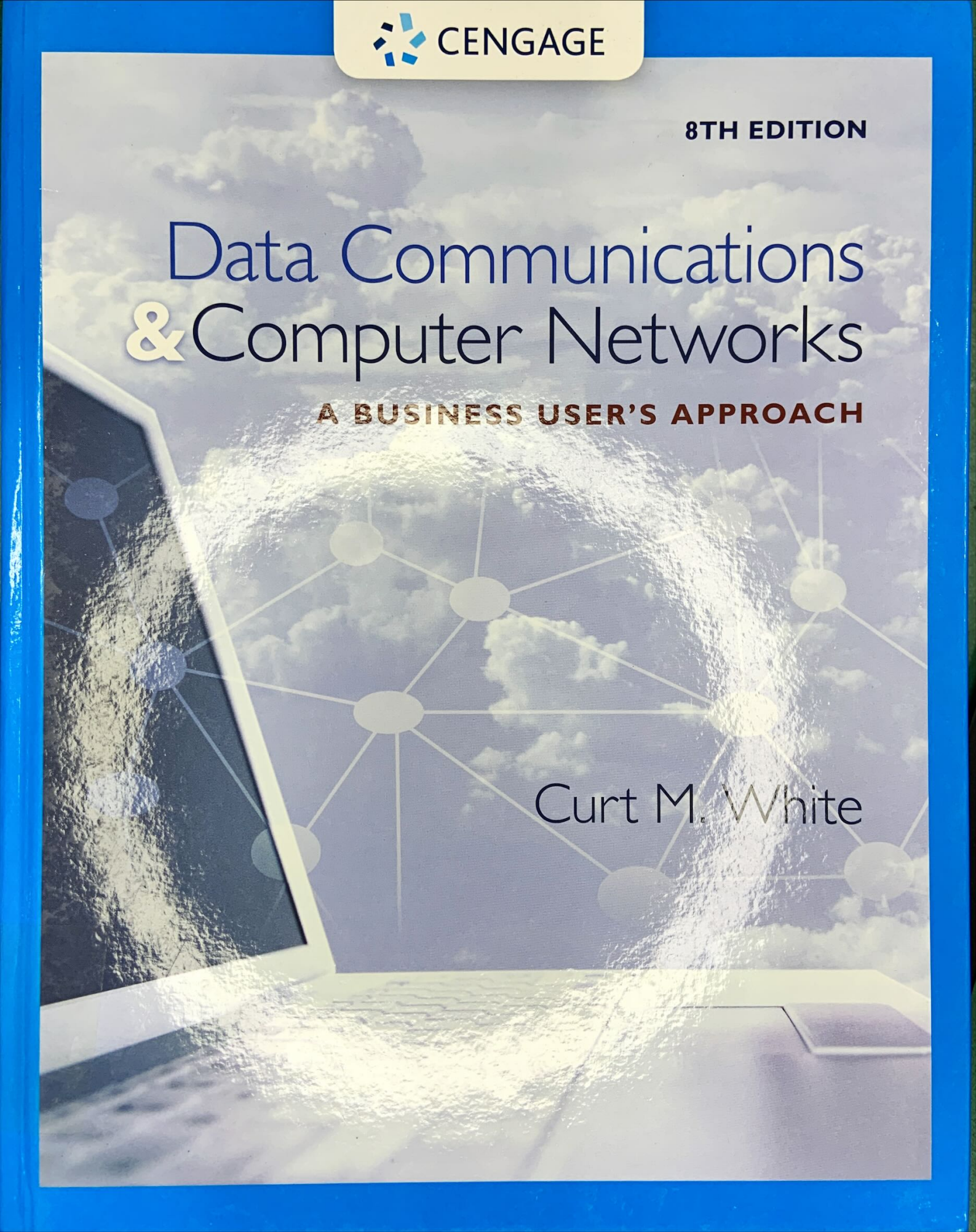
CENGAGE
8TH EDITION
Data Communications
& Computer Networks
A BUSINESS USER'S APPROACH
Curt M. White

EIGHTH EDITION

Data Communications & Computer Networks

A Business User's Approach

Curt M. White
DePaul University

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Preface

Today's business world could not function without data communications and computer networks. Most people cannot make it through an average day without coming in contact with or using some form of computer network. In the past, this field of study occupied the time of only engineers and technicians, but it now involves business managers, end users, programmers, and just about anyone who might use a telephone or computer! Because of this, *Data Communications & Computer Networks: A Business User's Approach*, Eighth Edition maintains a business user's perspective on this vast and increasingly significant subject.

In a generic sense, this book serves as an owner's manual for the individual computer user. In a world in which computer networks are involved in nearly every facet of business and personal life, it is paramount that each of us understands the basic features, operations, and limitations of different types of computer networks. This understanding will make us better managers, better employees, and simply better computer users. As a computer network *user*, you will probably not be the one who designs, installs, and maintains the network. Instead, you will have interactions—either direct or indirect—with the individuals who do. Reading this book should give you a strong foundation in computer networks, which will enable you to work effectively with network administrators, network installers, and network designers.

Here are some of the many scenarios in which the knowledge contained in this book would be particularly useful:

- You work for a company and must deal directly with a network specialist. To better understand the specialist and be able to conduct a meaningful dialog with him or her, you need a basic understanding of the many aspects of computer networks.
- You are a manager within a company and depend on a number of network specialists to provide you with recommendations for the company's network. You do not want to find yourself in a situation in which you must blindly accept the recommendations of network professionals. To ensure that you can make intelligent decisions regarding network resources, you need to know the basic concepts of data communications and computer networks.
- You work in a small company, in which each employee wears many hats. Thus, you may need to perform some level of network assessment, administration, or support.

- You have your own business and need to fully understand the advantages of using computer networks to support your operations. To optimize those advantages, you should have a good grasp of the basic characteristics of a computer network.
- You have a computer at home or at work, and you simply wish to learn more about computer networks.
- You have realized that to keep your job skills current and remain a key player in the information technology arena, you must understand how different computer networks work and become familiar with their advantages and shortcomings.

Audience

Data Communications & Computer Networks: A Business User's Approach, Eighth Edition is intended for a one-semester course in business data communications for students majoring in business, information systems, management information systems, and other applied fields of computer science. Even computer science departments will find the book valuable, particularly if the students read the Details sections accompanying most chapters. It is a readable resource for computer network users that draws on examples from business environments.

In a university setting, this book can be used at practically any level above the first year. Instructors who wish to use this book at the graduate level can draw on the many advanced projects provided at the end of each chapter to create a more challenging environment for the advanced student.

Defining Characteristics of This Book

The major goal of this eighth edition is the same as that of the first edition: to go beyond simply providing readers with a handful of new definitions, and instead introduce them to the next level of details found within the fields of computer networks and data communications. This higher level of detail includes the network technologies and standards necessary to support computer network systems and their applications. This book is more than just an introduction to advanced terminology. It involves introducing concepts that will help the reader achieve a more in-depth understanding of the often complex topic of data communications. It is hoped that once readers attain this in-depth understanding, the topic of networks and data communications will be less intimidating to them. To facilitate this understanding, the book strives to maintain high standards in three major areas: readability, a balance between the technical and the practical, and currency.

Readability

Great care has been taken to provide the technical material in as readable a fashion as possible. Each new edition has received a complete rewrite, in which every sentence has been reexamined in an attempt to convey the concepts as clearly as possible. Given the nature of this book's subject matter, the use of terminology is unavoidable. However, every effort has been made to present terms in a clear fashion, with minimal use of acronyms and even less use of computer jargon.

Balance between the Technical and the Practical

As in the very successful first edition, a major objective in writing *Data Communications & Computer Networks*, Eighth Edition was to achieve a good balance between the more technical aspects of data communications and its everyday practical aspects. Throughout each chapter, there are sections entitled "Details," which delve into the more specialized aspects of the topic at hand.

Should readers not have time to explore this technical information, they can skip these Details sections without missing out on the basic concepts of the topic.

Current Technology

Because of the fast pace of change in virtually all computer-related fields, every attempt has been made to present the most current trends in data communications and computer networks. Some of these topics include:

- More detail on arithmetic checksum
- An introduction to a number of new terms and concepts such as: zero client, Internet of Things, socially-engineered attack, malware, campus area network, near field communications, and Lightning interface
- The most recent Ethernet standard of 40 GbE and 100 GbE
- An update on Transport Layer Security (TLS) and Hypertext Transfer Protocol Secure (HTTPS)
- The most recent Wi-Fi standard for wireless local area networks: IEEE 802.11ac

It is also important to remember the many older technologies still in prevalent use today. Discussions of these older technologies can be found, when appropriate, in each chapter of this book.

Organization

The organization of *Data Communications & Computer Networks*, Eighth Edition roughly follows that of the TCP/IP protocol suite, from the physical layer to the upper layers. In addition, the book has been carefully designed to consist of 13 chapters in order to fit well into a typical 15- or 16-week semester (along with any required exams). Although some chapters may not require an entire week of study, other chapters may require more than one week. The intent was to design a balanced introduction to the study of computer networks by creating a set of chapters that is cohesive but at the same time allows for flexibility in the week-to-week curriculum.

Thus, instructors may choose to emphasize or de-emphasize certain topics, depending on the focus of their curriculums. If all 13 chapters cannot be covered during one term, it is possible for the instructor to concentrate on certain chapters. For example, if the curriculum's focus is information systems, the instructor might concentrate on Chapters 1, 3, 4, 6–8, 10, 12, and 13. If the focus is on the more technical aspects of computer networks, the instructor might concentrate on Chapters 1–11. It is the author's recommendation, however, that all chapters be covered in some level of detail.

Features

To assist readers in better understanding the technical nature of data communications and computer networks, each chapter contains a number of significant features. These features are based on older, well-tested pedagogical techniques as well as some newer techniques.

Opening Case

Each chapter begins with a short case or vignette that emphasizes the main concept of the chapter and sets the stage for exploration. These cases are designed to spark readers' interest and create a desire to learn more about the chapter's concepts.

Learning Objectives

Following the opening case is a list of learning objectives that should be accomplished by the end of the chapter. Each objective is tied to the main sections of

the chapter. Readers can use the objectives to grasp the scope and intent of the chapter. The objectives also work in conjunction with the end-of-chapter summary and review questions, so that readers can assess whether they have adequately mastered the material.

Details

Many chapters contain one or more Details sections, which dig deeper into a particular topic. Readers who are interested in more technical details will find these sections valuable. Since the Details sections are physically separate from the main text, they can be skipped if the reader does not have time to explore this level of technical detail. Skipping these sections will not affect the reader's overall understanding of a chapter's material.

In Action

At the end of each chapter's main content presentation is an In Action example that demonstrates an application of the chapter's key topic in a realistic environment. Although a number of In Action examples include imaginary people and organizations, every attempt was made to make the hypothetical scenarios as representative as possible of situations and issues found in real-world business and home environments. Thus, the In Action examples help the reader visualize the concepts presented in the chapter.

End-of-Chapter Material

The end-of-chapter material is designed to help readers review the content of the chapter and assess whether they have adequately mastered the concepts. It includes:

- A bulleted summary that readers can use as a review of the key topics of the chapter and as a study guide.
- A list of the key terms used within the chapter.
- A list of review questions that readers can use to quickly check whether or not they understand the chapter's key concepts.
- A set of exercises that draw on the material presented in the chapter.
- A set of Thinking Outside the Box exercises, which are more in-depth in nature and require readers to consider various possible alternative solutions by comparing their advantages and disadvantages.
- A set of Hands-On Projects that require readers to reach beyond the material found within the text and use outside resources to compose a response. Many of these projects lend themselves nicely to writing assignments. Thus, they can serve as valuable tools for instructors, especially at a time when more and more colleges and universities are seeking to implement "writing across the curriculum" strategies.

Glossary

At the end of the book, you will find a glossary that includes the key terms from each chapter.

Student Online Companion

The student online companion for this book can be found at *www.cengagebrain.com*, and search by title, author name, or ISBN. It contains a number of features, including:

- Hands-on labs that allow students to practice one or more of the chapter concepts
- A set of more in-depth discussions on older topics such as X.21, dial-up modems, ISDN, Dijkstra's algorithm, SDLC, and BISYNC
- Suggestions for further readings on numerous topics within the book

This Web site also presents visual demonstrations of many key data communications and networking concepts introduced in this text. A visual demonstration accompanies the following concepts:

- Chapter 1: Introduction to Computer Networks and Data Communications—Layer encapsulation example
- Chapter 4: Making Connections—RS-232 example of two modems establishing a connection
- Chapter 5: Making Connections Efficient: Multiplexing and Compression—Example of packets from multiple sources coming together for synchronous TDM, and a second example demonstrating statistical TDM
- Chapter 6: Errors, Error Detection, and Error Control—Sliding window example using ARQ error control
- Chapter 7: Local Area Networks: Part I—CSMA/CD example with workstations sending packets and collisions happening
- Chapter 7: Local Area Networks: Part I—Two LANs with a bridge showing how bridge tables are created and packets routed; a second example shows one LAN with a switch in place of a hub
- Chapter 9: Introduction to Metropolitan Area Networks and Wide Area Networks—Datagram network sending individual packets; and virtual circuit network first creating a connection and then sending packets down a prescribed path
- Chapter 10: The Internet—Domain Name System as it tries to find the dotted decimal notation for a given URL

Changes to the Eighth Edition

In order to keep abreast of the changes in computer networks and data communications, this Eighth Edition has incorporated many updates and additions in every chapter, as well as some reorganization of sections within chapters. Here's a summary of the major concepts that can be found in each of the following chapters:

Chapter 1, Introduction to Computer Networks and Data Communications, introduces rewrite on the different types of computer networks, along with many of the major concepts that will be discussed in the following chapters, with an emphasis on the TCP/IP protocol suite followed by the OSI models. The topic of convergence has been introduced in this first chapter and will be revisited as needed in subsequent chapters.

Chapter 2, Fundamentals of Data and Signals, covers basic concepts that are critical to the proper understanding of all computer networks and data communications.

Chapter 3, Conducted and Wireless Media, introduces the different types of media for transmitting data. The topic of near field communications was introduced.

Chapter 4, Making Connections, discusses how a connection or interface is created between a computer and a peripheral device, with a stronger emphasis on the USB interface. The Apple Lightning interface was added to the other types of interfaces.

Chapter 5, Making Connections Efficient: Multiplexing and Compression, introduces the topic of compression. Lossless compression techniques such as run-length encoding are discussed, as well as lossy compression techniques such as MP3 and JPEG.

Chapter 6, Errors, Error Detection, and Error Control, explains the actions that can take place when a data transmission produces an error. The concept of arithmetic checksum, as it is used on the Internet, is included, and has been expanded in the edition.

Chapter 7, Local Area Networks: Part I, is devoted to the basic concepts of local area networks. These two chapters on local area networks have

been reorganized. The topics of minimum spanning tree, link aggregation, and quality of service were introduced in the previous edition. In this edition, we add to the list of Ethernet versions with 40 gigabit Ethernet and 100 gigabit Ethernet.

Chapter 8, Local Area Networks: Part II, introduces wireless local area networks and discusses the various network operating systems and other network software, with updated material on Microsoft, Linux, Unix, and the MAC OS X Server. The zero-client workstation was introduced along with the latest Wi-Fi version IEEE 802.11ac.

Chapter 9, Introduction to Metropolitan Area Networks and Wide Area Networks, introduces the basic terminology and concepts of both metropolitan area networks and wide area networks. Cloud computing is also introduced.

Chapter Ten, The Internet, delves into the details of the Internet, including TCP/IP, DHCP, ARP, MPLS, and DHCP. The new topic of the Internet of Things (IoT) was introduced.

Chapter 11, Voice and Data Delivery Networks, provides a detailed introduction to the area of telecommunications—in particular, networks that specialize in local and long-distance delivery of data. Frame relay, asynchronous transfer mode, and MPLS/VPN are presented as viable data link layer protocols.

Chapter 12, Network Security, covers the current trends in network security. The topics of malware, Transport Layer Security (TLS), and Hypertext Transfer Protocol Secure (HTTPS) were updated, and the concept of socially engineered attacks was introduced.

Chapter 13, Network Design and Management, introduces the systems development life cycle, feasibility studies, capacity planning, and baseline studies, and shows how these concepts apply to the analysis and design of computer networks.

Teaching Tools

The following supplemental materials are available when this book is used in a classroom setting. All of the teaching tools available with this book are provided to the instructor on a single CD-ROM. Many can also be found at the Cengage Web site (*login.cengage.com/sso*).

Electronic Instructor's Manual—The Instructor's Manual that accompanies this textbook includes additional instructional material to assist in class preparation, including Sample Syllabi, Chapter Outlines, Technical Notes, Lecture Notes, Quick Quizzes, Teaching Tips, Discussion Topics, and Key Terms.

ExamView®—This textbook is accompanied by ExamView, a powerful testing software package that allows instructors to create and administer printed, computer (LAN-based), and Internet exams. ExamView includes hundreds of questions that correspond to the topics covered in this text, enabling students to generate detailed study guides that include page references for further review. The computer-based and Internet testing components allow students to take exams at their computers and also save the instructor time by grading each exam automatically.

PowerPoint Presentations—This book comes with Microsoft PowerPoint slides for each chapter. These are included as a teaching aid for classroom presentation, to make available to students on the network for chapter review, or to be printed for classroom distribution. Instructors can add their own slides for additional topics they introduce to the class.

Acknowledgments

Producing a textbook requires the skills and dedication of many people. Unfortunately, the final product displays only the author's name on the cover and not the names of those who provided countless hours of input and professional advice.

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Curt M. White