DATA TRANSMISSION

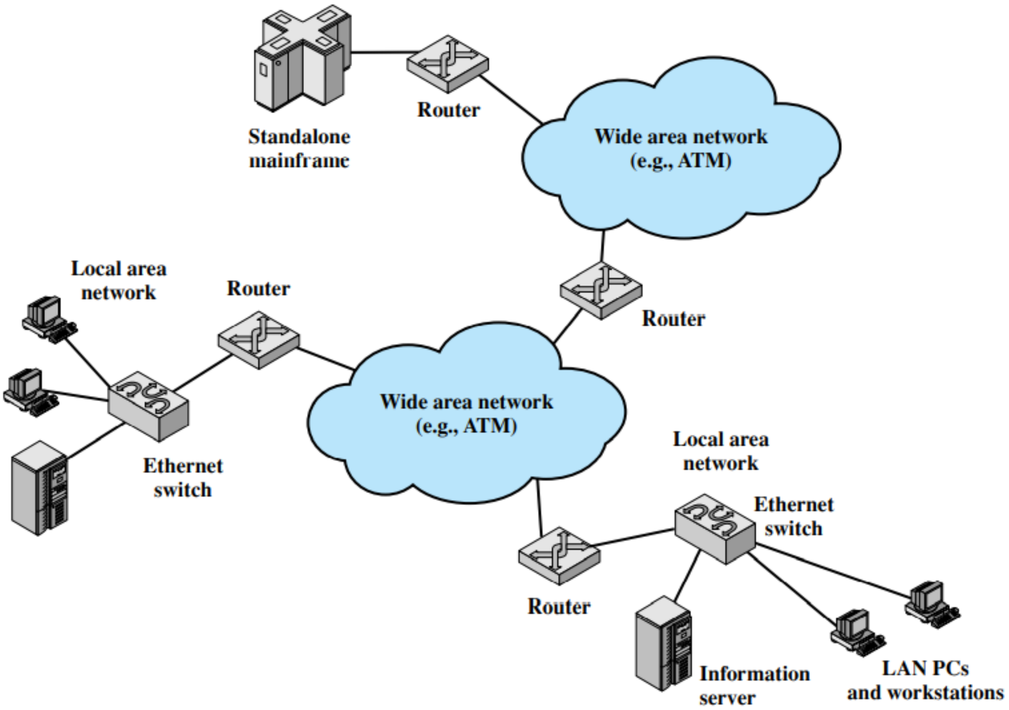


Figure 1.4 Key Elements of the Internet

THE NEED FOR A PROTOCOL ARCHITECTURE

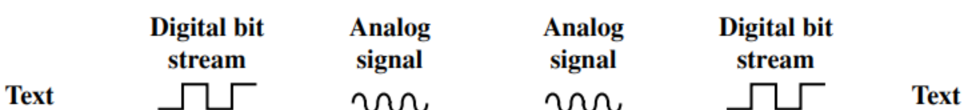
The key features of a protocol are as follows:

- Syntax: Concerns the format of the data blocks
- Semantics: Includes control information for coordination and error handling
- Timing: Includes speed matching and sequencing

Data Transmission Terminology:

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.

What is a Signal?

A signal is an electrical or electromagnetic current that is used to transfer data from one network to another. There are two types of signals which are used in computer networking, such as analog and digital signals.

What is Analog Signal?

These are the signals which can have an infinite number of different magnitude or values. They vary continuously with time. They are generated by signal generations hardware. In computer networks, analogue signals are mainly classified into two types as follows.

- Simple Analog Signal
- Composite Analog Signal.

Simple Analog Signal

It is the analog signal which cannot be decomposed into further simpler signals. There are two types of simple analog signals, such as sine wave and cosine wave.

Composite Analog Signal

It is composed or made of multiple sines or cosine waves. The composite signal is further divided into three parts, such as square, triangle and pulse waves.

What is Digital Signal?

A digital signal is a discrete-time signal having finite no. of amplitudes. They are discrete in nature. Binary signals are examples of digital signals. The following diagram shows the diagrammatic comparison of the digital and analog signals.

Analog and Digital Signal Difference

The following table shows the analog and digital signals difference in computer networking.

Analog Signal	Digital Signal
It uses a continuous range of values to represent information.	Digital signal uses discrete signals to represent information.
The bandwidth of the analog signal is low.	The bandwidth of a digital signal is high.
There is no fixed range in analog signals.	Digital signal has a finite range, i.e. 0 and 1
It is denoted by sine waves, as shown in the above diagram.	It is denoted by square waves as shown in the above diagram
Analog signals are used in temperature sensors, FM radio, photocells and light sensors.	Digital signals are used in computers, DVDs and CDs

Time Domain Concepts:
Viewed as a function of time, an electromagnetic signal can be either analog or digital.

An analog signal is one in which the signal intensity varies in a smooth fashion over time. In other words, there are no breaks or discontinuities in the signal.

A digital signal is one in which the signal intensity maintains a constant level for some period of time and then abruptly changes to another constant level.
The continuous signal might represent speech, and the discrete signal might represent binary 1s and 0s.

The simplest sort of signal is a periodic signal, in which the same signal pattern repeats over time.

Figure 3.2 shows an example of a periodic continuous signal (sine wave) and a periodic discrete signal (square wave).

Mathematically, a signal s(t) is defined to be periodic if and only if where the constant T is the period of the signal (T is the smallest value that satisfies the equation). Otherwise, a signal is aperiodic.

The sine wave is the fundamental periodic signal. A general sine wave can be represented by three parameters: peak amplitude (A), frequency (f), and phase

The peak amplitude is the maximum value or strength of the signal over time; typically, this value is measured in volts.

The frequency is the rate [in cycles per second, or Hertz (Hz)] at which the signal repeats. An equivalent parameter is the period (T) of a signal, which is the amount of time it takes for one repetition; therefore, Phase is a measure of the relative position in time within a single period of a signal.

Analog and Digital Data:

The concepts of analog and digital data are simple enough. Analog data take on continuous values in some interval. For example, voice and video are continuously varying patterns of intensity. Most data collected by sensors, such as temperature and pressure, are continuous valued.

Digital data take on discrete values; examples are text and integers. The most familiar example of analog data is audio, which, in the form of acoustic sound waves, can be perceived directly by human beings. Figure 3.9 shows the acoustic spectrum for human speech and for music.

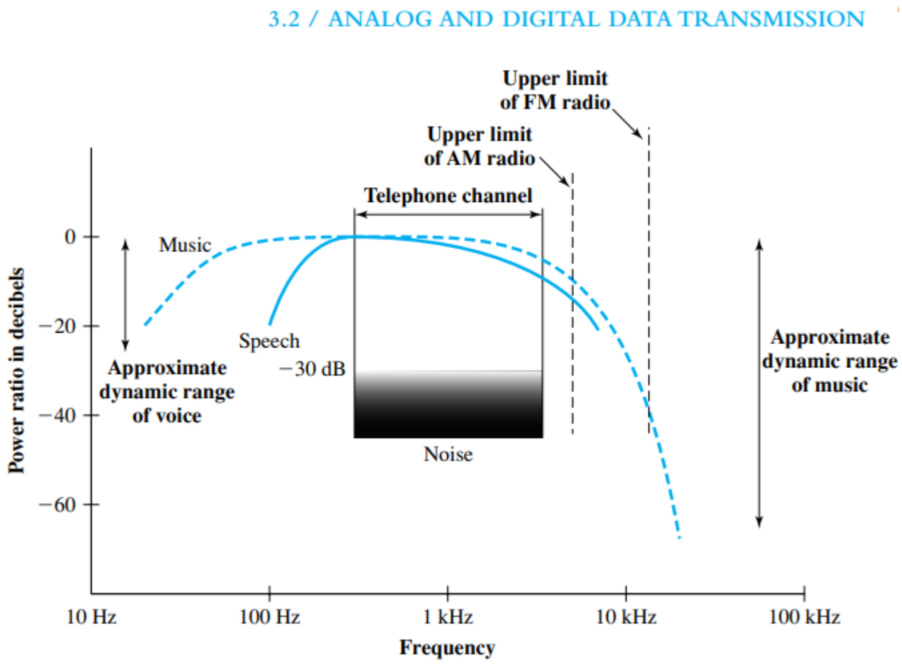


Figure 3.9 Acoustic Spectrum of Speech and Music [CARN99a]

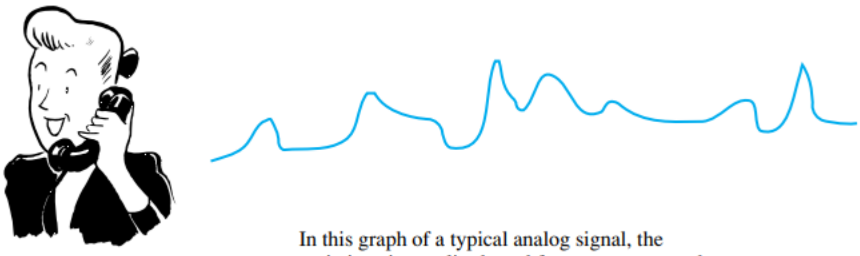
Frequency components of typical speech may be found between approximately 100 Hz and 7 kHz. Although much of the energy in speech is concentrated at the lower frequencies, tests have shown that frequencies below 600 or 700 Hz add very little to the intelligibility of speech to the human ear. Typical speech has a dynamic range of about 25 dB;6 that is, the power produced by the loudest shout may be as much as 300 times greater than the least whisper.

Figure 3.9 also shows the acoustic spectrum and dynamic range for music. Another common example of analog data is video. Here it is easier to characterize the data in terms of the TV screen (destination) rather than the original scene (source) recorded by the TV camera. To produce a picture on the screen, an electron beam scans across the surface of the screen from left to right and top to bottom. For black-and-white television, the amount of illumination produced (on a scale from black to white) at any point is proportional to the intensity of the beam as it passes that point.Thus at any instant in time the beam takes on an analog value of intensity to produce the desired brightness at that point on the screen.

Analog and Digital Signals:

In a communications system, data are propagated from one point to another by means of electromagnetic signals. An analog signal is a continuously varying electromagnetic wave that may be propagated over a variety of media, depending on spectrum; examples are wire media, such as twisted pair and coaxial cable; fiber optic cable; and unguided media, such as atmosphere or space propagation.

Examples Let us return to our three examples of the preceding subsection. For each example, we will describe the signal and estimate its bandwidth. The most familiar example of analog information is audio, or acoustic, information, which, in the form of sound waves, can be perceived directly by human beings. One form of acoustic information, of course, is human speech. This form of information is easily converted to an electromagnetic signal for transmission (Figure 3.12).



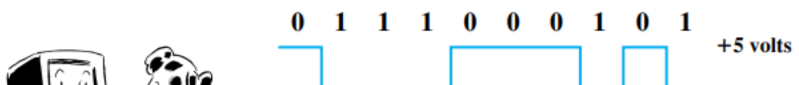
In this graph of a typical analog signal, the variations in amplitude and frequency convey the gradations of loudness and pitch in speech or music. Similar signals are used to transmit television pictures, but at much higher frequencies.

Figure 3.12 Conversion of Voice Input to Analog Signal

A digital signal is a sequence of voltage pulses that may be transmitted over a wire medium; for example, a constant positive voltage level may represent binary 0 and a constant negative voltage level may represent binary 1.

Binary data is generated by terminals, computers, and other data processing equipment.

3.2 / ANALOG AND DIGITAL DATA TRANSMISSION



and then converted into digital voltage pulses for transmission, as illustrated in Figure 3.13.

A commonly used signal for such data uses two constant (dc) voltage levels, one level for binary 1 and one level for binary 0.

The principal advantages of digital signaling are that it is generally cheaper than analog signaling and is less susceptible to noise interference.

The principal disadvantage is that digital signals suffer more from attenuation than do analog signals.
Figure 3.11 shows a sequence of voltage pulses, generated by a source using two voltage levels, and the received voltage some distance down a conducting medium. Because of the attenuation, or reduction, of signal strength at higher frequencies, the pulses become rounded and smaller. It should be clear that this attenuation can lead rather quickly to the loss of the information contained in the propagated signal.

Data and Signals:

In the foregoing discussion, we have looked at analog signals used to represent analog data and digital signals used to represent digital data.
Generally, analog data are a function of time and occupy a limited frequency spectrum; such data can be represented by an electromagnetic signal occupying the same spectrum.

Digital data can be represented by digital signals, with a different voltage level for each of the two binary digits. As Figure 3.14 illustrates, these are not the only possibilities.

Digital data can also be represented by analog signals by use of a modem (modulator/demodulator). The modem converts a series of binary (two-valued) voltage pulses into an analog signal by encoding the digital data onto a carrier frequency.

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.