

# PREFACE

**T**echnologies related to data communication and networking may be the fastest growing in our culture today. The appearance of some new social networking applications every year is a testimony to this claim. People use the Internet more and more every day. They use the Internet for research, shopping, airline reservations, checking the latest news and weather, and so on.

In this Internet-oriented society, specialists need be trained to run and manage the Internet, part of the Internet, or an organization's network that is connected to the Internet. This book is designed to help students understand the basics of data communications and networking in general and the protocols used in the Internet in particular.

## Features

Although the main goal of the book is to teach the principles of networking, it is designed to teach these principles using the following goals:

### *Protocol Layering*

The book is designed to teach the principles of networking by using the protocol layering of the Internet and the TCP/IP protocol suite. Some of the networking principles may have been duplicated in some of these layers, but with their own special details. Teaching these principles using protocol layering is beneficial because these principles are repeated and better understood in relation to each layer. For example, although *addressing* is an issue that is applied to four layers of the TCP/IP suite, each layer uses a different addressing format for different purposes. In addition, addressing has a different domain in each layer. Another example is *framing and packetizing*, which is repeated in several layers, but each layer treats the principle differently.

### *Bottom-Up Approach*

This book uses a bottom-up approach. Each layer in the TCP/IP protocol suite is built on the services provided by the layer below. We learn how bits are moving at the physical layer before learning how some programs exchange messages at the application layer.

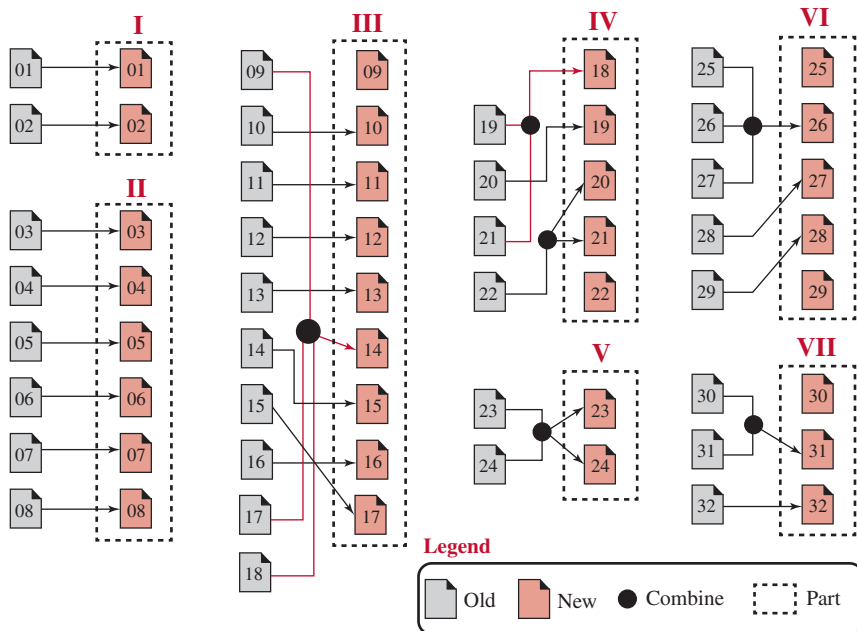
## Changes in the Fifth Edition

I have made several categories of changes in this edition.

### *Changes in the Organization*

Although the book is still made of seven parts, the contents and order of chapters have been changed. Some chapters have been combined, some have been moved, some are

new. Sometimes part of a chapter is eliminated because the topic is deprecated. The following shows the relationship between chapters in the fourth and fifth editions.



- Some chapters have been combined into one chapter. Chapters 9, 17, and 18 are combined into one chapter because some topics in each chapter have been deprecated. Chapters 19 and 21 are combined into Chapter 18. Chapters 25, 26, and 27 are also combined into one chapter because the topics are related to each other. Chapters 30 and 31 are also combined because they cover the same issue.
- Some chapters have been split into two chapters because of content augmentation. For example, Chapter 22 is split into Chapters 20 and 21.
- Some chapters have been first combined, but then split for better organization. For example, Chapters 23 and 24 are first combined and then split into two chapters again.
- Some chapters have been moved to better fit in the organization of the book. Chapter 15 now becomes Chapter 17. Chapters 28 and 29 now become Chapters 27 and 28.
- Some chapters have been moved to fit better in the sequence. For example, Chapter 15 has become Chapter 17 to cover more topics.
- Some chapters are new. Chapter 9 is an introduction to the data-link layer. Chapter 25 is an introduction to the application layer and includes socket-interface programming in C and Java. Chapter 30 is almost new. It covers QoS, which was part of other chapters in the previous edition.

### ***New and Augmented Materials***

Although the contents of each chapter have been updated, some new materials have also been added to this edition:

- ❑ *Peer-to-Peer paradigm* has been added as a new chapter (Chapter 29).
- ❑ *Quality of service (QoS)* has been augmented and added as a new chapter (Chapter 30).
- ❑ Chapter 10 is augmented to include the *forward error correction*.
- ❑ WiMAX, as the wireless access network, has been added to Chapter 16.
- ❑ The coverage of the transport-layer protocol has been augmented (Chapter 23).
- ❑ Socket-interface programming in Java has been added to Chapter 25.
- ❑ Chapter 28, on multimedia, has been totally revised and augmented.
- ❑ Contents of unicast and multicast routing (Chapters 20 and 21) have gone through a major change and have been augmented.
- ❑ The next generation IP is augmented and now belongs to Chapter 22.

### ***Changes in the End-Chapter Materials***

The end-chapter materials have gone through a major change:

- ❑ The practice set is augmented; it has many new problems in some appropriate chapters.
- ❑ Lab assignments have been added to some chapters to allow students to see some data in motion.
- ❑ Some applets have been posted on the book website to allow students to see some problems and protocols in action.
- ❑ Some programming assignments allow the students to write some programs to solve problems.

### ***Extra Materials***

Some extra materials, which could not be fit in the contents and volume of the book, have been posted on the book website for further study.

## **New Organization**

This edition is divided into seven parts, which reflects the structure of the Internet model.

### ***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. It is made of six chapters. 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.

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

The third part is devoted to the discussion of the data-link layer of the Internet model. It is made of nine chapters. Chapter 9 introduces the data-link layer. Chapter 10 covers error detection and correction, which can also be used in some other layers. Chapters 11 and 12 discuss issues related to two sublayers in the data-link layer. Chapters 13 and 14 discuss wired networks. Chapters 15 and 16 discuss wireless networks. Chapter 17 shows how networks can be combined to create larger or virtual networks.

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

The fourth part is devoted to the discussion of the network layer of the Internet model. Chapter 18 introduces this layer and discusses the network-layer addressing. Chapter 19 discusses the protocols in the current version. Chapters 20 and 21 are devoted to routing (unicast and multicast). Chapter 22 introduces the next generation protocol.

### ***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. Chapter 24 discusses the transport-layer protocols in the Internet: UDP, TCP, and SCTP.

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

Chapter 25 introduces the application layer and discusses some network programming in both C and Java. Chapter 26 discusses most of the standard client-server programming in the Internet. Chapter 27 discusses network management. Chapter 28 is devoted to the multimedia, an issue which is very hot today. Finally, Chapter 29 is an introduction to the peer-to-peer paradigm, a trend which is on the rise in the today's Internet.

### ***Part Seven: Topics Related to All Layers***

The last part of the book discusses the issues that belong to some or all layers. Chapter 30 discusses the quality of service. Chapters 31 and 32 discuss security.

### ***Appendices***

The appendices (available online at <http://www.mhhe.com/forouzan>) are intended to provide a quick reference or review of materials needed to understand the concepts discussed in the book. There are eight appendices that can be used by the students for reference and study:

- Appendix A: Unicode
- Appendix B: Positional Numbering System
- Appendix C: HTML, CSS, XML, and XSL
- Appendix D: A Touch of Probability
- Appendix E: Mathematical Review

- Appendix F: 8B/6T Code
- Appendix G: Miscellaneous Information
- Appendix H: Telephone History

### ***References***

The book contains a list of references for further reading.

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

The book contains an extensive glossary and a list of acronyms for finding the corresponding term quickly.

### ***Pedagogy***

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

### ***Visual Approach***

The book presents highly technical subject matter without complex formulas by using a balance of text and figures. More than 830 figures accompanying the text provide a visual and intuitive opportunity for understanding the material. Figures are particularly important in explaining networking concepts. For many students, these concepts are more easily grasped visually than verbally.

### ***Highlighted Points***

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

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

Whenever appropriate, I have included examples that illustrate the concepts introduced in the text. Also, I have added some real-life applications throughout each chapter to motivate students.

### ***End-of-Chapter Materials***

Each chapter ends with a set of materials that includes the following:

#### ***Key Terms***

The new terms used in each chapter are listed at the end of the chapter and their definitions are included in the glossary.

#### ***Recommended Reading***

This section gives a brief list of references relative to the chapter. The references can be used to quickly find the corresponding literature in the reference section at the end of the book.

#### ***Summary***

Each chapter ends with a summary of the material covered by that chapter. The summary glues the important materials together to be seen in one shot.

### ***Practice Set***

Each chapter includes a practice set designed to reinforce salient concepts and encourage students to apply them. It consists of three parts: quizzes, questions, and problems.

### ***Quizzes***

Quizzes, which are posted on the book website, provide quick concept checking. Students can take these quizzes to check their understanding of the materials. The feedback to the students' responses is given immediately.

### ***Questions***

This section contains simple questions about the concepts discussed in the book. Answers to the odd-numbered questions are posted on the book website to be checked by the student. There are more than 630 questions at the ends of chapters.

### ***Problems***

This section contains more difficult problems that need a deeper understanding of the materials discussed in the chapter. I strongly recommend that the student try to solve all of these problems. Answers to the odd-numbered problems are also posted on the book website to be checked by the student. There are more than 600 problems at the ends of chapters.

### ***Simulation Experiments***

Network concepts and the flow and contents of the packets can be better understood if they can be analyzed in action. Some chapters include a section to help students experiment with these. This section is divided into two parts: applets and lab assignments.

### ***Applets***

Java applets are interactive experiments that are created by the authors and posted on the website. Some of these applets are used to better understand the solutions to some problems; others are used to better understand the network concepts in action.

### ***Lab Assignments***

Some chapters include lab assignments that use Wireshark simulation software. The instructions for downloading and using Wireshark are given in Chapter 1. In some other chapters, there are a few lab assignments that can be used to practice sending and receiving packets and analyzing their contents.

### ***Programming Assignments***

Some chapters also include programming assignments. Writing a program about a process or procedure clarifies many subtleties and helps the student better understand the concept behind the process. Although the student can write and test programs in any computer language she or he is comfortable with, the solutions are given in Java language at the book website for the use of professors.

## **Audience**

This book is written for both academic and professional audiences. 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. It is designed for the last year of undergraduate study or the first year of graduate study. Although some problems at the end of the chapters require some knowledge of probability, the study of the text needs only general mathematical knowledge taught in the first year of college.

## **Instruction Resources**

The book contains complete instruction resources that can be downloaded from the book site <http://www.mhhe.com/forouzan>. They include:

### ***Presentations***

The site includes a set of colorful and animated PowerPoint presentations for teaching the course.

### ***Solutions to Practice Set***

Solutions to all questions and problems are provided on the book website for the use of professors who teach the course.

### ***Solution to Programming Assignments***

Solutions to programming assignments are also provided on the book website. The programs are mostly in Java language.

## **Student Resources**

The book contains complete student resources that can be downloaded from the book website <http://www.mhhe.com/forouzan>. They include:

### ***Quizzes***

There are quizzes at the end of each chapter that can be taken by the students. Students are encouraged to take these quizzes to test their general understanding of the materials presented in the corresponding chapter.

### ***Solution to Odd-Numbered Practice Set***

Solutions to all odd-numbered questions and problems are provided on the book website for the use of students.

### ***Lab Assignments***

The descriptions of lab assignments are also included in the student resources.

### ***Applets***

There are some applets for each chapter. Applets can either show the solution to some examples and problems or show some protocols in action. It is strongly recommended that students activate these applets.

### ***Extra Materials***

Students can also access the extra materials at the book website for further study.

## How to Use the Book

The chapters in the book are organized to provide a great deal of flexibility. I suggest the following:

- ❑ Materials provided in Part I are essential for understanding the rest of the book.
- ❑ Part II (physical layer) is essential to understand the rest of the book, but the professor can skip this part if the students already have the background in engineering and the physical layer.
- ❑ Parts III to VI are based on the Internet model. They are required for understanding the use of the networking principle in the Internet.
- ❑ Part VII (QoS and Security) is related to all layers of the Internet mode. It can be partially or totally skipped if the students will be taking a course that covers these materials.

## Website

The McGraw-Hill website 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.



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Behrouz A. Forouzan  
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