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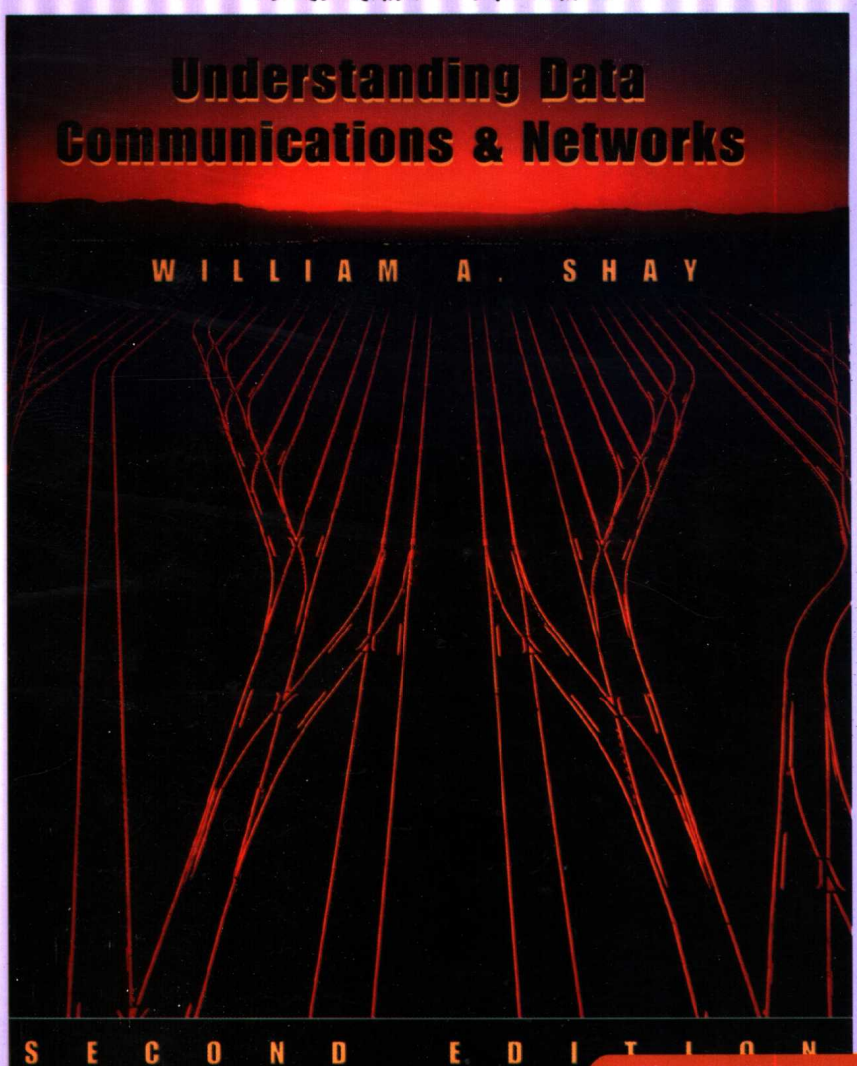
数据通信与网络教程

（英文版 · 第2版）



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Understanding Data Communications & Networks

(Second Edition)

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PREFACE

PURPOSE

The first edition of this book first appeared four years ago; much in the fields of data communications and computer networks has changed since then. Probably most visible is the emergence of the World Wide Web (WWW) and the many applications it supports. Perhaps less visible is the impact the Web has had on underlying network protocols to support these applications and the increased importance of issues involving privacy and security. In just a few years the scope of network users has changed forever. Not long ago most network users were primarily professionals, who might use email occasionally to talk to colleagues or request some vital information. Now network users number in the tens of millions and their uses range from professional needs to purely recreational activities.

Although much of this book's content has changed, its purpose is still fundamentally the same. It is designed for junior-level students in a computer science program who have a minimum of two semesters of programming and a knowledge of precalculus and discrete mathematics. It covers standard topics found in a typical introductory course in data communications and computer networks, such as transmission media, analog and digital signals, data transmissions, compression and encryption methods, network topologies, data security, Ethernets and token ring protocols, wide area network protocols, and World Wide Web applications. This book is designed to help the reader understand

- The differences, advantages, and disadvantages of different transmission media
- Analog and digital signals, modulation and demodulation techniques, and how modems work
- The effect of noise on transmissions and the need for error detection and correction, the mechanisms used, and their advantages and disadvantages

- Standards such as RS-232, RS-449, HDLC, SDLC, DES, X.25, OSI, SNA, IEEE 802.3, IEEE 802.4, IEEE 802.5, ATM, JPEG, MPEG, and TCP/IP, standards organizations, and why standards are needed
- The need for data compression techniques and a comparison of the different methods used.
- Worms and viruses and how they can affect a system
- The need for security, and various encryption techniques
- Differences between public and private key encryption systems
- The need for flow control and various ways of implementing it
- Local area network protocols and contention strategies for shared transmission media
- Methods of connecting local area networks
- Packet-switched networks and routing strategies
- The need for protocols to support real-time video applications and the emergence of ATM
- How to design and set up working client/server applications
- How increased Web use and the proliferation of multimedia applications have affected existing protocols and what is being done to deal with it
- How to incorporate client/server programming techniques into Web page development

Major changes have been made to the first edition, some based on comments I received from its readers and the rest based on the evolution of technology. Many involve clarification of figures or an improved description of protocols. However, the most significant changes from the first edition include the following:

- Improved coverage of wireless communications, especially satellite transmission, and a discussion of low earth orbit satellites.
- Update of the modulation/demodulation standards used in modem technology.
- New section on cable modems.
- Expanded coverage of Lempel-Ziv compression techniques.
- New sections on both JPEG and MPEG compression techniques for graphic and multimedia transmissions.
- Increased coverage of encryption methods, including new sections on the clipper chip and the Diffie-Hellman key exchange method.
- Increased coverage of public key encryption, including new material on authentication using hash-based schemes.
- Update of the section on viruses to include virus evolution and polymorphic viruses.
- Updated coverage of local area network standards to include 100 Mbps technologies.

- Revised discussion of Novell NetWare to include NetWare 4.0.
- Expanded discussion of routing techniques to include additional protocols such as link state routing and the Border Gateway Protocol.
- Expanded and revised discussion of the Internet protocol to include descriptions of the Domain Name System (DNS) and Internet protocol version 6.
- Revised coverage of TCP, including congestion control.
- New section on socket programming to include coverage of the client/server paradigm and the inclusion of a working client/server model that implements a file transfer protocol using socket connections.
- A new section on the World Wide Web with a focus on the use of client/server programming in the development of Web pages. Again, working models of client-side JavaScript programming and server-side CGI programming in C are presented.
- A new section on the Asynchronous Transfer Mode (ATM) protocol.

Although it would be difficult (almost certainly impossible) to cover all these subjects in a one-semester course, the range of topics allows instructors flexibility in choosing the topics best suited for their students.

An *Instructor's Solutions Manual,* with answers to review questions and exercises, is available from the publisher. Also, Web page support for this text is accessible via the URL http://www.pws.com/compsci/authors/shayw.

ORGANIZATION AND OUTLINE

This text offers a mix of theory and application. The theory provides a solid foundation for further study and the application brings students closer to the realities of communications systems and networks. It also gives them valuable experience. All students should benefit from the applications, and the more theoretical material will challenge the more ambitious students. In addition, the last two chapters present actual models of working client and server programs on which the student can build.

Each chapter serves as a base on which to build the next. For example, when studying multiplexing, contention, or compression, students should have an understanding of how signals propagate through different media. When studying local area networks, they should understand problems of contention on multiple-access lines, noisy channels, and flow control. When studying wide area network protocols, they should understand local area network protocols and why these are not suitable for larger networks. Essentially, the text uses a bottom-up approach.

Chapter 1 provides an introduction to the field, touching on current issues and applications in the field of communications and networks. It describes the needs for standards and lists relevant standards organizations, and then summarizes a long-standing protocol model, the Open System Interconnect.

Chapters 2 and 3 deal mainly with kinds of transmission media, signal types, and data transmission, including modulation techniques and modems, interface

standards, multiplexing, contention, and data compression. Chapter 4 covers the security and integrity of transmitted data. It deals with methods used to detect or even correct transmission errors. It also covers different ways of encrypting data and authenticating its sender. This chapter concludes with a section on viruses and how they have evolved over the years. Together these chapters form the "data communications" part of the text.

Chapter 5 begins the "computer networks" part by discussing general protocols that regulate the flow of information between stations. It also presents some of the standard protocols used in local area networks. Chapter 6 covers local area networks (LANs), discussing the standards that define Ethernets and token ring and token bus networks. It then addresses the issues of connecting multiple LANs and the problem of ensuring that information gets to its intended destination and closes with a discussion of Novell NetWare, one of the most popular LAN managers.

Chapter 7 covers wide area networks (WANs) and the need for protocols different from LAN protocols. It describes different ways of routing information within a network and outlines some different methods for dealing with congestion. It also gives significant attention to four important protocols: the X.25 packet-switched network interface, both the old and new versions of the Internet Protocol (IP), and the Transmission Control Protocol (TCP). Chapter 7 finishes with a development of a working client/server model that uses UNIX socket connections to transfer a file between two computers connected to the Internet. Finally, Chapter 8 covers applications and additional protocols such as TCP/IP applications, WWW, X.400 email standards, ISDN (a worldwide digital network standard), Asynchronous Transfer Mode (ATM), and IBM's System Network Architecture (SNA). The section on the Web also contains a discussion of developing a Web page and supporting its use with client-side programs written in JavaScript and server-side programs written in C.

The questions at the end of each chapter are divided into two groups. The first group, Review Questions, contains questions for which answers can be obtained directly from the corresponding chapter. These questions encourage the reader to go back through the text and pick out what the author or instructor believes is important. I believe this method to be better pedagogically than simply listing important topics at the end, which encourages students to read textbooks as they would a novel—linearly. Learning complex material, however, often requires reading, rereading, and going back through the text to sort out and understand different concepts. A colleague related a conversation she had with a student having some difficulty with course work. The student had a part-time job during which he had some free time. Rather than fight boredom he decided to bring his textbook to work and read when he had the opportunity. Later in the semester his performance improved, and he related to the instructor that after reading the material four or five times, it actually began to make sense.

Review questions are not enough though. The second group, Exercises, contains questions that challenge readers to apply what they have learned and to compare, make logical deductions, and consider alternatives. The answers are not always simply stated and may be more elusive but that's typical of real problems.

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Finally, to those who will eventually read this text, I would very much appreciate your opinion. Please feel free to send any comments to William Shay, Department of Information and Computing Sciences, University of Wisconsin-Green Bay, Green Bay, WI 54311-7001, or via email at shayw@uwgb.edu.

William A. Shay

CONTENTS

CHAPTER 1

INTRODUCTION TO COMMUNICATIONS, STANDARDS, AND PROTOCOLS

The love of learning, the sequestered nooks, And all the sweet serenity of books.
—**Henry Wadsworth Longfellow** (1807–1882), U.S. poet

1.1 WHY STUDY COMMUNICATIONS?

Why should we study computer and data communications? The many reasons range from "It is an absolutely fascinating field" to "I have to know how to connect my PC to the company's network." But one of the most compelling reasons is that communication technology has invaded virtually every aspect of daily life, from professional and educational uses to purely recreational ones. It has become so pervasive that we either take it for granted or are simply not aware of its applications.

A BRIEF HISTORY

The field of communications is certainly not new: People have been communicating since early humans grunted and scratched pictures on cave walls. For thousands of years people communicated using little more than words, parchments, stone tablets, and smoke signals. The primary forms of sending information were based on the auditory and visual senses. You either heard someone speaking or saw the letters and symbols that defined a message.

Communications changed drastically in 1837, when Samuel Morse invented the telegraph. This invention made it possible to send information using electrical impulses over a copper wire. Messages were sent by translating each character into a sequence of long or short electrical impulses (or in less technical terms, dots and dashes) and transmitting them. This association of characters with electrical impulses was called the **Morse code.** The ability to send information with no