

# 数据通信与网络

(英文版·第4版)

Behrouz A. Forouzan



## Data Communications and Networking

Fourth Edition

(美) Behrouz A. Forouzan 著  
迪 安 那 大 学



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China Machine Press



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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，还揭开了学术的源变，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、研究及度藏。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，有的还专程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。

权威的作者、经典的教材、一流的译者、严格的审校、精细的编辑,这些因素使我们的图书有了质量的保证,但我们的目标是尽善尽美,而反馈的意见正是我们达到这一终极目标的重要帮助。教材的出版只是我们的后续服务的起点。华章公司欢迎老师和读者对我们的工作提出建议或给予指正,我们的联系方式如下:

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To my wife, Faezeh, with love

Behrouz Forouzan

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# Preface

Data communications and networking may be the fastest growing technologies in our culture today. One of the ramifications of that growth is a dramatic increase in the number of professions where an understanding of these technologies is essential for success—and a proportionate increase in the number and types of students taking courses to learn about them.

## Features of the Book

Several features of this text are designed to make it particularly easy for students to understand data communications and networking.

### Structure

We have used the five-layer Internet model as the framework for the text not only because a thorough understanding of the model is essential to understanding most current networking theory but also because it is based on a structure of interdependencies: Each layer builds upon the layer beneath it and supports the layer above it. In the same way, each concept introduced in our text builds upon the concepts examined in the previous sections. The Internet model was chosen because it is a protocol that is fully implemented.

This text is designed for students with little or no background in telecommunications or data communications. For this reason, we use a bottom-up approach. With this approach, students learn first about data communications (lower layers) before learning about networking (upper layers).

### Visual Approach

The book presents highly technical subject matter without complex formulas by using a balance of text and figures. More than 700 figures accompanying the text provide a visual and intuitive opportunity for understanding the material. Figures are particularly important in explaining networking concepts, which are based on connections and transmission. Both of these ideas are easy to grasp visually.

### Highlighted Points

We emphasize important concepts in highlighted boxes for quick reference and immediate attention.



### ***Examples and Applications***

When appropriate, we have selected examples to reflect true-to-life situations. For example, in Chapter 6 we have shown several cases of telecommunications in current telephone networks.

### ***Recommended Reading***

Each chapter includes a list of books and sites that can be used for further reading.

### ***Key Terms***

Each chapter includes a list of key terms for the student.

### ***Summary***

Each chapter ends with a summary of the material covered in that chapter. The summary provides a brief overview of all the important points in the chapter.

### ***Practice Set***

Each chapter includes a practice set designed to reinforce and apply salient concepts. It consists of three parts: review questions, exercises, and research activities (only for appropriate chapters). Review questions are intended to test the student's first-level understanding of the material presented in the chapter. Exercises require deeper understanding of the material. Research activities are designed to create motivation for further study.

### ***Appendixes***

The appendixes are intended to provide quick reference material or a review of materials needed to understand the concepts discussed in the book.

### ***Glossary and Acronyms***

The book contains an extensive glossary and a list of acronyms.

## **Changes in the Fourth Edition**

The Fourth Edition has major changes from the Third Edition, both in the organization and in the contents.

### ***Organization***

The following lists the changes in the organization of the book:

1. Chapter 6 now contains multiplexing as well as spreading.
2. Chapter 8 is now totally devoted to switching.
3. The contents of Chapter 12 are moved to Chapter 11.
4. Chapter 17 covers SONET technology.
5. Chapter 19 discusses IP addressing.
6. Chapter 20 is devoted to the Internet Protocol.
7. Chapter 21 discusses three protocols: ARP, ICMP, and IGMP.
8. Chapter 28 is new and devoted to network management in the Internet.
9. The previous Chapters 29 to 31 are now Chapters 30 to 32.

## **Contents**

We have revised the contents of many chapters including the following:

1. The contents of Chapters 1 to 5 are revised and augmented. Examples are added to clarify the contents.
2. The contents of Chapter 10 are revised and augmented to include methods of error detection and correction.
3. Chapter 11 is revised to include a full discussion of several control link protocols.
4. Delivery, forwarding, and routing of datagrams are added to Chapter 22.
5. The new transport protocol, SCTP, is added to Chapter 23.
6. The contents of Chapters 30, 31, and 32 are revised and augmented to include additional discussion about security issues and the Internet.
7. New examples are added to clarify the understanding of concepts.

## **End Materials**

1. A section is added to the end of each chapter listing additional sources for study.
2. The review questions are changed and updated.
3. The multiple-choice questions are moved to the book site to allow students to self-test their knowledge about the contents of the chapter and receive immediate feedback.
4. Exercises are revised and new ones are added to the appropriate chapters.
5. Some chapters contain research activities.

## **Instructional Materials**

Instructional materials for both the student and the teacher are revised and augmented. The solutions to exercises contain both the explanation and answer including full colored figures or tables when needed. The Powerpoint presentations are more comprehensive and include text and figures.

## **Contents**

The book is divided into seven parts. The first part is an overview; the last part concerns network security. The middle five parts are designed to represent the five layers of the Internet model. The following summarizes the contents of each part.

### **Part One: Overview**

The first part gives a general overview of data communications and networking. Chapter 1 covers introductory concepts needed for the rest of the book. Chapter 2 introduces the Internet model.

### **Part Two: Physical Layer**

The second part is a discussion of the physical layer of the Internet model. Chapters 3 to 6 discuss telecommunication aspects of the physical layer. Chapter 7 introduces the transmission media, which, although not part of the physical layer, is controlled by it. Chapter 8 is devoted to switching, which can be used in several layers. Chapter 9 shows how two public networks, telephone and cable TV, can be used for data transfer.

### **Part Three: Data Link Layer**

The third part is devoted to the discussion of the data link layer of the Internet model. Chapter 10 covers error detection and correction. Chapters 11, 12 discuss issues related to data link control. Chapters 13 through 16 deal with LANs. Chapters 17 and 18 are about WANs. LANs and WANs are examples of networks operating in the first two layers of the Internet model.

### **Part Four: Network Layer**

The fourth part is devoted to the discussion of the network layer of the Internet model. Chapter 19 covers IP addresses. Chapters 20 and 21 are devoted to the network layer protocols such as IP, ARP, ICMP, and IGMP. Chapter 22 discusses delivery, forwarding, and routing of packets in the Internet.

### **Part Five: Transport Layer**

The fifth part is devoted to the discussion of the transport layer of the Internet model. Chapter 23 gives an overview of the transport layer and discusses the services and duties of this layer. It also introduces three transport-layer protocols: UDP, TCP, and SCTP. Chapter 24 discusses congestion control and quality of service, two issues related to the transport layer and the previous two layers.

### **Part Six: Application Layer**

The sixth part is devoted to the discussion of the application layer of the Internet model. Chapter 25 is about DNS, the application program that is used by other application programs to map application layer addresses to network layer addresses. Chapter 26 to 29 discuss some common applications protocols in the Internet.

### **Part Seven: Security**

The seventh part is a discussion of security. It serves as a prelude to further study in this subject. Chapter 30 briefly discusses cryptography. Chapter 31 introduces security aspects. Chapter 32 shows how different security aspects can be applied to three layers of the Internet model.

## **Online Learning Center**

The McGraw-Hill Online Learning Center contains much additional material. Available at [www.mhhe.com/forouzan](http://www.mhhe.com/forouzan). As students read through *Data Communications and Networking*, they can go online to take self-grading quizzes. They can also access lecture materials such as PowerPoint slides, and get additional review from animated figures from the book. Selected solutions are also available over the Web. The solutions to odd-numbered problems are provided to students, and instructors can use a password to access the complete set of solutions.

Additionally, McGraw-Hill makes it easy to create a website for your networking course with an exclusive McGraw-Hill product called PageOut. It requires no prior knowledge of HTML, no long hours, and no design skills on your part. Instead, PageOut offers a series of templates. Simply fill them with your course information and

click on one of 16 designs. The process takes under an hour and leaves you with a professionally designed website.

Although PageOut offers "instant" development, the finished website provides powerful features. An interactive course syllabus allows you to post content to coincide with your lectures, so when students visit your PageOut website, your syllabus will direct them to components of Forouzan's Online Learning Center, or specific material of your own.

## How to Use the Book

This book is written for both an academic and a professional audience. The book can be used as a self-study guide for interested professionals. As a textbook, it can be used for a one-semester or one-quarter course. The following are some guidelines.

- ☐ Parts one to three are strongly recommended.
- ☐ Parts four to six can be covered if there is no following course in TCP/IP protocol.
- ☐ Part seven is recommended if there is no following course in network security.

## Acknowledgments

It is obvious that the development of a book of this scope needs the support of many people.

### Peer Review

The most important contribution to the development of a book such as this comes from peer reviews. We cannot express our gratitude in words to the many reviewers who spent numerous hours reading the manuscript and providing us with helpful comments and ideas. We would especially like to acknowledge the contributions of the following reviewers for the third and fourth editions of this book.

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