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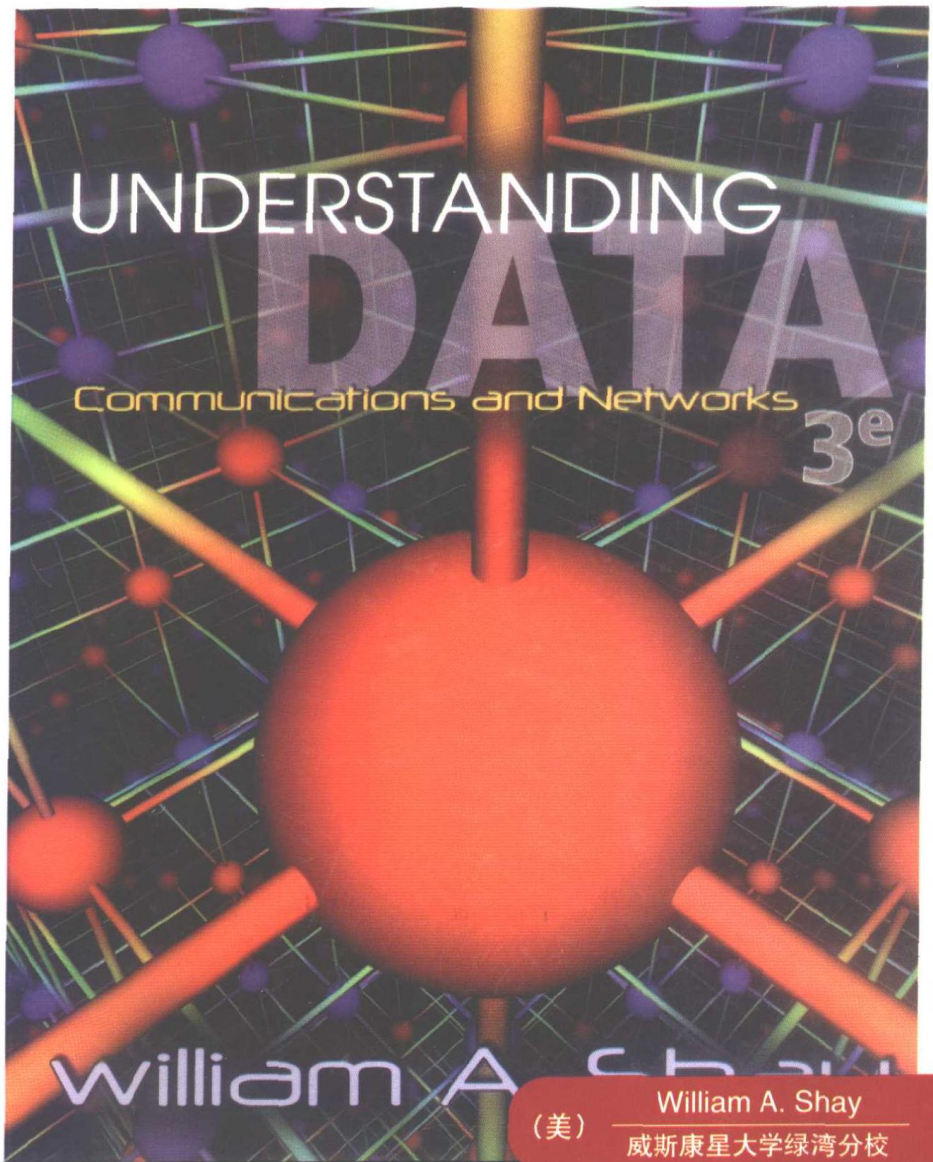
（英文版·第3版）



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数据通信与网络教程

（英文版·第3版）

Understanding Data Communications and Networks

(Third Edition)

(美) William A. Shay
威斯康星大学绿湾分校 著

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出版者的话

文艺复兴以降，源远流长的科学精神和逐步形成的学术规范，使西方国家在自然科学的各个领域取得了垄断性的优势；也正是这样的传统，使美国在信息技术发展的六十多年间名家辈出、独领风骚。在商业化的进程中，美国的产业界与教育界越来越紧密地结合，计算机学科中的许多泰山北斗同时身处科研和教学的最前线，由此而产生的经典科学著作，不仅擘划了研究的范畴，还揭橥了学术的源变，既遵循学术规范，又自有学者个性，其价值并不会因年月的流逝而减退。

近年，在全球信息化大潮的推动下，我国的计算机产业发展迅猛，对专业人才的需求日益迫切。这对计算机教育界和出版界都既是机遇，也是挑战；而专业教材的建设在教育战略上显得举足轻重。在我国信息技术发展时间较短、从业人员较少的现状下，美国等发达国家在其计算机科学发展的几十年间积淀的经典教材仍有许多值得借鉴之处。因此，引进一批国外优秀计算机教材将对我国计算机教育事业的发展起积极的推动作用，也是与世界接轨、建设真正的世界一流大学的必由之路。

机械工业出版社华章图文信息有限公司较早意识到“出版要为教育服务”。自1998年开始，华章公司就将工作重点放在了遴选、移译国外优秀教材上。经过几年的不懈努力，我们与Prentice Hall，Addison-Wesley，McGraw-Hill，Morgan Kaufmann等世界著名出版公司建立了良好的合作关系，从它们现有的数百种教材中甄选出Tanenbaum，Stroustrup，Kernighan，Jim Gray等大师名家的一批经典作品，以“计算机科学丛书”为总称出版，供读者学习、研究及庋藏。大理石纹理的封面，也正体现了这套丛书的品位和格调。

“计算机科学丛书”的出版工作得到了国内外学者的鼎力襄助，国内的专家不仅提供了中肯的选题指导，还不辞劳苦地担任了翻译和审校的工作；而原书的作者也相当关注其作品在中国的传播，有的还专诚为其书的中译本作序。迄今，“计算机科学丛书”已经出版了近百个品种，这些书籍在读者中树立了良好的口碑，并被许多高校采用为正式教材和参考书籍，为进一步推广与发展打下了坚实的基础。

随着学科建设的初步完善和教材改革的逐渐深化，教育界对国外计算机教材的需求和应用都步入一个新的阶段。为此，华章公司将加大引进教材的力度，在“华章教育”的总规划之下出版三个系列的计算机教材：除“计算机科学丛书”之外，对影印版的教材，则单独开辟出“经典原版书库”；同时，引进全美通行的教学辅导书“Schaum's Outlines”系列组成“全美经典学习指导系列”。为了保证这三套丛书的权威性，同时也为了更好地为学校和老师们服务，华章公司聘请了中国科学院、北京大学、清华大学、国防科技大学、复旦大学、上海交通大学、南京大学、浙江大学、中国科技大学、哈尔滨工业大学、西安交通大学、中国人民大学、北京航空航天大学、北京邮电大学、中山大学、解放军理工大学、郑州大学、湖北工学院、中国国

家信息安全测评认证中心等国内重点大学和科研机构在计算机的各个领域的著名学者组成“专家指导委员会”，为我们提供选题意见和出版监督。

这三套丛书是响应教育部提出的使用外版教材的号召，为国内高校的计算机及相关专业的教学度身订造的。其中许多教材均已为M. I. T.，Stanford，U.C. Berkeley，C. M. U. 等世界名牌大学所采用。不仅涵盖了程序设计、数据结构、操作系统、计算机体系结构、数据库、编译原理、软件工程、图形学、通信与网络、离散数学等国内大学计算机专业普遍开设的核心课程，而且各具特色——有的出自语言设计者之手、有的历经三十年而不衰、有的已被全世界的几百所高校采用。在这些圆熟通博的名师大作的指引之下，读者必将在计算机科学的宫殿中由登堂而入室。

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PREFACE

PURPOSE

The second edition of this book appeared five years ago, and much in the fields of data communications and computer networks has changed since then.

- Web-based software has become commonplace.
- The need for secure connections to Web sites is widespread.
- Security concerns and tools for dealing with security threats have increased.
- New encryption standards have been created, and old ones have been compromised.
- Quality-of-service issues have spawned the need for new protocols to run alongside existing ones.
- New connection technologies such as DSL, USB, and FireWire have become common.
- Ethernet networks have evolved to gigabit rates.
- Audio compression schemes such as MP3 and gaming have changed forever how people use the Internet.
- Wireless technologies have become a viable alternative for many.
- Protocols that were once common or thought to have promise for the future are rarely used.

We don't live in the same world that existed when the previous edition was published, and this new edition reflects these changes.

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 software design 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, network security, LAN protocols,

Internet-based protocols and applications, circuit-switching technologies, and Web applications. The goals of this book are to help the reader understand the following:

- The differences, advantages, and disadvantages of various transmission media
- Analog and digital signals, modulation and demodulation techniques, and how modulation devices such as modems, cable modems, and DSL modems work
- The effect of noise on transmissions and how protocols detect when information has been damaged
- How protocols respond to cases where noise causes information to be damaged or even lost
- Standards such as AES, ATM, DES, EIA-232, HDLC, IEEE 802.3, IEEE 802.5, IEEE 802.11, IPv6, JPEG, MP3, MPEG, OSI, SONET, TCP/IP, X.25, standards organizations, and why standards are needed
- Data compression techniques, types of data that can be compressed, and a comparison of the different methods used
- Worms, viruses, and other threats to networked computers
- The need for security and the effectiveness of various encryption methods
- Differences between public and private key encryption systems
- How to establish secure connections to remote sites
- The need for flow control and various ways of implementing it
- Local area network protocols and contention strategies for shared transmission media
- Wireless standards
- Methods of connecting local area networks
- Routing strategies
- The need for protocols to support real-time video applications and respond to quality-of-service issues
- How to design and set up a variety of 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

CONTENT AND ORGANIZATION

Major changes have been made to the third edition. Some were based on comments I received from readers, and the rest on the evolution of technology. Many involve clarification of figures or an improved description of protocols. The rest involve expansion of topics that have become commonplace, inclusion of new developments, and the removal of old topics that no longer play a significant role in this field.

Perhaps the most obvious change is the restructuring of the book into thirteen chapters as follows:

Chapter 1 Introduction to Communications Standards and Protocols

Chapter 2 Transmission Media and Codes

Chapter 3	Analog and Digital Signals
Chapter 4	Making Connections
Chapter 5	Data Compression
Chapter 6	Data Integrity
Chapter 7	Data Security
Chapter 8	Flow Control
Chapter 9	Local Area Networks
Chapter 10	Connecting Networks
Chapter 11	Internet Protocols and Applications
Chapter 12	Internet Programming
Chapter 13	Circuit Technologies

This restructuring should provide the instructor better guidance in focusing on specific topics necessary to meet the needs of his or her course. Some of these chapters correspond to chapter subsets from the previous edition; some were formed by combining sections of different chapters from the previous edition, and of course many chapters contain a lot of new material. The most significant changes include new or expanded coverage of the following:

- Media, including conductive metals, optics, wireless, and satellite communications
- DSL technologies
- Universal Serial Bus (USB) and FireWire (IEEE 1394 standard) Protocols
- Synchronous Optical Network (SONET)
- Arithmetic, facsimile, and MP3 compression techniques
- Advanced Encryption Standard (AES) and the Rijndael Algorithm
- Pretty Good Privacy security program
- Secure Sockets Layer, Transport Layer Security, and X.509 Certificates
- Firewalls
- Security threats
- Ethernet, Fast Ethernet, and Gigabit Ethernet standards, and an overview of the 10-gigabit Ethernet standard
- 802.11 Wireless LAN standard
- Switched Ethernet
- Virtual LANs
- Layer 3 and 4 protocols, including classless interdomain routing, routing and routers, multicasting, quality-of-service issues, Real-Time Transfer Protocol, and IPSec
- Internet applications
- Project-based CGI programming, including working examples of a Web-based ordering system using Linux and Perl Scripts
- Frame Relay Protocol

Although it would be difficult (almost 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.

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, while the more theoretical material will challenge the more ambitious students. In addition, Chapter 12 presents 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. Chapters are summarized as follows.

Chapter 1 provides an introduction to the field, touching on current issues and applications in the field of communications and networks. It describes the need for standards, lists relevant standards organizations, and then summarizes a long-standing protocol model, the Open System Interconnect. It finishes with projections of what we might see in the future.

Chapter 2 presents different types of transmission media (cable, wired, wireless, satellite, optical fiber), their advantages and disadvantages, and various codes used to assign meaning to data. Chapter 3 develops analog and digital signal types, modulation techniques needed to convert between them, and the effect that noise has on bit rates. It also discusses modems, cable modems, and DSL technologies.

Chapter 4 focuses on making connections, namely transmission modes, communications carriers (telephone system, SONET, and T1), interface standards (EIA-232, USB, and FireWire), and how multiple devices access common media (multiplexing methods and various contention protocols).

Chapter 5 covers data compression techniques suited to compressing different types of data and how they exploit different types of redundancy in the data. Chapter 6 deals with the integrity of transmitted data and includes error detection and correction techniques such as parity, CRC, and Hamming codes.

Chapter 7 discusses data security, including encryption techniques (both public and private key), encryption standards, key-exchange algorithms, authentication methods, X.509 certificates and secure connections, firewalls, and various threats (viruses, worms, hackers, and denial of service attacks).

Chapter 8 introduces flow control algorithms that outline how devices handle an exchange of information and account for lost or damaged data. It also outlines some techniques used for the formal verification of protocol correctness. Chapter 9 then presents LAN protocols, including several flavors of Ethernet (original, Fast Ethernet, and Gigabit Ethernet), Token Ring, and the IEEE 802.11 Wireless LAN standard.

Chapter 10 is about the ways various networks can be connected. It covers layer 2 connections (bridges and switches), address learning, spanning tree algorithm, switched Ethernet, and VLANs. It also deals with layer 3 connections and discusses various routing algorithms (Dijkstra, Bellman-Ford, RIP, BGP, and more). It also describes problems caused by network congestion and deadlock.

Chapter 11 is the Internet chapter. Both versions 4 and 6 of the Internet Protocol are covered, as well as quality-of-service issues, multicasting, and other protocols designed to provide some real-time service requirements to the Internet. It also covers TCP (connection management, flow control, and congestion management) and concludes with an outline of several common Internet applications (Telnet, SSH, FTP, and SMTP).

Chapter 12 is for those who wish to build student projects into the course. It provides working examples of client/server applications. Examples include socket programming, CGI programming using C and Perl, and sample code that illustrates how file transfers, search engines, and online ordering systems work.

Chapter 13 deals with circuit-based technologies such as ISDN, X.25, Frame Relay, and ATM.

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 only summarizing 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.

INSTRUCTOR SUPPLEMENTS

- An *Instructor's Solutions Manual,* with answers to review questions and exercises, is available to qualified instructors from the publisher.
- Sample exams are available to qualified instructors upon request. (email: shayw@uwgb.edu).
- Instructional aids are available via the author's Web site, http://www.uwgb.edu/shayw/udcn3. These include book figures in pdf format, corrections of any

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errors detected after printing, all copies of program code described in Chapter 12, and numerous Web links to other resources, organized by chapter.

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An undertaking such as writing a text is rarely, if ever, an individual effort. Many people have contributed and have given me valuable ideas, information, and support during this project. I especially would like to recognize the following people, who provided valuable advice during the writing of the first two editions.

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BILL SHAY

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