

third edition

Data Communications and Networking



Behrouz A. Forouzan

DATA COMMUNICATIONS AND NETWORKING

Third Edition

Behrouz A. Forouzan

DeAnza College

with

Sophia Chung Fegan



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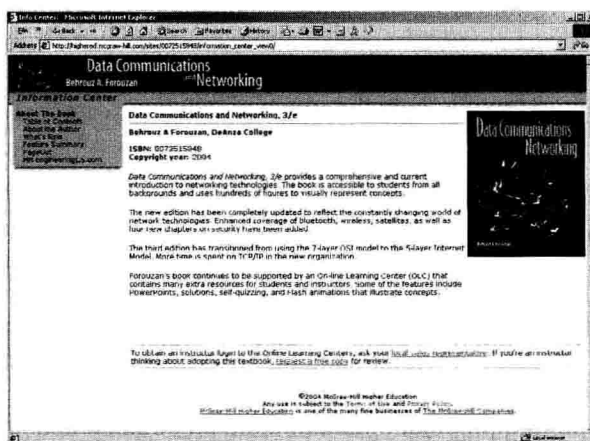
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For the student:

Approximately 80 automated quiz questions per chapter. This resource allows you to test your knowledge of concepts online. An immediate response will let you know how you are doing.

Animated figures from the book. Flash animations of selected figures from the book help networking concepts come to life. You can watch as the diagrams actively demonstrate their concepts.

Preface to the Third Edition

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. In this approach, students can learn first about data communications (lower layers) before learning about networking (upper layers). For example, students can learn about signaling, encoding, modulation, and error detection before learning about data transfer across the Internet. This eliminates the need for two courses: one for data communications and one for networking concepts.

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 are easy to grasp visually.

Highlighted Points

We have repeated important concepts in boxes for quick reference and immediate attention.

Examples and Applications

Whenever appropriate, we have included examples that illustrate the concepts introduced in the text. They also help students do the exercises at the end of each chapter. Also, we have added real-life applications throughout each chapter.

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 is 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, multiple-choice questions, and exercises. Review questions are intended to test the student's first-level understanding of the material presented in the chapter. Multiple-choice questions test the student's grasp of basic concepts and terminology. Exercises require deeper understanding of the material.

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.

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 of Data Communications and Networking

The first part gives a general overview of data communications and networking. It contains two chapters. 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. This part includes Chapters 3 to 9. 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. Chapters 8 and 9 introduce several protocols related mainly to the physical layer.

Part Three: Data Link Layer

The third part is devoted to the discussion of the data link layer of the Internet model. This part includes Chapters 10 to 18. Chapter 10 is devoted to error detection. Chapters 11, 12, and 13 discuss issues related to data link control. Some common data link protocols are also introduced in these three chapters. Chapters 14 through 16 are about LANs. LANs operate in the physical and data link layers. Chapter 14 is about the dominant wired LAN called Ethernet. Chapter 15 is about wireless LANs. Chapter 16 shows how to connect LANs to create backbone networks. Chapters 17 and 18 are about WANs, another technology that uses the physical and data link layers. Chapter 17 discusses mobile telephone systems and satellite systems. Chapter 18 explains switched WANs such as Frame Relay and ATM.

Part Four: Network Layer

The fourth part is devoted to the discussion of the network layer of the Internet model. This part includes Chapters 19 to 21. Chapter 19 is devoted to the concept and services of the network layer. This chapter also discusses routing and internetworking in the Internet. Chapter 20 covers the internetworking protocols in the Internet. The main internetworking protocol, IP, is discussed in some depth. Other protocols such as ARP, ICMP, and IGMP are discussed briefly to show how they support the operation of the IP protocol. Chapter 21 opens the discussion about routing protocols, both unicast and multicast. In unicast routing, the emphasis is mostly on concepts such as *distance vector routing*, *link state routing*, and *path vector routing*. However, RIP, OSPF, and BGP are also discussed in some depth as examples of unicast routing protocols. In multicast routing, the emphasis is on spanning tree methods. In addition, protocols such as DVMRP, MOSPF, CBT, PIM-DM, and PIM-SM are discussed to show real life applications. IGMP is introduced in this chapter to provide the necessary vehicle for multicast routing. At the end of the chapter, we introduce MBONE as a temporary multicast method.

Part Five: Transport Layer

The fifth part is devoted to the discussion of the transport layer of the Internet model. This part includes Chapters 22 and 23. Chapter 22 is an overview of the transport layer and discusses the services and duties of this layer. It also introduces the two transport layer protocols of the Internet, UDP and TCP. Chapter 23, although included in this part, discusses congestion control and quality of service, two issues related to the transport layer and the previous two layers. These topics are becoming increasingly important with the booming popularity of multimedia applications on the Internet.

Part Six: Application Layer

The sixth part is devoted to the discussion of the application layer of the Internet model. This part includes Chapters 24 and 28. Services in the application layer are the objective of the model. All the other layers exist so that users can access applications in this layer. We can not cover all applications in an introductory book like this; we have chosen some examples to show the concept. Chapter 24 defines the general idea, the client-server paradigm. We also briefly introduce the socket interface in this chapter as the prelude to client-server programming. 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 is about two popular applications, email and file transfer. We introduce the World Wide Web and the protocol that accesses it, HTTP, in Chapter 27. Chapter 28 is about multimedia. We introduce multimedia applications and the problems and issues involved. We also discuss some protocols that are used to provide Internet telephony, Internet teleconferencing, and audio/video streaming.

Part Seven: Network Security

The seventh part is devoted to a discussion of network security. Security today does not belong to just one specific layer; it is a concern of all layers. This part is a very brief discussion of the main ideas affecting security. Three chapters are included in this part. Chapter 29 discusses the general idea of cryptography. Symmetric (secret key) and asymmetric (public-key) cryptography are described without involving number theory. Chapter 30 introduces security services (message confidentiality, message authentication, message integrity, and message non-repudiation). It also shows some methods to authenticate users' access to the system. Finally there is a discussion on key management in both types of cryptography. Chapter 31 focuses on Internet security. It explores protocols used in the network, transport, and application layers. It also discusses firewalls and private virtual networks.

Online Supplementary Material at www.mhhe.com/forouzan

Online Learning Center

The McGraw-Hill Online Learning Center is a “digital cartridge” that contains the book’s pedagogy and supplements. As students read through *Data Communications and Networking*, they can go online to take self-grading quizzes. They also get appropriate access to lecture materials such as PowerPoint slides and animated figures from the book. 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 offers 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.

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