability, and performance. This choice is part of the over- all task of designing a LAN and thus cannot be made in isolation, independent of the choice of transmission medium, wiring layout, and access control technique. A few general remarks can be made at this point. There are four alternative media that can be used for a bus LAN:

• **Twisted pair**: In the early days of LAN development, voice-grade twisted pair was used to provide an inexpensive, easily installed bus LAN. A number of systems operating at 1 Mbps were implemented. Scaling twisted pair up to higher data rates in a shared-medium bus configuration is not practical, so this approach was dropped long ago.

• **Baseband coaxial cable**: A baseband coaxial cable is one that makes use of digital signaling.The original Ethernet scheme makes use of baseband coaxial cable.

• **Broadband coaxial cable**: Broadband coaxial cable is the type of cable used in cable television systems. Analog signaling is used at radio and television frequencies. This type of system is more expensive and more difficult to install and maintain than baseband coaxial cable. This approach never achieved popularity and such LANs are no longer made.

• **Optical fiber**: There has been considerable research relating to this alternative over the years, but the expense of the optical fiber taps and the availability of better alternatives have resulted in the demise of this option as well

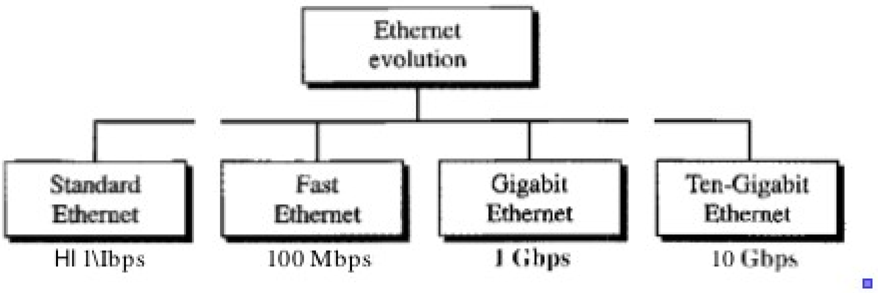
Choice of Transmission Medium The choice of transmission medium is determined by a number of factors. It is, we shall see, constrained by the topology of the LAN. Other factors come into play, including

1. Capacity: to support the expected network traffic
2. Reliability: to meet requirements for availability
3. Types of data supported: tailored to the application
4. Environmental scope: to provide service over the range of environments required

STANDARD ETHERNET

The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC). Since then, it has gone through four generations: Standard Ethernet (lot Mbps), Fast Ethernet (100 Mbps), Gigabit Ethernet (l Gbps), and Ten-Gigabit Ethernet (l0 Gbps), as shown in Figure 13.3.

Figure 13.3 *Ethernet evolution through four generations*



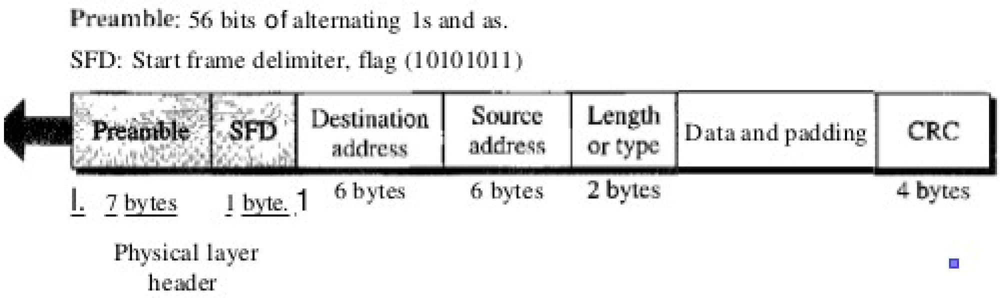
MAC Sublayer

In Standard Ethernet, the MAC sublayer governs the operation of the access method. It also frames data received from the upper layer and passes them to the physical layer.

Frame Format

The Ethernet frame contains seven fields: preamble, SFD, DA, SA, length or type of protocol data unit (PDU), upper-layer data, and the CRe. Ethernet does not provide any mechanism for acknowledging received frames, making it what is known as an unreliable medium. Acknowledgments must be implemented at the higher layers. The format of the MAC frame is shown in Figure 13.4.

Figure 13.4 *802.3 MAC frame*



Preamble. The first field of the 802.3 frame contains 7 bytes (56 bits) of alternating Os and Is that alerts the receiving system to the coming frame and enables it to synchronize its input timing. The pattern provides only an alert and a timing pulse. The 56-bit pattern allows the stations to miss some bits at the beginning of the frame. The preamble is actually added at the physical layer and is not (formally) part of the frame. Start frame delimiter (SFD). The second field (l byte: 10101011) signals the beginning of the frame. The SFD warns the station or stations that this is the last chance for synchronization. The last 2 bits is 11 and alerts the receiver that the next field is the destination address.

Destination address (DA). The DA field is 6 bytes and contains the physical address of the destination station or stations to receive the packet.

Source address (SA). The SA field is also 6 bytes and contains the physical address of the sender of the packet. *Length or type*. This field is defined as a type field or length field. The original Ethernet used this field as the type field to define the upper-layer protocol using the MAC frame. The IEEE standard used it as the length field to define the number of bytes in the data field. Both uses are common today.

Data. This field carries data encapsulated from the upper-layer protocols. It is a minimum of 46 and a maximum of 1500 bytes,

CRC. The last field contains error detection information, in this case a CRC-32

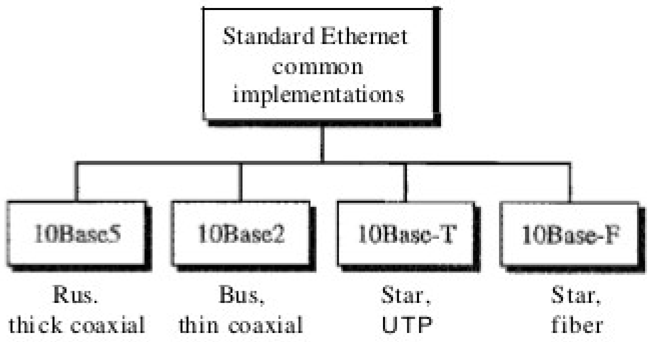
Physical Layer

The Standard Ethernet defines several physical layer implementations; four of the most common, are shown in Figure 13.8.

Encoding and Decoding

All standard implementations use digital signaling (baseband) at 10 Mbps. At the sender, data are converted to a digital signal using the Manchester scheme; at the receiver, the

Figure 13.8 *Categories ofStandard Ethernet*



received signal is interpreted as Manchester and decoded into data. Manchester encoding is self-synchronous, providing a transition at each bit interval.

lOBase5: Thick Ethernet

The first implementation is called 10BaseS, thick Ethernet, or Thicknet. The nickname derives from the size of the cable, which is roughly the size of a garden hose and too stiff to bend with your hands. lOBaseS was the first Ethernet specification to use a bus topology with an external transceiver (transmitter/receiver) connected via a tap to a thick coaxial cable. The transceiver is responsible for transmitting, receiving, and detecting collisions. The transceiver is connected to the station via a transceiver cable that provides separate paths for sending and receiving. This means that collision can only happen in the coaxial cable. The maximum length of the coaxial cable must not exceed 500 m, otherwise, there is excessive degradation of the signal. If a length of more than 500 m is needed, up to five segments, each a maximum of SOO-meter, can be connected using repeaters.

10Base2: Thin Ethernet

The second implementation is called lOBase2, thin Ethernet, or Cheapernet. IOBase2 also uses a bus topology, but the cable is much thinner and more flexible. The cable can be bent to pass very close to the stations. In this case, the transceiver is normally part of the network interface card (NIC), which is installed inside the station. Note that the collision here occurs in the thin coaxial cable. This implementation is more cost effective than 10BaseS because thin coaxial cable is less expensive than thick coaxial and the tee connections are much cheaper than taps. Installation is simpler because the thin coaxial cable is very flexible. However, the length of each segment cannot exceed 185 m (close to 200 m) due to the high level of attenuation in thin coaxial cable.

lOBase-T: Twisted-Pair Ethernet

The third implementation is called lOBase-T or twisted-pair Ethernet. 1OBase-T uses a physical star topology. The stations are connected to a hub via two pairs of twisted cable, Note that two pairs of twisted cable create two paths (one for sending and one for receiving) between the station and the hub. Any collision here happens in the hub. Compared to lOBaseS or lOBase2, wsince hub actually replaces the coaxial cable as far as a collision is concerned. The maximum length of the twisted cable here is defined as 100 m, to minimize the effect of attenuation in the twisted cable.

lOBase-F: Fiber Ethernet

Although there are several types of optical fiber lO-Mbps Ethernet, the most common is called 10Base-F. lOBase-F uses a star topology to connect stations to a hub. The stations are connected to the hub using two fiberoptic cables

*Reference:

1. Data and Computer Communications [William Stallings]
2. Data Communications and Networking [Behrouz A. Forouzan]