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Communications Systems

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Abstract: Information is measurable physical quantity, such as mass, heat or any other form of energy. It is the choice of one massage out of finite set of massage. Meaning is immaterial in this sense. Information dissemination is as old as man. Ability to communicate meaningfully and intelligently among people differentiates human beings from animals. In the olden days, man used pigeons and men ride on horses to deliver mail. There had existed some channels of making meaningful transfer of information in form of facts and useful ideas through diverse kinds of tangible and intengile media. These various means of communication were very primitive. This study titled Communication System however presents a brief history of communication system, the basic transmission and reception system, classification of communication system/lines. The study further argues the advantage of the digital transmission system over the analog systems and the modern communication system/equipment vis-a-vis Telephone system and the Global System for Mobile Communication (GSM). Some advantages/benigfits and services offered by the GSM were also highlighted.

Key words: Communication system, tangible, transmission, reception, classification, equipment

INTRODUCTION

Through ages, man has always tried to find a way for long distance communication. Man used pigeons and men riding horses to deliver mail. These two methods were inefficient; the first was limited to certain directions that the pigeons were trained to go to and the later took longer time for further distances. These methods were used till the 19th century, when Alexander Graham Bell succeeded in performing the first wired telephone call (transmitting an electrical signal) in 1875. This invention revolutionalized world communication.

Since the invention of the telephone, communications industry kept on growing and widening. Another important invention was accomplished by Guglielmo Marconi, who was the first to transmit electrical signals. Through the air and then receive the transmitted signal using a receiver. The first transmission through the Atlantic was in 1901 which opened for radio broadcasting.

In World War I and II, wireless radio was very important in command and control of troops. Analog modulation scheme were used to transmit the information signal (Voice) via the air. This was however accomplished using the Analog Modulation process.

Right after World War II, the idea of having Global Wireless information transmission arose. The developed countries started their rally of launching satellites to ease global communications, by covering larger areas that receive satellite transmission. Also the Digital Modulation technology started to develop.

Nowadays, modern mobile communication systems use digital modulation techniques. Advancements in VLSI (Very Large Scale Integration) and DSP (Digital Signal Processing) made digital modulation more cost efficient than analog modulation. (Mills and Skillen) There other advantages of digital over analog systems including greater noise immunity, robustness to channel impairments, easier multiplexing and greater security. These will be discussed in details in this chapter.

WHAT IS COMMUNICATION?

Communication is the *transmission, reception and processing* of information with the use of electronic circuits. The basic concepts involved in communications have not changed much since the inception, although the methods by which these concepts are implemented have undergone tremendous and dramatic changes. The Fig. 1 below shows a communication system in its simplest for, which comprises three primary sections: a *Source* (transmitter), a *Destination* (receiver) and a transmission medium (a pair of wire, coaxial cable, fiber optics or free space i.e., air).

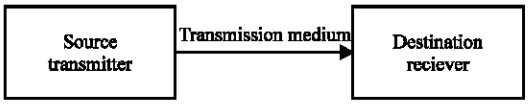

Fig 1: Block diagram of a communications system in its simplest form

CLASSIFICATIONS OF COMMUNICATIONS SYSTEMS

Broadly speaking, communications system can be classified as

- Analog communications system
- Digital communications system.

In communications systems, the source information (intelligence signal) acts upon or modulates a single frequency sinusoidal signal. To *modulate* means to vary or change. Therefore the source information is called the *modulating signal*, the signal that is acted upon (modulated) is called the *carrier* and the resultant signal is called the *modulated wave*. In essence, the source information is transported through the system on the carrier.

With analog communications system, *modulation* is the process of changing some property of an analog carrier in accordance with the original source information. Conversely, *demodulation* is the process of converting the changes in the analog carrier back to the original source information. At this juncture, it will be appropriate to define the term 'information' in a communications system. Information is a measurable physical quantity, such as mass, heat, or any other form of energy. *Information can be defined as the choice of one message out of a finite set of messages. Meaning* is immaterial; in xthis sense (Ronald, 1980). The information that is propagated through a communications system can be analog (proportional), such as the human voice, video picture information, or music; it can be digital pulses, such as binary-coded numbers, alpha/numeric codes, graphic symbols, microprocessor op-codes or data base information. However, very often the source information is unsuitable for transmission in its original form and therefore must be converted to a more suitable form prior to transmission. For example, with digital communications systems, analog information is converted to digital signals prior to transmission and with analog communications systems, digital data are converted to analog signals prior to transmission.

TRANSMISSION AND RECEPTION SYSTEM

Shown in Fig. 2 is a diagram of a typical transmission and reception systems. The functions of each block denoted as A to K are briefly summarized:

A = Source encoder
B = Encryptor
C = Channnel encoder

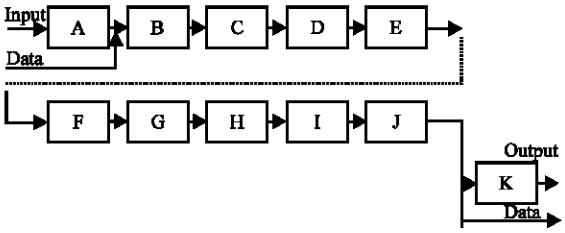

Fig. 2: A block diagram of a typical transmission and reception of a communications system

D = Carrier modulator
E = Spread spectrum modulator
F = Spread spectrum demodulator
G = Carrie demodulator
H = Symbol synchronizer
I = Channel decoder
J = Decryptor
K = Source decoder

Source encoder: This operates upon one or more analog signals to produce a periodic train of symbols. These symbols may be '1' or '0' or may be members of a set with more than two elements. It should be noted that with channels, which are used to communicate from more than one source at the same time, source encoder may contain a multiplexer. Note that this block may not necessary if we begin with a data signal such as might occur as the output of a digital computer. It is absolutely important, i.e the block when the original signal to be communicated is analog.

Encryption: This is a means by which security is provided such that only intended receiver can understand the message and that only the authorized sender can transmit it. Security in communication is a relatively recent concern. The encryption techniques can be achieved in three ways (a) by confining the information that is being sent (signal) to a wire transmission channel. This however is an old method, (b) By disguising the information in such a way that an unauthorized listener would not be able to tell the difference between the information (signal) and background noise and (c) By disguising the actual information (data) using coding techniques so that the message will be incomprehensive to an unauthorized listener even though that listener may correctly receive the signal. It should be noted here that only (b) and (c) above are worth investigating. (Bejide, 2001).

Channel encoder: This provides a different type of communication security than that provided by the encryptor. It increases efficiency/ or decreases the effects of transmissions errors.

Carrier modulator: This block produces analog waveform corresponding to the discrete symbols at its input.

Spread spectrum: Additional security is often provided by the use of spread spectrum techniques. It throws out the minimum bandwidth requirements and intentionally uses a bandwidth that is at least 10 times and typically over 100 times, the minimum required to send the signal information. If this spectrum spreading is done properly, the transmitted signal looks to the unauthorized listener like wideband noise.

It can be seen from the above arrangement of the block diagram that the receiver is simply a mirror image of the transmitter. The only variation from this one-to-one correspondence is that the carrier modulator of the transmitter has been replaced by two blocks in the receiver: the carrier demodulator and the symbol synchronizer.

Once the analog waveforms are produced at the receiver, it is critical that the overall signal be properly partitioned into segments corresponding to each symbol and to each message. This partitioning is a function of the synchronizer.

REASONS FOR THE USE OF DIGITAL TRANSMISSIONS

There is a sharp increase in digital communication, perhaps even at the expense of analog communication due to two interworking factors.

The first is the plain fact that a lot of information to be transmitted is in pulse form to start with and so sending it in that form is clearly the simplest technique.

The second factor has been the advent of Large Scale Integration (LSI) and Very Large Scale Integration (VLSI) which has permitted the use of complex coding systems that take the best advantage of channel capacities in terms of size and cost.

The third reason is that repeaters are used instead of amplifiers; the effects of noise and other signal impairments are not commutative. It is possible, then to transmit data longer distance and over lesser quality lines by digital means while maintaining the integrity of the data.

The fourth is the fact that it has become very economical to build transmission links of very high bandwidth including satellite channels and connections involving optical fibre. A high degree of multiplexing is needed to effectively utilize such capacity and this is more easily and cheaply achieved with digital (time-division) rather than analog (frequency-division) techniques.

The fifth reason is that Encryption techniques that provides security and privacy to information to information being sent and received can readily be applied to digital and to analog information that have been digitized.

CLASSIFICATIONS OF COMMUNICATION LINES

Essentially, there four modes of transmission for communications circuits (data) : s*implex, half duplex, full duplex* and *full-full duplex* (Wayne, 1998).

Simplex: With simplex operation, transmission is unidirectional; information can be sent only in one direction. Simplex lines are also called receive- only, transmit- only, or one-way-only lines. Examples of this is the television and radio system because it always transmit the signal to its listeners and never allows them to transmit back.

Half Duplex (HDX): The half duplex transmission line is the one in which data transmission is possible in both direction but not at the same time. Its direction may be reversed but not simultaneously. They are also called two-way alternate lines. Examples of this is the radiophone system.

Full Duplex (FDX): In the full duplex mode, transmissions are possible in both direction but they must be between the same two location. Full duplex lines are also called two way simultaneous, or both way line or simply duplex lines. It really consists of two simplex channels, a forward channel and reverse channel, linking the same points. Examples of this is a standard telephone system and the GSM.

Full-Full Duplex (F/FDX): In the full- full duplex mode, transmission is possible in both direction at the same time but not between the same two station. A station is transmitting to a second station and receiving from a third station at the same time. Full duplex is possible only on multipoint circuits.

MODERN COMMUNICATIONS SYSTEMS/EQUIPMENT

Telephone system: The term *telephony* implies a system, which enables speech to be conveyed beyond the range of human voice and hearing. By this system messages are sent and received in spoken form using instruments called telephone. The sound waves comprising speech

are used to control the transmission of electrical signals in the form of alternating current at the same frequencies, as sound waves and these current are latter used to reproduce the original sound waves at the receiving end. Each instrument is usually connected by its own line to a central office called Exchange. All public telephone includes facilities for switching at the exchange. Such switching is either manual or automatic. In manual switching, the user requesting operator to connect him while in automatic switching the operation is carried out by automatic apparatus under the control of the calling subscriber dial.

Telephone instruments are installed at private subscriber premises or in public place (for coin operated phone). Each of these installations is connected by a pair of wires called subscriber's line to a local telephone exchange which typically serves up to 10,000 lines. In some cases more than one subscriber's instrument may be connected to the line. Each local exchange provides the means of connecting any of its subscriber's line to each other. The local exchange is also connected to other similar exchange in the same area. e.g (same town) by further pair of line called junctions. For calls outside this area, junctions are provided with trunk exchanges which provide the means of connecting calls over the long distant routes (trunk line) to subscriber in other areas any where in the world. The long distant line may use cables, optical fibre or satellite as means of transmission.

The basic speech apparatus used in telephone consists of the *transmitter* and the *receiver*.

Mobile phones: Mobile phones are also called cellular phones. Basically this can be analog or digital. Digital phones are commonly referred to as GSM phones, the operation or concept of the analog and digital phones are similar.

Concept of a cell: Wireless communication systems originally did not use the concept of cellular networks. In the conventional wireless communication system, a single high power transmitter was used to provide communication in an entire metropolitan area this prove to be infeasible due to the substantial power requirement and capacity limits. It is known that transmitted energy decreases inversely proportional to the square of distance thus by using a single antenna also brought about limitation in the number of channels that can be provided in the given allocated band. For modern cellular systems, we use several low power systems to provide coverage to metropolitan area. This technique involves the concept of frequency reuse, which increases system capacity. In the cellular system the low power transmitter covers a small area which we call a cell and the transmitting equipment within the cell is called the cellsite (Edeko, 1997). Normally, the cells are represented as hexagons and can be of any shape .

Global System for Mobile communication (GSM): In the early eighties in Europe, individual countries operated in compatible individual systems. Because of this, a conference on post telegraphs formed an alliance called Group System Mobile (GSM) to harmonize and achieve a single telecommunication in Europe. This new standard had to meet the following criteria:

- Should support international roaming
- Should support handheld terminals
- Should operate within a specified frequency band with high spectra density.
- Should be compatible with IDSN (International Digital System Network) i.e., ability to interconnect landlines.

The technology adopted at that time did not include the existing ones, instead the group opted for TDMA (Time Division Multiple Access). Commercial GSM actually began in the mid 1990s and has rapidly advanced covering over 80 countries in the world and representing about 85% of total subscriber's base.

In the years that GSM has been operational, millions of subscriber (about 50 million) now use it. GSM operates using PCS1900 and DCS1800. PCS1900 means Personal Communication Services of 1900MHz frequency while DCS means Digital Cellular System of 1800MHz frequency.

GSM architecture: GSM is composed of three broad components:

- Mobile Station (MS).
- Base Station Subsystem (BSS).
- Network Sub-System (NSS).

The Mobile Station (MS): This consists of a handset and a smart card (Subscriber's Identity Module, SIM).

By inserting a SIM card into a GSM terminal, the subscriber is able to make and receive calls at that terminal. The SIM card contains the international mobile subscriber identity used to identify the subscriber in the network, including a secret key for authentication. This SIM is protected against unauthorized user by a password or a Personal Identity Number (PIN).

The Base Station Subsystem (BSS): This consists of two parts: Base Transceiver Station (BTS) and the Base Station Controller (BSC). The BTS houses the radio

transceiver that defines a call and handles radio link protocol with MS. The BSC manages radio resources for one or more BTS. It handles radio channel setup, frequency hopping and Hand off. BSC is the link between the handset (Mobile link) and the Mobile Switching Center (MSC).

The Network Sub-System (NSS): The centre component of the network subsystem is the Mobile Service Switching Centre, MSSC. It acts as a normal switching mode of a public switch telephone network or the integrated service digital network. It also provides additional services needed to handle subscriber activities e.g registration, authentication location identification or roaming subscriber.

Benefits and advantages of GSM:

- Globally accepted technology
- GSM standards are specific and complete. This means that it has Open Standard Interface (OSI). This ensures multiple vendor and application.
- Technology is ready to be deployed
- GSM have differential features and services, i.e you can send short messages and data
- GSM permits national and international roaming i.e all mobiles can be supported by any GSM network.

Services offer By GSM

Call forwarding: Allows users to transfer call to subscriber. This option includes mobile subscriber busy, no reply, mobile not reachable

Call baring: The user can prevent ongoing or oncoming calls.

Short message services: It allows the transmission of a message up to 160 alpha numeric characters.

Voice mail: Messages are transmitted with operator call back services.

International roaming: Allows you to receive call outside your "home network''

- Fax and data transmission
- Call line identification
- Advice on charge
- Call waiting services: It allows a user to put calls on hold.
- Conference call: It permits user to call several numbers simultaneously for conversation with all participants.
- Radio reception
- Closer user group: Restrict call to a group of subscriber thereby reducing fees.

MODEMS: MODEMS means Modulator-Demodulators They are used to interface digital equipment with analog transmission medium. Most transmission medium are analogue that is, operates with continuous range of frequencies and data communication equipment transmit discrete voltage levels. For the transmitted discrete voltage levels to be transmitted through the analog line, they must be converted into a continuous range of frequencies. The process for converting a digital bit stream into an analog signal is a form of modulation.

At the receiving end however, the analog signal must be converted back to digital formats for the data equipment at the receiving end, this process is called demodulation. The equipment that performs the two conversions is the MODEM. To connect digital equipments using an analog line must be a modem between, their data machine and the line at each end. A sending MODEM modulates digital signals into analog signals and a receiving modem Demodulates analog signal back into digital signals.

Multiplexor: Multiplexors are data communication network equipment use to increase the utilization of telecommunication lines. It allows a single high capacity links to be divided into several lower capacity links. Its main job is to combine the data being transmitted over a number of low bandwidth data links for transmission over one or more channels of higher bandwidth.

Telegraph: The telegraph was invented and established in the 1830s after the connection between electricity and magnetism had been established. They are used to send out digital bit using some form of keyboard arrangement. The telegraph has the transmitting side and the receiving side that we call the teletypewriter. The teletypewriter was originally designed for transmission and reception of written texts including letters and numbers and they are modeled as extension of the original typewriter. The teletypewriter consist of two keyboards, sends, receive unit that is used for direct communication between two operators. They are used to send messages over long distances. The message is lodged in written form and the agency concerned sends the telegraph message and is delivered to the destination also in the written form.

Telegraph signals are formed supply by switching an electric current on and off or by reversing its direction of flow. The means for producing these current changes are some form of make and break contact. The instrument for sending signals, such as teleprinters or paper tape-reader,

make or break the circuit at appropriate times, the on and off pulses from a code that is appropriately interpreted by the receiving device.

The telegraph uses some codes to represent each character and these codes are sent over the telegraph line in form of current are made within the telegraph circuit, while an `o` or space is sent when the current is broken between the telegraph current. Ones a key is pressed, the key is coded using pulse code modulation and form a code. The code is then transmitted through the medium that may be telephone line, at the receiving end; the code received is then decoded and printed out at the receiving end printer.

Telex: Telex is also used to send out digital bit and is very similar to telegraphy. The only difference being that the wanted subscriber has its own machine where the message is printed out. The message is typed out at one end of a link and printed out at the other end simultaneously or very soon afterward.

PABX: The Private Automatic Branch Exchange (PABX) is a switching device use to interconnect an organization's telephone with one another and also with the public network. These private switching facilities can also be used for data communicating by employing appropriate modems and other line termination equipment, the earlier version are manually controlled by operators and they are called private branch exchange. Advance in technology however gave birth to the computer-controlled type. In the computer controlled type, each extension has its own individual telephone number. Some PABXS are specifically designed to support users of data communication services and use digital technology. A digital PABX can often be use to connect data processing equipment directly with digital circuits, thus avoiding the use of modems.

Front end processor: The front-end processor is also known as communication controller and it is a device used at the location of the host computer. A front-end processor is often a stored-program device that performs many communication related functions, thus freeing up the host computer for application related work. It is therefore on interface between the host computer and the communication lines.

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