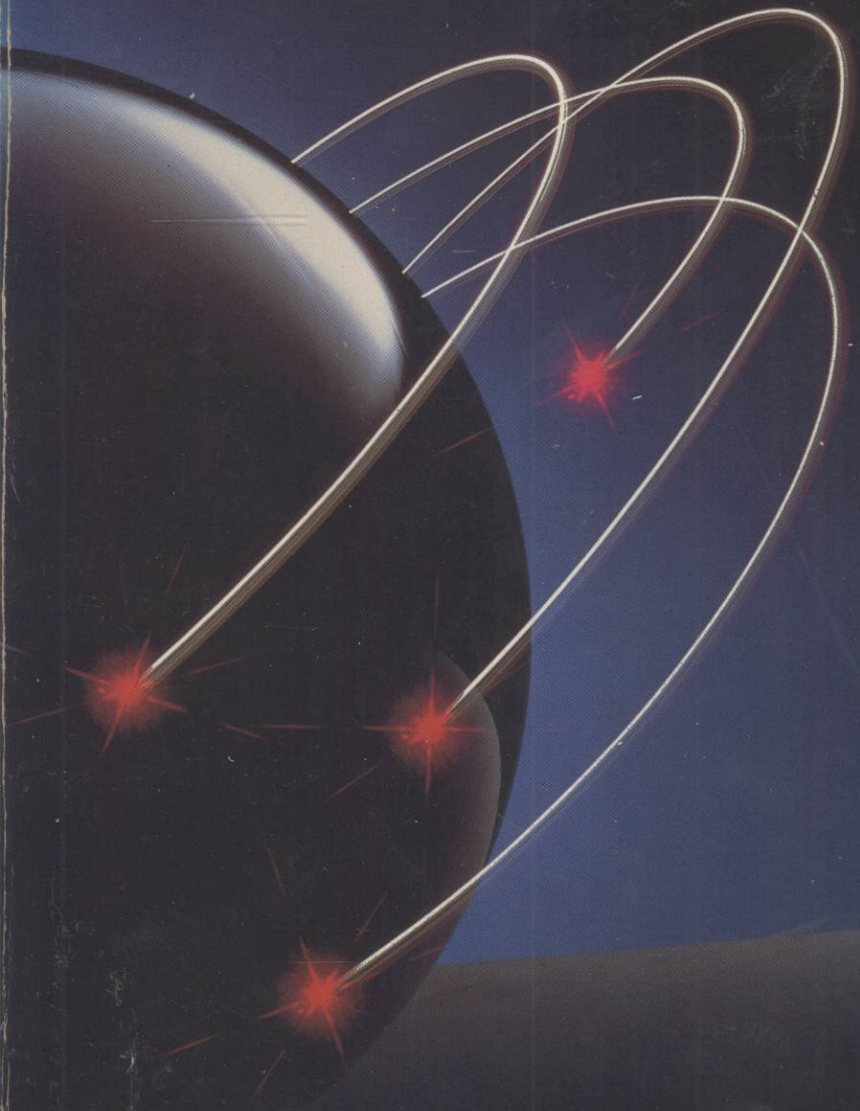
June Miles



Data Communications Fundamentals

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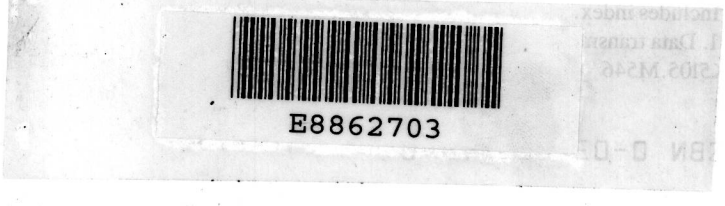

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Preface

The objective of this book is to introduce the concepts of data communications. The transmission of voice and data has become an accepted part of almost all aspects of our private lives as well as our business world. All levels of government depend on the rapid availability of information from various locations. Most other organizations, whether involved in manufacturing, transportation, retail, education, health or finance, rely ever more heavily on instant up-to-date information.

Advances, both in technology and amount of usage, are occurring so rapidly that it is nearly impossible to stay abreast of all new developments. Data communications has become both necessary and complex. It is extremely important that one who is interested in data processing study data communications in order to build a foundation of knowledge upon which to add the new technologies as they are developed.

Although voice, image and data are all transmitted in telecommunications, this book addresses data communications; that is, data sent to or from terminals and computers for the purpose of data processing. Voice or image applications are touched upon only briefly where it is deemed necessary.

The book is intended as a text for either an introductory or sole course in data communications offered by colleges or universities. The simplicity of approach also makes it appropriate for the community college curriculum. The material is covered in adequate depth to be of use to professionals in the field of data processing who wish to become familiar with data communications.

The basic concepts are introduced in a simple manner, requiring no knowledge of electronics, engineering or mathematics. Only after the foundations have been built are the more complex technologies addressed. It is generally helpful, however, that those wishing to study data communications have at least a minimal understanding of computers and their processes.

The book is divided into three parts. Part one, the first four chapters, covers only the basics of how data are transmitted from one source to another. Chapter 1 is an overview of communications. It accents telecommunications, including the history of its development. Chapter 2 covers data and its various formats; Chapter 3 explains the electronic details of transmission. Chapter 4 contains error detection and correction possibilities.

Part two, consisting of three chapters, concerns networks. Chapter 5 describes the components of a network. Chapter 6 explains many of the different protocols that are used in networking. Chapter 7 covers the design and configurations of networks.

Part three covers the more administrative details of the network. Chapter 8 discusses several levels of commercial services that can be purchased, and Chapter 9 covers the security of data. Chapter 10 concerns the research and development being explored today, together with some predictions for the future.

Descriptions of the communications control characters are detailed in Appendix A. Certain of these are also covered at appropriate points in the text where understanding them is integral to the content.

Probably the most confusing new material for those who have not had extensive experience in data processing (as well as a few who have) is in the use of unfamiliar terms. These terms are explained at the time they are first introduced into the text. To assist in more complete understanding, a glossary of terms has been added as Appendix B.

PART I

Part one is an overview of the communications process. It covers types of communication, with emphasis on data communications, and the means by which it is accomplished.

Chapter 1 explains the process of communications and how it relates to the long distance transmission of data. There is a brief history of the development of telecommunications and a few case histories of special recent uses of the concepts.

Chapter 2 explains the types of data and codes used for electronic data transmission. The binary system that is internal to the computer is described, together with the binary combinations that make up several of the most often used codes.

Chapter 3 explains the transmission of these codes. This involves the characteristics of electrical signals and how they may be modified to produce binary data. Several modes of transmission lines are also explained in some detail.

Chapter 4 involves error handling, beginning with error types and the sources that impose errors into the data being transmitted. Error reduction techniques are discussed for each of the error sources, and for instances where the reduction methods are not adequate, some error detection and correction methods are explained.

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1

Objectives

This chapter will cover the basic components of a communications system and the characteristics of the components as they relate to data communications. It will also include some of the evolutionary steps that have contributed to the accomplishments of data communications today. It will enable the reader to:

- Know the necessary components of a communications system.
- Know the interrelationships necessary to complete a communications process.
- Know the various types of terminals that can make up the first basic component.
- Know the various types of media used in data transmission.
- Have an awareness of the growth of the communications industry from the 1600's to modern times.
- Be aware of some of the exciting uses of data communications in today's world.

1 The Communications Process

A Communications System

Communication is essential to our lives. We are constantly involved in some form of communication, whether written, oral, audio or visual. Most teenagers manage to be involved in two or more at any time. They watch TV while talking on the phone and listen to the stereo while doing their homework.

Components

Figure 1.1 shows the four basic components to any communications system. There must be

1. a *sender* to originate communications
2. by creating a *message*,
3. placing it on a *medium*
4. to be delivered to a *receiver*.

Characteristics

These components can vary greatly according to the type of message, but all four must be present. In addition, all components must have been designed for the same purpose. Consider how the voice (sender) gives information in a language (message), and the sound waves (medium) carry the information to the ear (receiver).

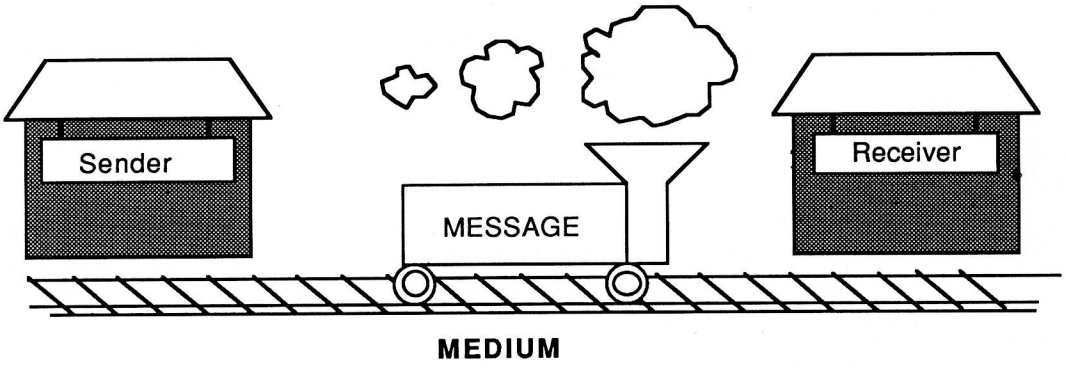


Figure 1.1 Components of a Communications System

In the same manner, we can have communication where the four components consist of a book, the written words, light waves and the eye; or a telephone transmitter, carrier signals, the carrier wire and a telephone receiver.

All four components must also share three basic principles to give satisfactory performance.

First, the receiver must be able to understand the message. An English-speaking person probably could not understand a text written in Russian or a speech given in Chinese, therefore communication could not be completed in these circumstances.

Second, the characteristics of the system are defined and limited by the characteristics of the four basic components. A picture of a new car cannot be displayed over the ordinary residential telephone, and a great symphony rendition cannot be realized by a snapshot camera.

Third, interference, called "noise", can corrupt the communications process. The audience cannot view a movie if someone is standing in front of the projector. A musician's drum practice can destroy any conversation, and it is impossible to pour a glass of milk if the cap is on the bottle.

A Data Communications System

Telecommunications is the process of communicating across distances. Data communications is more specific. It is the transmission of data from one point to another via telecommunications. The two terms are often used interchangeably when speaking of the transmission of data for use by computers, however, data communications is more exact.

Components

All of the requirements described for a communications system must be met in order to transmit data effectively. Figure 1.2 shows the four components of a data communications system.

Sender

The sender, in most instances, is a computer terminal. Actually, when communication takes place, data usually flows in both directions, so a terminal can act as either sender or receiver. Many of the various types of terminals are shown in Figure 1.3. Terminals are covered more fully in Chapter 5.

Teleprinter terminals. Teleprinters, also called teletypewriters, have keyboard input, which could include control function keys, and printed output. Printed output is called "hardcopy" as opposed to "softcopy", where results might be written on disk or magnetic tape. Some of these are impact printers having either solid or dot matrix characters. Some are non-impact, such as electrical thermal or ink jet.

Video terminals. A video terminal also has keyboard input, but the output is shown on a video screen. The screen is usually a Cathode Ray Tube (CRT), although many new technologies are available today.

Remote job entry stations. A remote job entry station (RJE) has keyboard input on a console and also, normally has a card reader and line printer. In addition, most usually have tape and/or disk storage units.

Transaction terminals. These are terminals that enter transactions at the point-of-sale. They would include Automatic Teller Machines (ATM), the Universal Product Code (UPC) readers used in most of our major grocery chains or the optical wand used to read tags on items in department stores. Most of the UPC processors show the prices on a video screen, and some of the newer ones also announce the prices and items aloud. These use a voice synthesizer, another computer function.

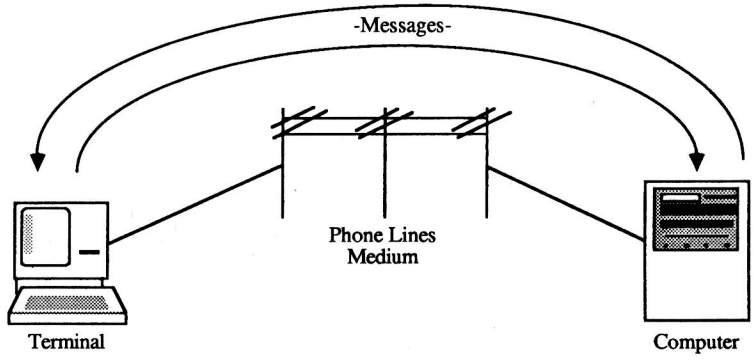


Figure 1.2 A Data Communications System

Optical character recognition. Optical characters are those strange looking characters that appear on some of our bills and checks. These units may include multiple character sets or styles of type (called fonts) or they can be restricted to only one.

Intelligent work stations. Intelligent work stations are actually micro- or mini-computer systems. Therefore, they can have many types of peripherals: (devices such as tape units, disk units, and printers).

Graphics terminals. A graphics terminal can perform high resolution graphics. Input can be by means of keyboard, digitizer (a device that translates a position into digits representing X and Y coordinates) or a light pen. Output graphics can be displayed on a screen (CRT) or printed on a plotter, a device whose sole purpose is to draw pictures.

Message

Messages in data communications consist of encoded electrical signals that are capable of traveling either on wires or through open space. There must also be some type of interface to convert these signals into characters, numbers and words. Chapter 2 covers these characters, codes and conversions in some detail.

TELEPRINTERS	KEYBOARD INPUT, PRINTED OUTPUT PAPER TAPE, PUNCH, READER
VIDEO TERMINALS	KEYBOARD INPUT, SCREEN OUTPUT ALPHA-NUMERIC
REMOTE JOB ENTRY STATIONS	KEYBOARD CONTROL UNIT, CARD READER, LINE PRINTER, CONSOLE, TAPE, DISK STORAGE
TRANSACTION TERMINALS	POINT OF SALE, AUTOMATIC TELLER, CREDIT CHECK, KEYBOARD OPTICAL WAND, MAGNETIC CARDS PRINTED SCREEN, AUDIO OUTPUT
OPTICAL CHARACTER	SINGLE FONT OR MULTIFONT
INTELLIGENT WORKSTATIONS	MINI/MICRO COMPUTER SYSTEMS, KEYBOARD, SCREEN, PRINTER, DISKS, TAPES
GRAPHICS	HIGH RESOLUTION, KEYBOARD, DIGITIZER, LIGHT PEN INPUTS, SCREEN, PLOTTER PRINTER OUTPUTS

Figure 1.3 Terminals

Medium

The medium is a common carrier designed for electrical signal transmission capabilities. Common carrier is a service providing the transportation of goods, more specifically in this instance, transport of electrical signals. Physical media can be wires, coaxial cable, or optic fiber. Media can also consist of radio or microwave signals that travel through free space. These are all used by our telephone companies for the transmission of data through their systems. A brief description of each follows:

Open wire pairs. Figure 1.4 illustrates open wire pairs, consisting of bare wires separated by a distance of eight to twelve inches. Although they are tied to glass insulators, the wires themselves have no insulation. Open wire pairs are in use primarily in remote rural areas, and even there they are becoming relics of our past.

Twisted wire pairs. Figure 1.4 also shows an illustration of wire pairs consisting of twisted insulated wires. They are insulated with paper or plastic. Each pair is capable of carrying one voice-grade telephone channel. These can again be twisted and bundled into large groups within a cable. The cables are covered with lead or plastic and can be either hung or buried. Wire cables are the standard medium between your home or business and the local telephone office.

Coaxial cable. Coaxial cable, shown in Figure 1.5, is probably most familiar to us because of its use in cable TV. The cable consists of a solid copper core with an outside cylinder of conductive material. Between these two layers are insulators spaced every few inches. The cables may be bundled into groups of twenty for a capability of approximately 20,000 voice channels. Coaxial cable is normally buried or placed within walls of a building.

Optic fiber. Optic fiber is becoming more and more popular as a medium in data communications. Figure 1.6 shows optic fiber. The optic fiber used in data transmission consists of glass (or glass-like material) tubes surrounded by cladding. The cladding is made of a glass or plastic coating that blankets the core and has optical properties different from those of the core.

The entire core is then surrounded by a jacket composed of plastic or other materials layered to protect against any environmental problems. The jacket is designed specifically for the application. For example, fiber designed to be suspended would have added strength against ice formations and high winds. Fiber intended to be buried would have protection against moisture, crushing, burrowing animals, etc.

A laser or light-emitting diode sends a signal by transmitting non-conducting photons (instead of electrons as in metallic cables) down the fiber, where it reflects off the cladding to continue the transmission.

Microwaves. For conditions where physical media are not ideal, microwave transmission can be used. Signals are transmitted via electromagnetic radiation to a tower which then retransmits the signals to another tower. Advantages are that no physical medium such as buried cables or strings of telephone poles, is needed.

A major drawback to the use of microwaves is that they operate only in line-of-sight (see Figure 1.7). Microwaves cannot transmit through mountains or tall buildings, nor can they follow the curvature of the earth. Therefore, they require relay stations in areas where

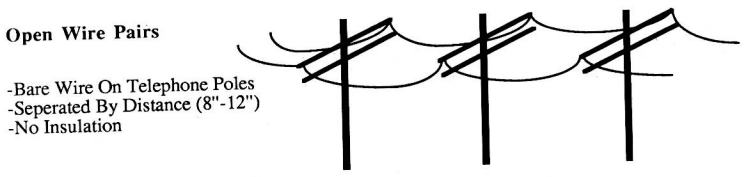
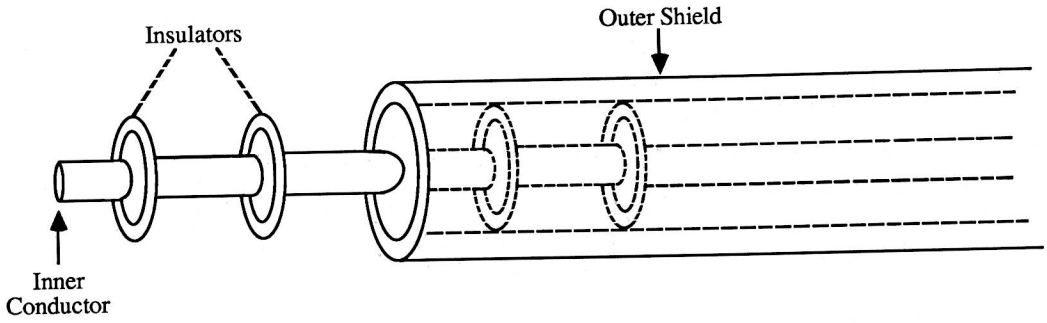
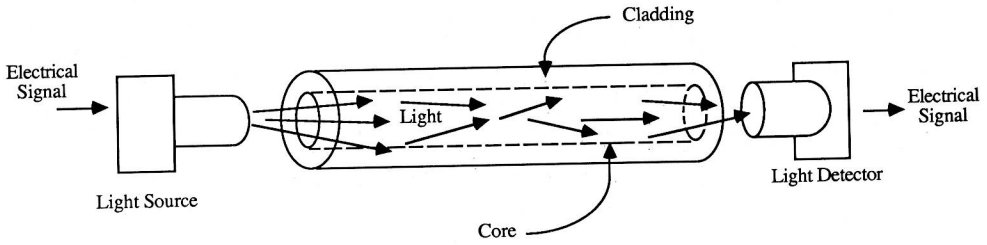


Figure 1.4 Transmission Wire Pairs



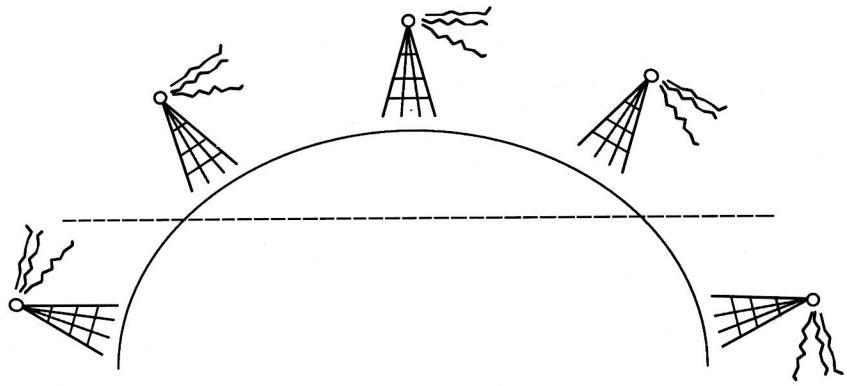
- Outer Conducted Braided Shield
- Inner Conducter Solid Metal
- Seperated By Insulating Material
- Covered By Padding

Figure 1.5 Coaxial Cable



- Glass surrounded by cladding
- Laser or light emitting diode
- Specially designed jacket
- Small size and weight

Figure 1.6 Optical Fiber



- Dish Antenna
- Radiation
- Line Of Sight
- Repeater Stations At High Points

Figure 1.7 Microwave Transmission

there are any obstructions. As a result, relay or repeater stations are usually located about 30 miles apart, either atop mountains or tall buildings.

Many of our toll and long distance phone calls, and our TV transmissions, are handled via microwaves.

Satellite. A more recently developed medium that overcomes the line-of-sight limitation is satellite transmission. Figure 1.8 is an illustration of a satellite system. Three satellites orbit the earth at an altitude of approximately 22,300 miles above the equator at the speed of the earth's rotation. The result of their traveling in exactly the same orbit is geo-synchronization. That means they are synchronized with the earth's orbit. The effect of this is that they appear to be stationary. Therefore, the satellites operate in the same manner as would microwave towers stationed miles above the earth. This perfect synchronization is not always completely achieved; however, it is the goal.

Signals are beamed through the atmosphere to the satellite and back to earth, without obstructions such as microwave transmissions encounter. These three satellites are positioned at 120° intervals to allow world-wide broadcast capability. Only the north and south polar areas are not serviced.

Receiver

Let us think of the receiver in data communications as a computer. Once again, be aware that both terminal and computer can function as both sender and receiver.

The computer that handles in data communications is commonly referred to as the *host*. Although all sizes of computers are used to perform some telecommunications processing, persons in the field generally accept that the amount of work to be accomplished requires a large main frame computer if any applications processing needs to be done (see Figure 1.9). Some newer systems connect many powerful personal computers and somewhat eliminate this requirement.