Media Selection

Which media are best? It is hard to say, particularly when manufacturers continue to improve various media products. Several factors are important in selecting media.

1. **The type of network** is one major consideration. Some media are used only for WANs (microwaves and satellite), whereas others typically are not (twisted pair, coaxial cable, and radio). Fiber-optic cable is unique in that it can be used for virtually any type of network.
2. **Cost** is always a factor in any business decision. Costs are always changing as new technologies are developed and as competition among vendors drives prices down. Among the guided media, twisted pair wire is generally the cheapest, coaxial cable is somewhat more expensive, and fiber-optic cable is the most expensive. The cost of the wireless media is generally driven more by distance than any other factor. For very short distances, radio is the cheapest; for moderate distances (several hundred miles), microwave is cheapest; and for long distances, satellite is cheapest.
3. **Transmission distance** is a related factor. Twisted-pair wire coaxial cable and radio can transmit data only a short distance before the signal must be regenerated. Twisted-pair wire and radio typically can transmit up to 100 to 300 meters, and coaxial cable typically between 200 and 500 meters. Fiber optics can transmit up to 75 miles, and new types of fiber-optic cable can reach more than 600 miles.
4. **Security** is primarily determined by whether the media are guided or wireless. Wireless media are the least secure because their signals are easily intercepted. Guided media are more secure, with fiber optics being the most secure.
5. **Error Rates** are also important. Wireless media are most susceptible to interference and thus have the highest error rates. Among the guided media, fiber optics provides the lowest error rates, coaxial cable the next best, and twisted pair cable the worst, although twisted pair cable is generally better than the wireless media.
6. **Transmission speeds** vary greatly among the different media. It is difficult to quote specific speeds for different media because transmission speeds are constantly improving and because they vary within the same type of media, depending on the specific type of cable and the vendor. In general, twisted pair cable and coaxial cable can provide data rates of between 1Mbps and 1Gbps whereas fiber-optic cable ranges between 1Gbps and 40 Gbps. Radio, microwave, and satellite generally provide 10 to 100 Mbps.

Guided Media

Media	Network Type	Cost	Transmission Distance	Security	Error Rates	Speed
Twisted Pair	LAN	Low	Short	Good	Low	Low-high
Coaxial Cable	LAN	Moderate	Short	Good	Low	Low-high
Fiber Optics	Any	High	Moderate-long	Very good	Very low	High-very high

Radiated Media

Media	Network Type	Cost	Transmission Distance	Security	Error Rates	Speed
Radio	LAN	Low	Short	Poor	Moderate	Moderate
Microwave	WAN	Moderate	Long	Poor	Low-moderate	Moderate
Satellite	WAN	Moderate	Long	Poor	Low-moderate	Moderate

Digital Transmission of Digital Data

All computer systems produce binary data. For these data to be understood by both the sender and receiver, both must agree on a standard system for representing the letters, numbers, and symbols that compose messages. The **coding scheme** is the language that computers use to represent data.

Coding

A character is a symbol that has a common, constant meaning. A character might be the letter A or B, or it might be a number such as 1 or 2. Characters also may be special symbols such as? or &. Characters in data communications, as in computer systems, are represented by groups of bits that are binary zeros (0) and ones (1). The groups of bits representing the set of characters that are the "alphabet" of any given system are called a coding scheme, or simply a code.

There are three predominant coding schemes:

1. **America Standard Code for Information Interchange(ASCII)**
2. **ISO 8859**
3. **Unicode**

America Standard Code for Information Interchange (ASCII)

It is the most popular code for data communications and is the standard code on most microcomputers. There are two types of ASCII; one is a 7-bit code that has 128 valid character combinations, and the other is an 8-bit code that has 256 combinations. The number of combinations can be determined by taking the number 2 and raising it to the power equal to the number of bits in the code because each bit has two possible values, a 0 or a 1. In this case, $2^7 = 128$ characters or $2^8 = 256$ characters.

ISO 8859

It is standardized by the International Standards Organization. ISO 8859 is an 8-bit encoding, allowing for the representation of 256 different characteristics. The first 128 characters are identical to those in the 7—bit ASCII character set, ensuring compatibility with the English language and basic symbols. The remaining 128 characters are reserved for characters specific to the covered languages or regions. ISO 8859 were widely used in earlier computer systems prior to the widespread adoption of Unicode.

Unicode

It is the other commonly used coding scheme. There are many different versions of Unicode designed to support a vast range of characters and symbols from multiple languages and scripts around the world. Unicode uses 16-bit, 32-bit, or variable length encoding to represent a broader set of characters, making it essential for multilingual text and internationalization in digital communication and software development.

Transmission Modes

During data transmission the things to be considered are:

- Mutual understanding
- Co-operation
- Synchronization.

Different types of data transmissions are:

1. **Parallel Transmission**
2. **Serial Transmission**

Parallel Transmission

Multiple bits are sent simultaneously down different wires (channels) within the same cable. As many bits is to be transferred from source to destination, there is the requirement of that much different individual wires. Single wire is used for handling single bit of data.

E.g. if 8 bits data is to be transmitted from source to destination, 8 different wires are required. Supports faster transmission but is costly, not suitable for every environment and limited to short distance only.

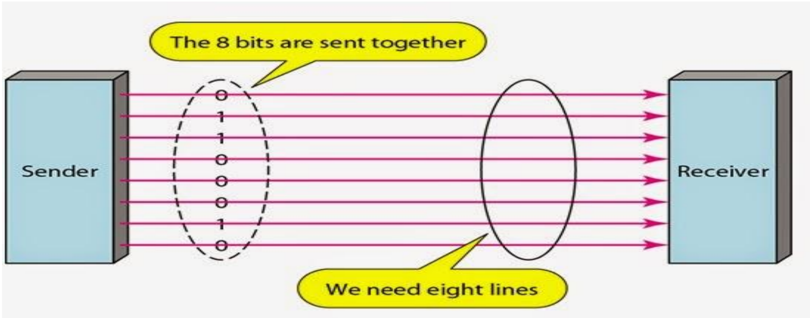

Fig: Parallel Transmission

Serial Transmission

The bits are sent sequentially (one after the other) down the same wire .Data is transmitted from source to destination bit by bit as a stream of 0's and 1's.

Serial transmission is less expensive compared to parallel transmission. The serial transmissions are of types: **asynchronous and synchronous transmission.**

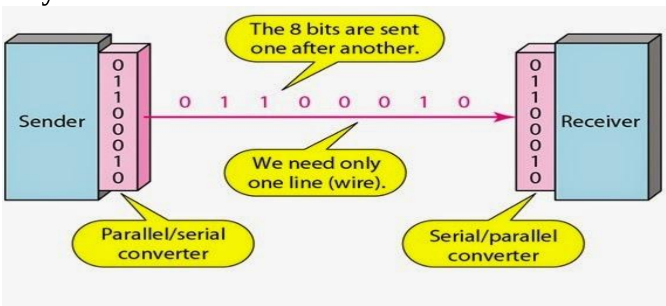

Fig: Serial Transmission

Digital Transmission of Analog Data

In the same way that digital computer data can be sent over analog telephone networks using analog transmission, analog voice data can be sent over digital networks using digital transmission. This process is somewhat similar to the analog transmission of digital data. A pair of special devices called *codecs* (*co*de/*dec*ode) is used in the same way that a pair of modems is used to translate the data to send across the circuit.

Translating from Analog to Digital

Analog voice data must first be translated into a series of binary digits before they can be transmitted over a digital circuit. This is done by sampling the amplitude of the sound wave at regular intervals and translating it into a binary number. There are two basic approaches:

i. **Pulse Code Modulation (PCM):** the common technique to change analog signal to digital data is PCM. It has three processes: **sampling (**the analog signal is sampled**) quantization (**the sampled signal is quantized between maximum amplitude value and minimum amplitude value of analog signal**) and encoding (**the approximated quantized value are converted into binary numbers**).**
ii. **Delta Modulation**

Q. Explain PCM and delta Modulation

How Modems Transmit Data

The **modem** (an acronym for *mo*dulator/*dem*odulator) takes the digital data from a computer in the form of electrical pulses and converts them into the analog signal that is needed for transmission over an analog voice-grade circuit. There are many different types of modems available today from **dial-up modems to cable modems.**

How Telephones Transmit Voice Data

When a telephone call is made, the telephone converts the analog voice data into a simple analog signal and sends it down the circuit from our home to the telephone company's network. This process is almost unchanged from the one used by Bell when he invented the telephone in 1876. With the invention of digital transmission, the common carriers (i.e., the telephone companies) began converting their voice networks to use digital transmission. Today, all of the common carrier networks use digital transmission, except in the local loop (sometimes called the last mile), the wires that run from our home or business to the telephone switch that connects our local loop into the telephone network. This switch contains a codec that converts the analog signal from our phone into a digital signal. This digital signal is then sent through the telephone network until it hits the switch for local loop for the person we are calling.
This switch uses its codec to convert the digital signal used inside the phone network back into the analog signal needed by that person's local loop and telephone.

There are many different combinations of sampling frequencies and numbers of bits per sample that could be used. For example, one could sample 4,000 times per second using 128 amplitude levels (i.e., 7 bits) or sample at 16,000 times per second using 256 levels (i.e., 8 bits).

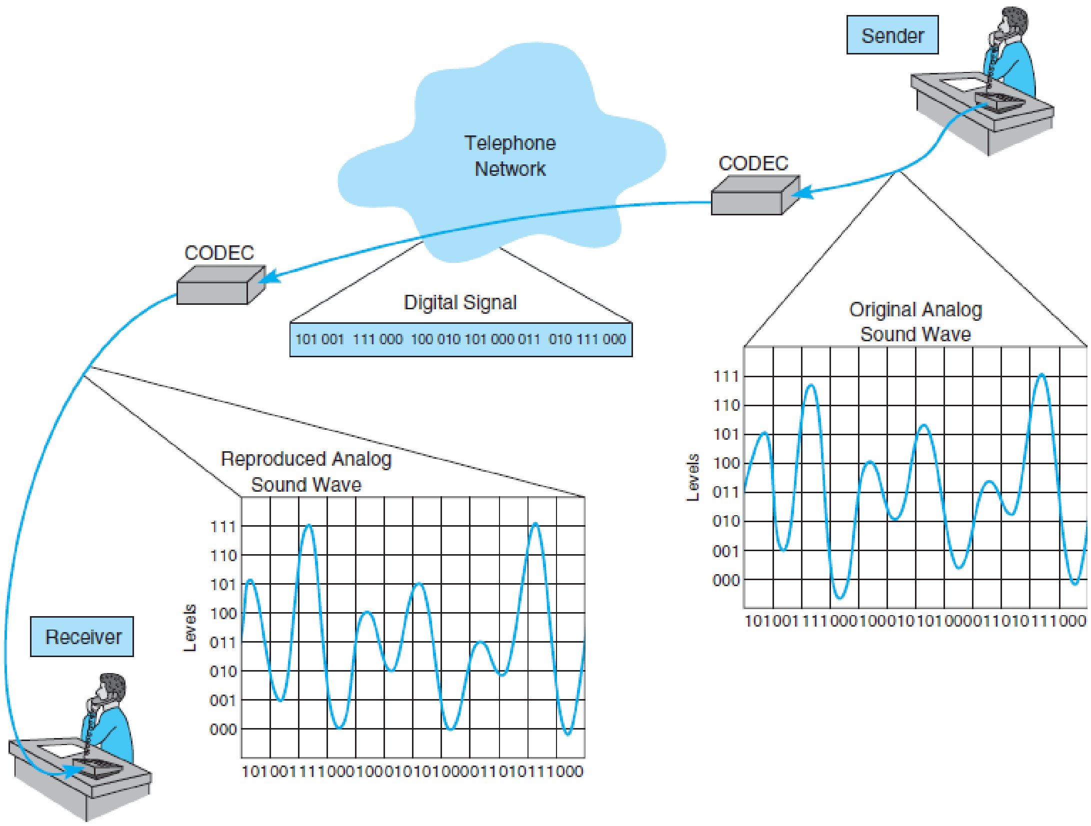

Fig: Telephone Communication Process

How Instant Messenger Transmits Voice Data

A 64Kbps digital circuit works very well for transmitting voice data because it provides very good quality. The problem is that it requires a lot of capacity.

Adaptive differential pulse code modulation (ADPCM) is the alternative used by IM and many other applications that provide voice services over lower-speed digital circuits.

ADPCM is digital audio compression technique commonly used to reduce the data rate audio signals. Unlike PM which encodes audio sample independently, ADPCM quantizes the difference between consecutives samples, adapting the quantization step size based on signal characteristics. This adaptive approach allows ADPCM to compress data efficiently. ADPCM is often used in real time applications such as VoIP communication, digital telephony where conserving bandwidth and minimizing data transmission delays are important.

Voice over Internet Protocol

Voice over Internet Protocol (VoIP)is commonly used to transmit phone conversations over digital networks. VoIP is a relatively new standard that uses digital telephones with built-in codec to convert analog voice data into digital data, which is then transmitted in packets over the internet. This process involves several key steps including analog-to-digital conversion, packetization, internet transmission and digital-to-analog conversion (if receiver is traditional phone equipment). VoIP relies on specific protocols like SIP (Session Initiation Protocol), H.323 for call setup, control and implements Quality of Service mechanism to prioritize voice traffic, ensuring low latency and high call quality. VoIP offers various features such as call forwarding, voicemail and video conferencing making it essential technology for both personal and business communication. VoIP is more affordable, flexible and versatile voice communication options.

Some terms

i. **Spectrum**
ii. **Bandwidth**
iii. **Bit rate**
iv. **Baud rate**

Spectrum

Range of the frequency the signal contains is spectrum Set of all possible frequencies is called electromagnetic spectrum.

It is measured in Hz/KHz/MHz/GHz etc.

Bandwidth

It is the measure of how much information can flow from one place to another in given amount of time. It is range of frequency that the medium can pass. It is like width of a pipe, lanes in highway.

Mathematically,

Bandwidth= Highest frequency-

Example, Radio has a frequency spectrum of 88MHz to 108 MHz

Bandwidth (Bw) = 108-88 = 20 MHz

Bandwidth is determined by following factors:

- Internetworking device
- Topology
- Number of users
- User's Computer
- Type of data being transferred

Importance

i. Bandwidth is finite, regardless of media,
ii. Knowing the working process of bandwidth which is finite save lots of money.
iii. Major factor in analyzing network performance.

Types:

1. **Absolute Bandwidth**

2. **Effective Bandwidth**

Absolute Bandwidth

The total signals that has been transmitted by transmitter. It is the Maximum capacity of medium in which data can be transmitted. Absolute bandwidth of a signal is the width of the spectrum.

Effective Bandwidth

It is the band within which most of the signal energy is concentrated. Minimum frequency required for accurate reception of data. Also, minimum frequency required for accurate transmission where no noise exists.

Effective bandwidth = highest frequency – lowest frequency.

Bit Rate

It is the number of bits per second that can be transmitted in a digital network. Information transmitted in 1 second or per second. Measured in terms of bps (bits per second)

Relationship of Data Rate and Bandwidth

The higher the data rate of signal, the greater is its required effective bandwidth.

Baud Rate

It is the total number of bits used to represent single information. It is measured in terms of baud. It is even termed as **symbol rate.**

Capacity of a Circuit

The data capacity of a circuit is the fastest rate at which you can send your data over the circuit in terms of the number of bits per second. The **data rate** (or bit rate) is calculated by multiplying the number of bits sent on each symbol by the maximum **symbol rate**. The number of bits per symbol depends on the modulation technique (e.g., QAM sends 4 bits per symbol).

The maximum symbol rate in any circuit depends on the **bandwidth** available and the **signal-to-noise ratio** (the strength of the signal compared with the amount of noise in the circuit). The **bandwidth** is the difference between the highest and the lowest frequencies in a band or set of frequencies.

The maximum symbol rate for analog transmission is usually the same as the bandwidth as measured in Hertz. If the circuit is very noisy, the maximum symbol rate may fall as low as 50% of the bandwidth. If the circuit has very little noise, it is possible to transmit at rates up to the bandwidth.

Digital transmission symbol rates can reach as high as two times the bandwidth for techniques that have only one voltage change per symbol (e.g., NRZ). For digital techniques that have two voltage changes per symbol (e.g., RZ, Manchester), the maximum symbol rate is the same as the bandwidth.

Standard telephone lines provide a bandwidth of 4,000 Hz. Under perfect circumstances, the maximum symbol rate is therefore about 4,000 symbols per second. If we were to use basic AM (1 bit per symbol), the maximum data rate would be 4,000 **bits per second (bps).** If we were to use QAM (4 bits per symbol), the maximum data rate would be 4 bits per symbol × 4,000 symbols per second = 16,000 bps.