PART II

Data Communications

The basics of media, encoding, transmission, modulation, multiplexing, connections, and remote access

Chapters

Chapter Contents

5

Overview Of Data Communications

5.1 Introduction

The first part of the text discusses network programming and reviews Internet applications. The chapter on socket programming explains the API that operating systems provide to application software, and shows that a programmer can create applications that use the Internet without understanding the underlying mechanisms. In the remainder of the text, we will learn about the complex protocols and technologies that support communication, and see that understanding the complexity can help programmers write better code.

This part of the text explores the transmission of information across physical media, such as wires, optical fibers, and radio waves. We will see that although the details vary, basic ideas about information and communication apply to all forms of transmission. We will understand that data communications provides conceptual and analytical tools that offer a unified explanation of how communication systems operate. More important, data communications tells us what transfers are theoretically possible as well as how the reality of the physical world limits practical transmission systems.

This chapter provides an overview of data communications and explains how the conceptual pieces form a complete communication system. Successive chapters each explain one concept in detail.

5.2 The Essence Of Data Communications

What does data communications entail? As Figure 5.1 illustrates, the subject is an interesting combination of ideas and approaches from three disciplines.

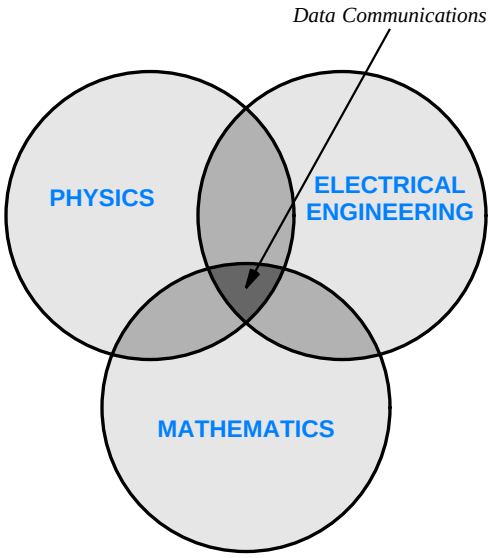

Figure 5.1 The subject of data communications lies at the intersection of Physics, Mathematics, and Electrical Engineering.

Because it involves the transmission of information over physical media, data communications touches on physics. The subject draws on ideas about electric current, light, and other forms of electro-magnetic radiation. Because information is digitized and digital data is transmitted, data communications uses mathematics and includes various forms of analysis. Finally, because the ultimate goal is to develop practical ways to design and build transmission systems, data communications focuses on developing techniques that electrical engineers can use. The point is:

> *Although it includes concepts from physics and mathematics, data communications does not merely offer abstract theories. Instead, data communications provides a foundation that is used to construct practical communication systems.*

5.3 Motivation And Scope Of The Subject

Three main ideas provide much of the motivation for data communications and help define the scope.

- The sources of information can be of arbitrary types
- Transmission uses a physical system
- Multiple sources of information can share the underlying medium

The first point is especially relevant considering the popularity of multimedia applications: information is not restricted to bits that have been stored in a computer. Instead, information can also be derived from the physical world, including audio and video. Thus, it is important to understand the possible sources and forms of information and the ways that one form can be transformed into another.

The second point suggests that we must use natural phenomena, such as electricity and electromagnetic radiation, to transmit information. Thus, it is important to understand the types of media that are available and the properties of each. Furthermore, we must understand how physical phenomena can be used to transmit information over each medium, and the relationship between data communications and the underlying transmission. Finally, we must understand the limits of physical systems, the problems that can arise during transmission, and techniques that can be used to detect or solve the problems.

The third point suggests that sharing is fundamental. Indeed, we will see that sharing plays a fundamental role in most computer networks. That is, a network usually permits multiple pairs of communicating entities to communicate over a given physical medium. Thus, it is important to understand the possible ways underlying facilities can be shared, the advantages and disadvantages of each, and the resulting modes of communication.

5.4 The Conceptual Pieces Of A Communication System

To understand data communications, imagine a working communication system that accommodates multiple sources of information, and allows each source to send to a separate destination. It may seem that communication in such a system is straightforward. Each source needs a mechanism to gather the information, prepare the information for transmission, and transmit the information across the shared physical medium. Similarly, a mechanism is needed that extracts the information for the destination and delivers the information. Figure 5.2 illustrates the simplistic view.

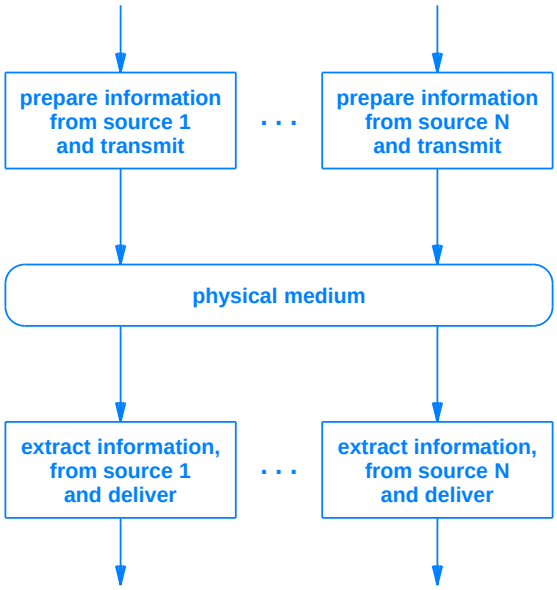

Figure 5.2 A simplistic view of data communications with a set of sources sending to a set of destinations across a shared medium.

In practice, data communications is much more complex than the simplistic diagram in Figure 5.2 suggests. Because information can arrive from many types of sources, the techniques used to handle sources vary. Before it can be sent, information must be digitized, and extra data must be added to protect against errors. If privacy is a concern, the information may need to be encrypted. To send multiple streams of information across a shared communication mechanism, the information from each source must be identified, and data from all the sources must be intermixed for transmission. Thus, a mechanism is needed to identify each source, and guarantee that the information from one source is not inadvertently confused with information from another source.

To explain the major aspects of data communications, engineers have derived a conceptual framework that shows how each subtopic fits into a communication system. The idea is that each item in the framework can be studied independently, and once all pieces have been examined, the entire subject will be understood. Figure 5.3 illustrates the framework, and shows how the conceptual aspects fit into the overall organization of a communication system.

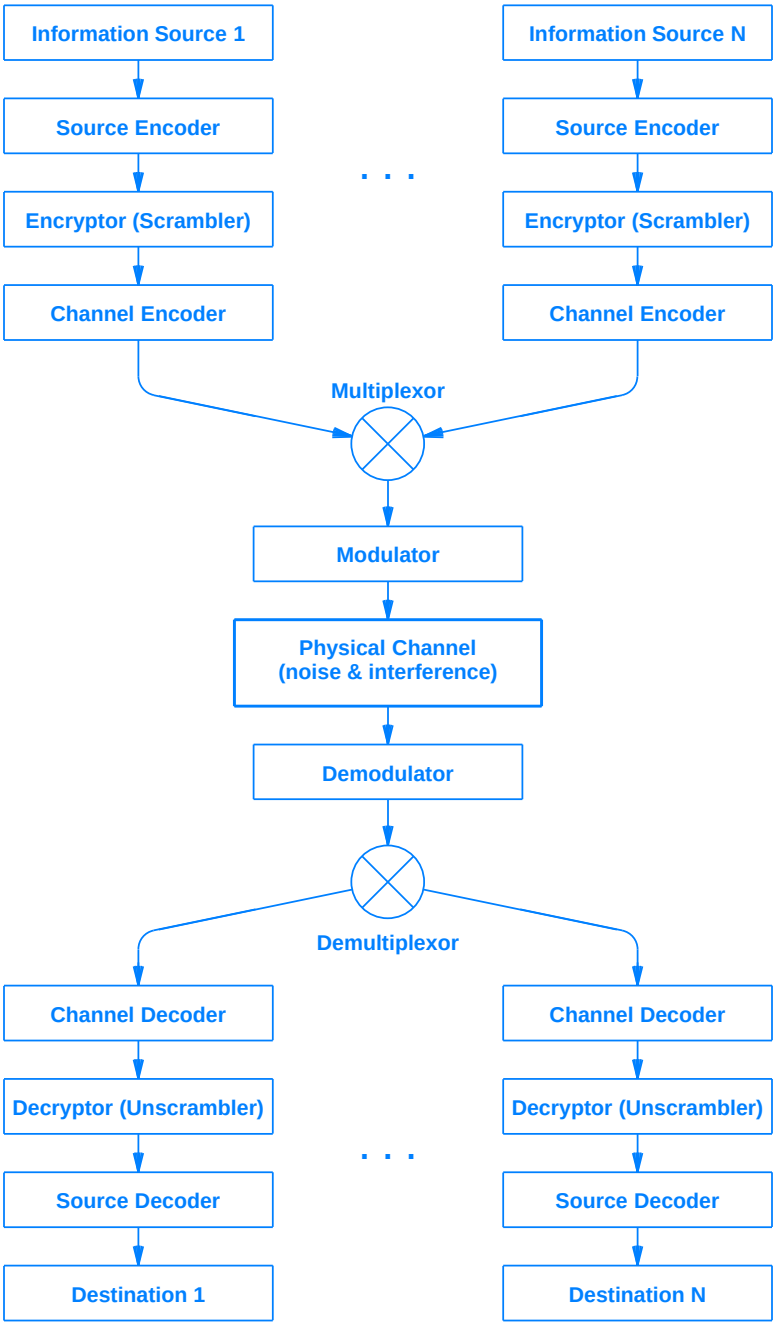

Figure 5.3 A conceptual framework for a data communications system. Multiple sources send to multiple destinations through an underlying physical channel.

5.5 The Subtopics Of Data Communications

Each of the boxes in Figure 5.3 corresponds to one subtopic of data communications. The following paragraphs explain the terminology. Successive chapters each examine one of the conceptual subtopics.

- *Information Sources*. The source of information can be either analog or digital. Important concepts include characteristics of signals, such as amplitude, frequency, and phase, and classification as either periodic or aperiodic. In addition, the subtopic focuses on the conversion between analog and digital representations of information.

- *Source Encoder and Decoder*. Once information has been digitized, digital representations can be transformed and converted. Important concepts include data compression and consequences for communications.

- *Encryptor and Decryptor*. To protect information and keep it private, the information can be encrypted (i.e., scrambled) before transmission and decrypted upon reception. Important concepts include cryptographic techniques and algorithms.

- *Channel Encoder and Decoder*. Channel coding is used to detect and correct transmission errors. Important topics include methods to detect and limit errors, and practical techniques like parity checking, checksums, and cyclic redundancy codes that are employed in computer networks.

- *Multiplexor and Demultiplexor*. Multiplexing refers to the way information from multiple sources is combined for transmission across a shared medium. Important concepts include techniques for simultaneous sharing as well techniques that allow sources to take turns when using the medium.

- *Modulator and Demodulator*. Modulation refers to the way electromagnetic radiation is used to send information. Concepts include both analog and digital modulation schemes, and devices known as modems that perform the modulation and demodulation.

- *Physical Channel and Transmission*. The subtopic includes transmission media and transmission modes. Important concepts include bandwidth, electrical noise and interference, and channel capacity, as well as transmission modes, such as serial and parallel.

5.6 Summary

Because it deals with transmission across physical media and digital information, data communications draws on physics and mathematics. The focus is on techniques that allow Electrical Engineers to design practical communication mechanisms.

To simplify understanding, engineers have devised a conceptual framework for data communications systems. The framework divides the entire subject into a set of subtopics. Each of the successive chapters in this part of the text discuss one of the subtopics.

EXERCISES

5.1 What three disciplines are involved in data communications?

5.2 What are the motivations for data communications?

5.3 What are the conceptual pieces of a data communications system?

5.4 Which piece of a data communications system handles analog input?

5.5 Which piece of a data communications system prevents transmission errors from corrupting data?