UNIT 2 DATA TRANSMISSION & MULTIPLEXING

Structure **Page Nos.**

2.0 INTRODUCTION

In the previous unit the basics of computer network topics were discussed. This unit covers topics related to the physical layer, which will comprise of the difference between data rate and bandwidth, analog and digital and finally characteristics of different transmission media.

2.1 OBJECTIVES

After going through this unit you should be able to know:

- types of transmissions;
- time and frequency - domain concepts;
- difference between analog and digital signal;
- type of transmission impairments, and
- transmission media.

2.2 TRANSMISSION TERMINOLOGY

Data transmission occurs between transmitters and receivers over some transmission medium.

Transmission media may be classified as:

- Guided
- 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 provide a means for transmitting electromagnetic waves but do not guide them; examples are propagation through air, vacuum and seawater. In this unit we will discuss about guided media only.

The term direct link is used to refer to the transmission path between two devices in which signal propagate directly from transmitters to receivers with no intermediate devices, other than amplifiers or repeaters used to increase signal strength. This term can apply to both guided and unguided media.

A transmission may be

- Simplex
- Half-duplex
- Full duplex.

In simplex transmission, signals are transmitted in only one direction; one station is a transmitter and the other is the receiver. In the 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 same time.

2.2.1 Time-Domain Concepts

As a function of time, an electromagnetic signal can be either continuous or discrete. A continuous signal is one in which the signal amplitude or intensity varies in smooth fashion over time. There are no breaks or discontinuities in the signal. A discrete signal is one in which the signal intensity maintains a constant level for some period of time and then changes to another constant level.

2.2.2 Frequency Domain Concepts

In practice, an electromagnetic signal will be made up of many frequencies.

It can be shown, using a discipline known as Fourier analysis, that any signal is made up of components at various frequencies, in which each component is sinusoidal.

So, we can say that for each signal, there is a time-domain functions(t) that specifies the amplitude of the signal at each instance of time. Similarly, there is a frequency-domain function S(f) that specifies the constituent frequency of the signal. The spectrum of the signal is the range of frequencies that it contains.

2.2.3 Relationship between Data Rate and Bandwidth

The concept of effective bandwidth is somewhat fuzzy one. It is the band within which most of the energy is confined. The term “most” in this context is somewhat arbitrary. The important issue here is that, although a given waveform may contain frequencies over a broad range, as a practical matter any transmission medium that is used will be able to accommodate only a limited band of frequencies. This, in turn, limits the data rate that can be carried on the transmission.

2.3 ANALOG AND DIGITAL DATA TRANSMISSION

The terms analog and digital corresponds, roughly, to continuous and specific form of discrete, respectively. These two terms are used frequently in data communications at least in three contexts:

- Data
- Signal
- Transmission.

2.3.1 Data

Analog signal takes on continuous values on 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.

2.3.2 Signals

In a communication system, data are propagated from one point to another by means of electrical signals. An analog signal is a continuously varying electromagnetic wave that may be propagated over a variety of media, depending on spectrum.

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 1, and a constant negative voltage level may represent binary 0.

2.3.3 Transmissions

Both analog and digital signals may be transmitted on suitable transmission media. Analog transmission is a means of transmitting analog signal where some parameter(s) of the electromagnetic wave varieties according to the signal.

Analog data	**Analog signal** • Signal occupies the same order of spectrum as the analog data • Analog data are encoded to occupy a different portions of the spectrum.	**Digital signal** • 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.	• Signal consist of two voltages levels to represent the two binary values. • Digital data are encoded to produce a digital signal and occupies much larger spectrum compared to the original signal.

2.4 TRANSMISSION MEDIA

The purpose of the physical layer is to transport a raw bit stream form one machine to another. Various physical media can be used for the actual transmission. Each one has its own niche in terms of bandwidth, delay, cost, and ease of installation and maintenance. Media are roughly grouped into guided media, such as copper wire and fiber optics, and unguided media, such as radio and lasers through the air. We will look at these in this section and the next one.

2.4.1 Twiste d Pair

Although the bandwidth characteristics of magnetic tape are excellent, the delay characteristics are poor. Transmission time is measured in minutes or hours, not milliseconds. For many applications an on-line connection is needed. The oldest and

still most common transmission medium is twisted pair. A twisted pair consists of two insulated copper wires, typically about 1 mm thick. The wires are twisted together in a helical form. The purpose of twisting the wires is to reduce electrical interference form similar pairs close by.

The most common application of the twisted pair is the telephone systems. Twisted pairs can be used for either analog or digital transmission. The bandwidth depends on the thickness of the wire and the distance travelled, but several megabits/sec. can be achieved for a few kilometers in may cases. Due to there adequate performance and low cost, twisted pairs are widely used and are likely to remain so for years to come.

Twisted pair cabling comes in several varieties, two of which are important for computer networks. Category 3 twisted pairs consist of two insulated wires gently twisted together. Four such pairs are typically grouped together in a plastic sheath for protection and to keep the eight wires together.

Starting around 1988, the more advanced category 5 twisted pairs were introduced. They are similar to category 3 pairs, but with more twists per centimeter and insulation, which results in less cross talk and a better quality signal over longer distances, making them more suitable for high–speed computer communication. Both of these wiring types are often referred to as UTP (Unshielded Twisted Pair), to contrast them with the bulky, expensive, shielded twisted pair cables IBM introduced in the early 1980s, but which have not proven popular outside of IBM installations.

2.4.2 Baseband Coaxial Cable

Another communication transmission medium is the coaxial cable. It has better shielding than twisted pairs, so it can span longer distances at higher speeds. Two kinds of coaxial cable are widely used. One kind, 50-ohm cable is commonly used for digital transmission and is the subject of this section. The other kind, 75-ohm cable, is commonly used for analog transmission and will be described in the next section. This distinction is based on historical, rather than technical factor, (e.g., early dipole antennas had an impedance of 300 ohms, and it was easy to build 4:1 impedance matching transformers).

A coaxial cable consists of a stiff copper wire as the core, surrounded by an insulating material. The construction and shielding of the coaxial cable give it a good combination of high bandwidth and excellent noise immunity. The bandwidth possible depends on the cable length. For 1 km cables, a data rate 1 or 2 Gbps is feasible. Longer cables can also be used, to be widely used within the telephone systems but have not largely been replaced by fiber optics on long-haul routes. In the United States alone, 1000 km of fiber is installed every day (counting a 100 km bundle with 10 strands of fiber as 1000 km). Coaxial cables are still widely used for cable television and some local area networks.

2.4.3 Broadband Coaxial Cable

The other kind of coaxial cable systems uses analog transmission on standard cable television cabling. These can be used for digital data transfer also. It is cabled broadband. Although the term “broadband” come from the telephone world, where it refers to anything wider than 4 kHz, in the computer networking world “broadband cable” means any cable network using analog transmission.

Since broadband networks use standard cable television technology, the cables can be used up to 300 MHz (and often up to 450 MHz) and can run for nearly 100 km due to the analog signalling, which is much less critical than digital signalling. To transmit digital signals on an analog network, each interface must contain electronics to convert the outgoing bit stream to an analog signal, and the incoming analog signal to

a bit stream. Depending on the type of these electronics 1 bps may occupy roughly 1 Hz of bandwidth. At higher frequencies, many bits per Hz are possible using advanced modulation techniques.

Broadband systems are divided up into multiple channels. Frequently the 6MHz channels used for television broadc asting. Each channel can be used for analog television, CD-quality audio or a digital bit stream at, say 3 Mbps, independent of the others. Television and data can be mixed on one cable.

2.5 MULTIPLEXING

In communication, Multiplexing is a technique that transmits signals from several sources over a single communication channel. So in order to minimize the cost of communication bearer, various techniques of sharing a communication channel between several users have been devised. These are known as multiplexing techniques. In this section we will discuss about two multiplexing techniques viz. time and frequency division multiplexing .

Frequency Division Multiplexing (FDM)

In FDM the frequency spectrum is divided to form logical channels with each user having exclusive possession of the assigned channel.

Time Division Multiplexing (TDM)

In TDM, the users take turns (in a round robin), each one is periodically getting the entire bandwidth for the allotted time.

Television broadcasting provides an example of multiplexing. Each TV channel operates in a different frequency range, which is a portion of the allocated spectrum, with the inter-channel separation great enough to prevent interference. This system is an example of FDM. During the transmission of any program (Serial/film), there is an advertisement as well. These two alternate in time on the same frequency. This is an example of TDM.

☞ Check Your Progress

1) What is the difference between data rate and bandwidth?

……

……

……

……

2) List the characteristics of broadband coaxial cable.

……

……

……

……

2.6 SUMMARY

Transmissions can take place through the media of guided and unguided type and it can be simplex, Half duplex and Full duplex. In simplex the data/signals are transmitted in one direction by a station i.e., by the sender, in half duplex the transmission can be done in one direction at a time whereas in full duplex the transmission can take place in both directions. The concept of time domain and frequency domain deals with the electromagnetic signals and components at various frequencies spectrum. The concept of analog and digital transmission deals with data signalling and transmission which can be analog data i.e., signal occupies same spectrum and digital data are encoded using a modem to produce analog signal. The other type of signal is digital, which uses a bit steam. Media used in transmission are of Magnetic type is one of the most common ways to store data physically on tapes, floppy disks and hard disks. Twisted pairs are used both for analog as well as digital transmission. Twisted pair can be cat 3, cat 5. Both of them are UTP cables. Base band cable is used for longer distances at high-speed 50 ohm and 75 ohm are normally used. Broadband Coaxial cable refers to anything wider than 256kHz. Broadband capacity is divided into multiple channels and each channel can be used for analog signal also. It can be used for CD-quality audio (or a bit streams) and video data transfer.

2.7 SOLUTIONS/ANSWERS

1) The higher the bandwidth the more data rate can be achieved. The unit for bandwidth is Hz whereas the unit for measuring the data rate is bps (bits per second).

2)
- Uses analog transmission
- Frequency range is always more than 4kHz.
- Supports multiplexing of several channels.