大学计算机教育国外著名教材系列（影印版）

PEARSON Prentice Hall

BUSINESS DATA COMMUNICATIONS

FIFTH EDITION

数据通信

原理、技术与应用（第5版）

William Stallings 著

Pearson Education 清华大学出版社

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北京

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Original English language title from Proprietor's edition of the Work.

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北京市版权局著作权合同登记号　图字：01-2004-3856 号

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图书在版编目(CIP)数据

数据通信 = Business Data Communications：原理、技术与应用：第 5 版/(美)斯托林斯(Stallings, W.)著. —影印本. —北京：清华大学出版社，2005.7
(大学计算机教育国外著名教材系列)
ISBN 7-302-11152-9

Ⅰ. 数…　Ⅱ. 斯…　Ⅲ. 数据通信—高等学校—教材—英文　Ⅳ. TN919

中国版本图书馆 CIP 数据核字(2005)第 058939 号

出 版 者：清华大学出版社　　地　　址：北京清华大学学研大厦
　　http://www.tup.com.cn　　邮　　编：100084
　　社 总 机：010-62770175　　客户服务：010-62776969
印 刷 者：北京牛山世兴印刷厂
装 订 者：三河市春园印刷有限公司
发 行 者：新华书店总店北京发行所
开　　本：148×210　印张：18.625
版　　次：2005 年 7 月第 1 版　2005 年 7 月第1 次印刷
书　　号：ISBN 7-302-11152-9/TP·7368
印　　数：1～3000
定　　价：38.00 元

出 版 说 明

进入21世纪，世界各国的经济、科技以及综合国力的竞争将更加激烈。竞争的中心无疑是对人才的竞争。谁拥有大量高素质的人才，谁就能在竞争中取得优势。高等教育，作为培养高素质人才的事业，必然受到高度重视。目前我国高等教育的教材更新较慢，为了加快教材的更新频率，教育部正在大力促进我国高校采用国外原版教材。

清华大学出版社从1996年开始，与国外著名出版公司合作，影印出版了“大学计算机教育丛书(影印版)”等一系列引进图书，受到国内读者的欢迎和支持。跨入21世纪，我们本着为我国高等教育教材建设服务的初衷，在已有的基础上，进一步扩大选题内容，改变图书开本尺寸，一如既往地请有关专家挑选适用于我国高等本科及研究生计算机教育的国外经典教材或著名教材，组成本套“大学计算机教育国外著名教材系列(影印版)”，以飨读者。深切期盼读者及时将使用本系列教材的效果和意见反馈给我们。更希望国内专家、教授积极向我们推荐国外计算机教育的优秀教材，以利我们把“大学计算机教育国外著名教材系列(影印版)”做得更好，更适合高校师生的需要。

清华大学出版社

PREFACE

BACKGROUND

Four trends have made a solid understanding of the fundamentals of **data communications** essential to business and information management students:

- **The increasing use of data processing equipment.** As the cost of computer hardware has dropped, data processing equipment has become an increasingly important and pervasive part of the office, factory, and engineering environments.
- **The increasing use of distributed systems.** Dropping hardware costs have resulted in the increasing use of small systems, including servers, workstations, and personal computers. These systems are distributed throughout a business and must be interconnected to exchange messages, share files, and share resources, such as printers.
- **The increasing diversity of networking options.** The emergence of a broad range of local area network (LAN) standards plus the evolution of LAN technology have led to a broad, overlapping range of products for local area communications. Similarly, the planning for the next generation of telephone equipment and networks and the evolution of new transmission and networking technologies have led to a broad, overlapping range of options for long-distance communications.
- **The emergence of the Internet and the World Wide Web.** In a very short time, the Internet and especially the World Wide Web have attracted millions of business and personal users. No business can ignore the potential of this enormous facility.

As a result of these factors, business data communications courses have become common in business and information management sequences, and this book intends to address the needs for such a course. However, a focus on data communications is no longer enough.

Over the past twenty years, as data processing capability has been introduced into the office, data communications products and services have gradually assumed increasing importance. Now, technological developments and the widespread acceptance of standards are transforming the ways in which information is used to support the business function. In addition to the traditional communications requirements for voice and data (meaning text and numerical data), there is now the need to deal with pictorial images and video information. These four types of information (voice, data, image, and video) are essential to the survival of any business in today's competitive international environment. What is needed is a treatment not just of data communications but also of **information communications** for the business environment.

Information communications and computer networking have become essential to the functioning of today's businesses, large and small. Furthermore, they have become a major and growing cost to organizations. Management and staff need a thorough understanding of information communications in order to assess needs; plan for the introduction of products,

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services, and systems; and manage the systems and technical personnel that operate them. This understanding must comprise the following:

- **Technology:** The underlying technology of information communications facilities, networking systems, and communications software
- **Architecture:** The way in which hardware, software, and services can be organized to provide computer and terminal interconnection
- **Applications:** How information communications and networking systems can meet the requirements of today's businesses

APPROACH

The purpose of this text is to present the concepts of information communications in a way that relates specifically to the business environment and to the concerns of business management and staff. To this end, the book takes an approach based on requirements, ingredients, and applications:

- **Requirements:** The need to provide services that enable businesses to utilize information is the driving force behind data and information communications technology. The text outlines the specific requirements that this technology is intended to address. This linkage between requirements and technology is essential to motivate a text of this nature.
- **Ingredients:** The technology of information communications includes the hardware, software, and communications services available to support distributed systems. An understanding of this technology is essential for a manager to make intelligent choices among the many alternatives.
- **Applications:** Management and staff must understand not only the technology but also the way in which that technology can be applied to satisfy business requirements.

These three concepts structure the presentation. They provide a way for the student to understand the context of what is being discussed at any point in the text, and they motivate the material. Thus, the student will gain a *practical* understanding of business information communications.

An important theme throughout the book is the essential role of standards. The proliferation of personal computers and other computer systems inevitably means that the manager will be faced with the need to integrate equipment from a variety of vendors. The only way to manage this requirement effectively is through standards. And, indeed, increasingly vendors are offering products and services that conform to international standards. This text addresses some of the key groupings of standards that are shaping the marketplace and that define the choices available to the decision maker.

INTENDED AUDIENCE

This book is addressed to students and professionals who now have or expect to have some information communications management responsibility. As a full-time job, some readers may have or plan to have responsibility for management of the company's telecommunica-

tions function. But virtually all managers and many staff personnel will need to have a basic understanding of business information communications to perform their tasks effectively.

For students, this text is intended as an introductory course in information communications for business and information management students. It does not assume any background in data communications but does assume a basic knowledge of data processing.

The book is also intended for self-study and is designed for use as both a tutorial and a reference book for those already involved in business information communications.

PLAN OF THE TEXT

This text is a survey of the broad and fast-changing field of information communications. It is organized in such a way that new material is seen to fit into the context of the material already presented. By emphasizing requirements and applications as well as technology, the student is provided with motivation and a means of assessing the importance of a particular topic with respect to the whole. The book is divided into six parts:

1. **Requirements:** Defines the needs for information communications in the business environment. It discusses the way in which various forms of information are used and the need for interconnection and networking facilities. An examination of the nature and role of distributed data processing is the highlight of this first part.
2. **The Internet and Distributed Applications:** Provides an overview of the Internet and the basic protocols that are the foundation of the Internet and also addresses the critical issue of quality of service. This part also deals with the specific business applications that require information communications facilities and networks. This part presents key applications, such as electronic mail and the World Wide Web, and includes a discussion of client/server computing and intranets.
3. **Local Area Networks:** Explores the technologies and architectures that have been developed for networking over shorter distances. The transmission media, topologies, and medium access control protocols that are the key ingredients of a LAN design are explored and specific standardized LAN systems examined.
4. **Wide Area Networks:** Examines the internal mechanisms and user-network interfaces that have been developed to support voice, data, and multimedia communications over long-distance networks. The traditional technologies of packet switching and circuit switching are examined, as well as the more recent ATM and wireless WANs.
5. **Data Communications:** Deals with the basic technology of the communication of information. The emphasis is on digital communications techniques, since these are rapidly displacing analog techniques for all products and services related to information communications. Key topics include transmission media, data link control protocols, and multiplexing.
6. **Management Issues:** Deals with two key areas: network security and network management.

In addition, the book includes an extensive glossary, a list of frequently used acronyms, and a bibliography. Each chapter includes review questions, problems and suggestions for further reading. Finally, a number of real-world cases studies are sprinkled throughout the book.

NOTE TO THE INSTRUCTOR

The major goal of this text is to make it as effective a teaching tool for this exciting and fast-moving subject as possible. This goal is reflected both in the structure of the book and in the supporting material.

The book contains a number of features that provide strong pedagogical support for the instructor. Each chapter begins with a list of chapter objectives, which provides, in effect, an outline of the chapter and alerts the student to look for certain key concepts as the chapter is read. Key terms are introduced in boldface in the chapter, and all of the new key terms for that chapter are listed at the end of the chapter. Acronyms are highlighted and listed on the back endpaper; this is important because the field of information communications is loaded with acronyms. A glossary at the end of the book provides a handy summary of key terms. The summary at the end of each chapter highlights the key concepts and places them in the context of the entire book. In addition, there are questions and homework problems to reinforce and extend what has been learned. The book is also liberally supplied with figures and tables to enhance points made in the text.

Throughout the book a number of case studies are presented. These are not "made-up" or "toy" cases but actual cases reported in the literature. Each case is chosen to reinforce or extend concepts introduced prior to the case study.

The text is also accompanied by supplementary material that will aid the instructor. A solutions manual provides answers to all of the problems and questions at the end of each chapter. A test bank of additional problems is also available. PDF figures and PowerPoint slides are available on line and on a CD-ROM version of the instructor's manual.

TOP-DOWN AND BOTTOM-UP APPROACHES

The book is laid out to present the material in a top-down fashion. This has the advantage of immediately focusing on the most visible part of the material, the applications, and then seeing, progressively, how each layer is supported by the next layer down. This approach makes the most sense for many instructors and students. The application layer is the most visible layer to the student and typically provides the most interest. An understanding of the applications motivates the mechanisms found at the transport layer. The treatment of the application and transport layers enables the student to understand the many design issues at the internet layer, including quality of service and routing issues. Finally, computer networks and data link mechanisms can be treated.

Some readers, and some instructors, are more comfortable with a bottom-up approach. With this approach, each part builds on the material in the previous part, so that it is always clear how a given layer of functionality is supported from below. Accordingly, the book is organized in a modular fashion. After reading Part One, the other parts can be read in a number of possible sequences.

INTERNET SERVICES FOR INSTRUCTORS AND STUDENTS

There is a Web page for this book that provides support for students and instructors. The page includes links to relevant sites, transparency masters of figures in the book in PDF

(Adobe Acrobat) format, PowerPoint slides, and sign-up information for the book's Internet mailing list. The Web page is at WilliamStallings.com/BDC/BDC5e.html. An Internet mailing list has been set up so that instructors using this book can exchange information, suggestions, and questions with each other and with the author. As soon as typos or other errors are discovered, an errata list for this book will be available at WilliamStallings.com.

NOTE TO THE READER

In a book on this topic, for this sort of audience, it is tempting to launch immediately into a description of communications and networking technology and to examine and compare the various approaches. Certainly, this is an essential element of a book that deals with business information communications. However, we believe that this approach is inappropriate. The business reader wants, and rightly so, to see the technical material in the context of the needs of the business and the ways in which communications and networking technology support desired business functions. Thus this book begins by defining the requirements for information communications in business. The types of information and their utility are examined first. This sets the stage for a discussion of the applications that can meet those requirements and the role of the Internet in supporting the applications. We are then in a position to examine the communications networks, both LANs and WANs, that form the infrastructure for distributed applications and the network. Continuing in this top-down fashion, the book then examines fundamental communications technologies. Finally, security and network management issues are discussed. It is hoped that this strategy will make the material more comprehensible and provide a structure that is more natural to a reader with a business orientation.

WHAT'S NEW IN THE FIFTH EDITION

In the four years since the fourth edition of this book was published, the field has seen continued innovations and improvements. In this new edition, we try to capture these changes while maintaining a broad and comprehensive coverage of the entire field. To begin the process of revision, the fourth edition of this book was extensively reviewed by a number of professors who teach the subject and by professionals working in the field. The result is that, in many places, the narrative has been clarified and tightened, and illustrations have been improved. Also, a number of new "field-tested" problems have been added.

Beyond these refinements to improve pedagogy and user friendliness, there have been major substantive changes throughout the book. Highlights include the following:

- **Top-down organization:** The organization of the book has been radically changed in response to professors' inputs and to provide a greater emphasis on the Internet and on applications.
- **The Internet:** Considerable new material has been added on the organization and operation of the Internet.
- **LANs and WANs:** The fourth edition provided five chapters in one part covering networking. The fifth edition splits this material into two parts, providing greater detail and with an increased emphasis on wireless networks.

In addition, throughout the book, virtually every topic has been updated to reflect the developments in standards and technology that have occurred since the publication of the fourth edition.

ACKNOWLEDGMENTS

This new edition has benefited from review by a number of people, who gave generously of their time and expertise. The following people reviewed all or a large part of the manuscript: Ron Fulle (Rochester Institute of Technology), Rangadhar Dash (University of Texas–Arlington), Hugo Moortgat (San Francisco State), Pramod Pandya (Cal. State–Fullerton), Bongsik Shin (San Diego State University), and Zhangxi Lin (Tennessee Tech).

Bruce Hartpence (Department of Information Technology, Rochester Institute of Technology) authored the application notes at the end of each chapter and contributed a number of review questions and homework problems. Ric Heishman (Assistant Dean–Computer Science & Information Technology, Northern Virginia Community College) also contributed homework problems. Fernando Ariel Gont contributed a number of homework problems; he also provided detailed reviews of all of the chapters of the fifth edition.

Steven Kilby contributed the case study on ING Life, plus he contributed part of Chapter 4. Professor Varadharajan Sridhar of the Indian Institute of Management contributed the case study on Staten Island University Hospital.

Richard Van Slyke of Brooklyn Polytechnic Institute has made substantial contributions to the second and third editions of this book and was listed as a coauthor. Much of his contribution has been retained and revised.

Finally, I would like to thank the many people responsible for the publication of the book, all of whom did their usual excellent job. This includes the staff at Prentice Hall, particularly my editors Alan Apt and Toni Holm, their assistant Patrick Lindner, production manager Rose Kernan, and supplements manager Sarah Parker. Also, Jake Warde of Warde Publishers managed the reviews; and Patricia M. Daly did the copy editing.

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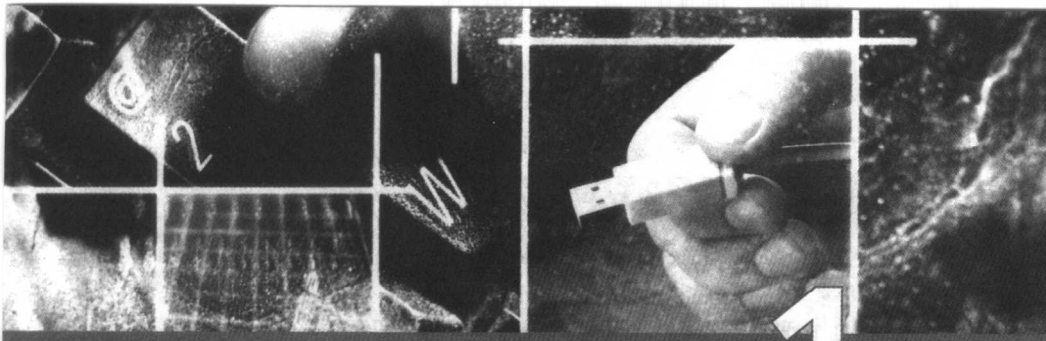

CHAPTER 1

INTRODUCTION

1.1 Information and Communication

1.2 Data Communications and Networking for Today's Enterprise

1.3 The Nature of Business Information Requirements

1.4 Distributed Data Processing

1.5 The Internet and Distributed Applications

1.6 Networks

1.7 The Transmission of Information

1.8 Management Issues

1.9 Standards

1.10 Internet Resources

1.11 Useful Publications

1.12 Review Questions

APPENDIX 1A Prefixes for Numerical Units

CHAPTER OBJECTIVES

After reading this chapter, you should be able to

- Understand the basic requirements for data communications and networking to support business information needs.
- See the "big picture" of the major topics discussed in the book.
- Appreciate the importance of the Internet and wireless communications in business planning.
- Understand the central role of standards in data communications and networking.

This introductory chapter begins with an overview of the role of data communications and networking in the enterprise. Then a brief discussion introduces each of the parts of this book.

1.1 INFORMATION AND COMMUNICATION

A confluence of computers, communication technologies, and demographics is transforming the way any enterprise conducts itself and carries out its organizational mandate. And it's happening fast. A business that ignores it will fall hopelessly to the rear in the global race for the competitive edge. At the heart of the transformation is information. No longer a byproduct—no longer, in many cases, even a cost center—the generation, storage, and movement of information have been made profitable by those companies that have taken up the technological challenge posed by the myriad machines that automate so much of our lives.

We are unquestionably dependent on computers and the communication devices and services that connect them. The number of computers and terminals at work in the world today is in the 100s of millions. It constitutes a critical mass: The overwhelming need of organizations and their workers now is for connectivity, for integration, for ease of access to information. So fundamental is information communication technology to business success that it is emerging as the foundation of a new strategy now taking shape in American businesses—using management structures to gain a competitive advantage.

As businesses are challenged by such forces as global competition, mergers, and acquisitions, time-tested management structures are putting a strain on corporate bottom lines. In response, companies are breaking down divisional walls and flattening top-heavy management pyramids to create new corporate structures that help them to compete more effectively. The technology that is making much of this possible is *networking*.

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