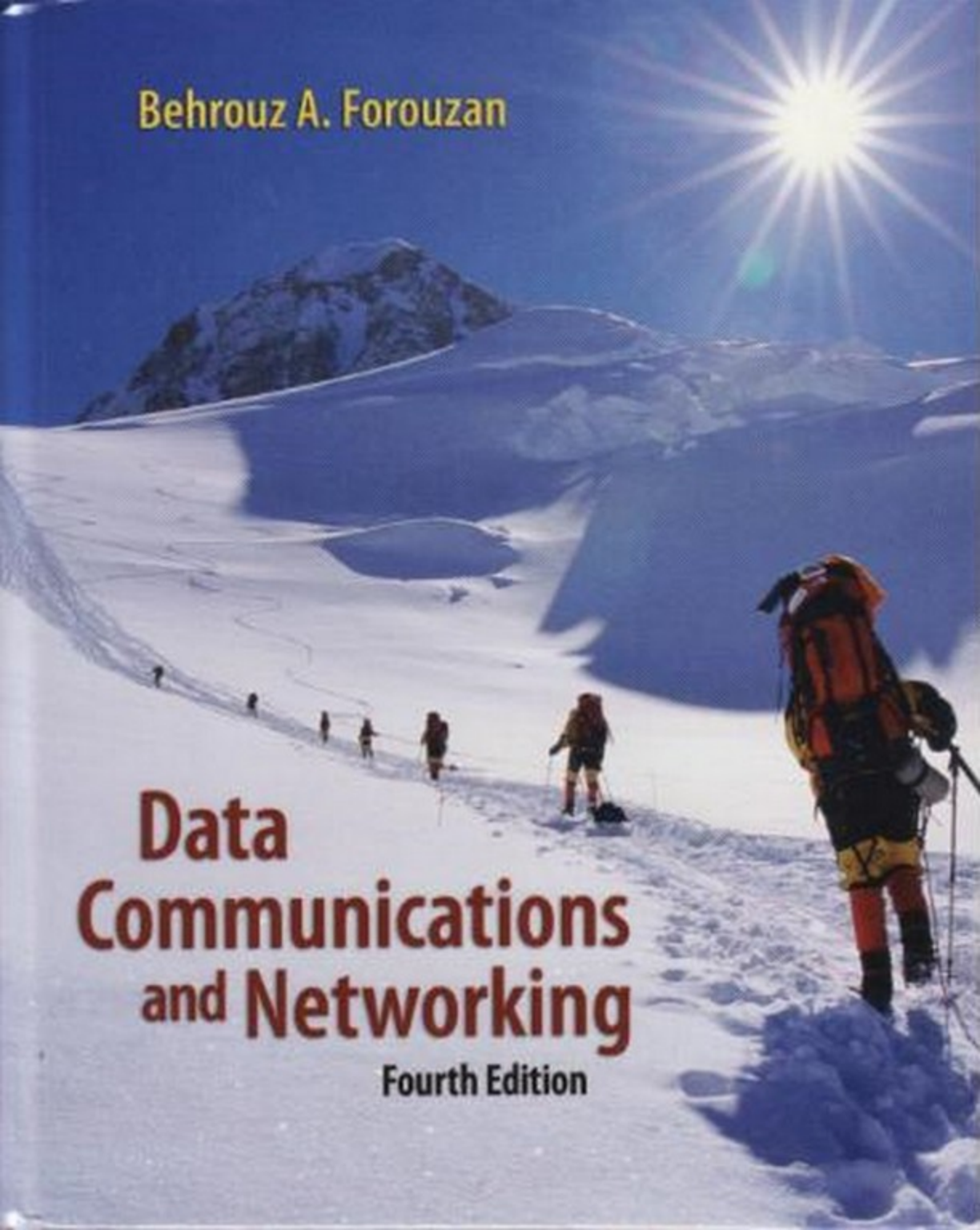
Behrouz A. Forouzan



Data Communications and Networking

Fourth Edition

Don't forget to check out the Online Learning Center, www.mhhe.com/forouzan for additional resources!

Instructors and students using *Data Communications and Networking,* Fourth Edition by Behrouz A. Forouzan will find a wide variety of resources available at the Online Learning Center, www.mhhe.comlforouzan

Instructor Resources

Instructors can access the following resources by contacting their McGraw-Hill Representative for a secure password.

- PowerPoint Slides. Contain figures, tables, highlighted points, and brief descriptions of each section.
- Complete Solutions Manual. Password-protected solutions to all end-of-chapter problems are provided.
- Pageout. A free tool that helps you create your own course website.
- Instructor Message Board. Allows you to share ideas with other instructors using the text.

Student Resources

The student resources are available to those students using the book. Once you have accessed the Online Learning Center, click on "Student Resources," then select a chapter from the drop down menu that appears. Each chapter has a wealth of materials to help you review communications and networking concepts. Included are:

- Chapter Summaries. Bulleted summary points provide an essential review of major ideas and concepts covered in each chapter.
- Student Solutions Manual. Contains answers for odd-numbered problems.
- Glossary. Defines key terms presented in the book.
- Flashcards. Facilitate learning through practice and review.
- Animated Figures. Visual representations model key networking concepts, bringing them to life.
- Automated Quizzes. Easy-to-use quizzes strengthen learning and emphasize important ideas from the book.
- Web links. Connect students to additional resources available online.

DATA COMMUNICATIONS AND NETWORKING

McGraw-Hill Forouzan Networking Series

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DATA COMMUNICATIONS AND NETWORKING

Fourth Edition

Behrouz A. Forouzan

DeAnza College

with

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To Iny wife, Faezeh, with love
Behrouz Forouzan

BRIEF CONTENTS

CONTENTS

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] 8 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. 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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PART 1

Overview

Objectives

Part 1 provides a general idea of what we will see in the rest of the book. Four major concepts are discussed: data communications, networking, protocols and standards, and networking models.

Networks exist so that data may be sent from one place to another-the basic concept of *data communications.* To fully grasp this subject, we must understand the data communication components, how different types of data can be represented, and how to create a data flow.

Data communications between remote parties can be achieved through a process called *networking,* involving the connection of computers, media, and networking devices. Networks are divided into two main categories: local area networks (LANs) and wide area networks (WANs). These two types of networks have different characteristics and different functionalities. The Internet, the main focus of the book, is a collection of LANs and WANs held together by internetworking devices.

Protocols and standards are vital to the implementation of data communications and networking. Protocols refer to the rules; a standard is a protocol that has been adopted by vendors and manufacturers.

Network models serve to organize, unify, and control the hardware and software components of data communications and networking. Although the term "network model" suggests a relationship to networking, the model also encompasses data communications.

Chapters

This part consists of two chapters: Chapter 1 and Chapter 2.

Chapter 1

In Chapter 1, we introduce the concepts of data communications and networking. We discuss data communications components, data representation, and data flow. We then move to the structure of networks that carry data. We discuss network topologies, categories of networks, and the general idea behind the Internet. The section on protocols and standards gives a quick overview of the organizations that set standards in data communications and networking.

Chapter 2

The two dominant networking models are the Open Systems Interconnection (OSI) and the Internet model (TCP/IP).The first is a theoretical framework; the second is the actual model used in today's data communications. **In** Chapter 2, we first discuss the OSI model to give a general background. We then concentrate on the Internet model, which is the foundation for the rest of the book.