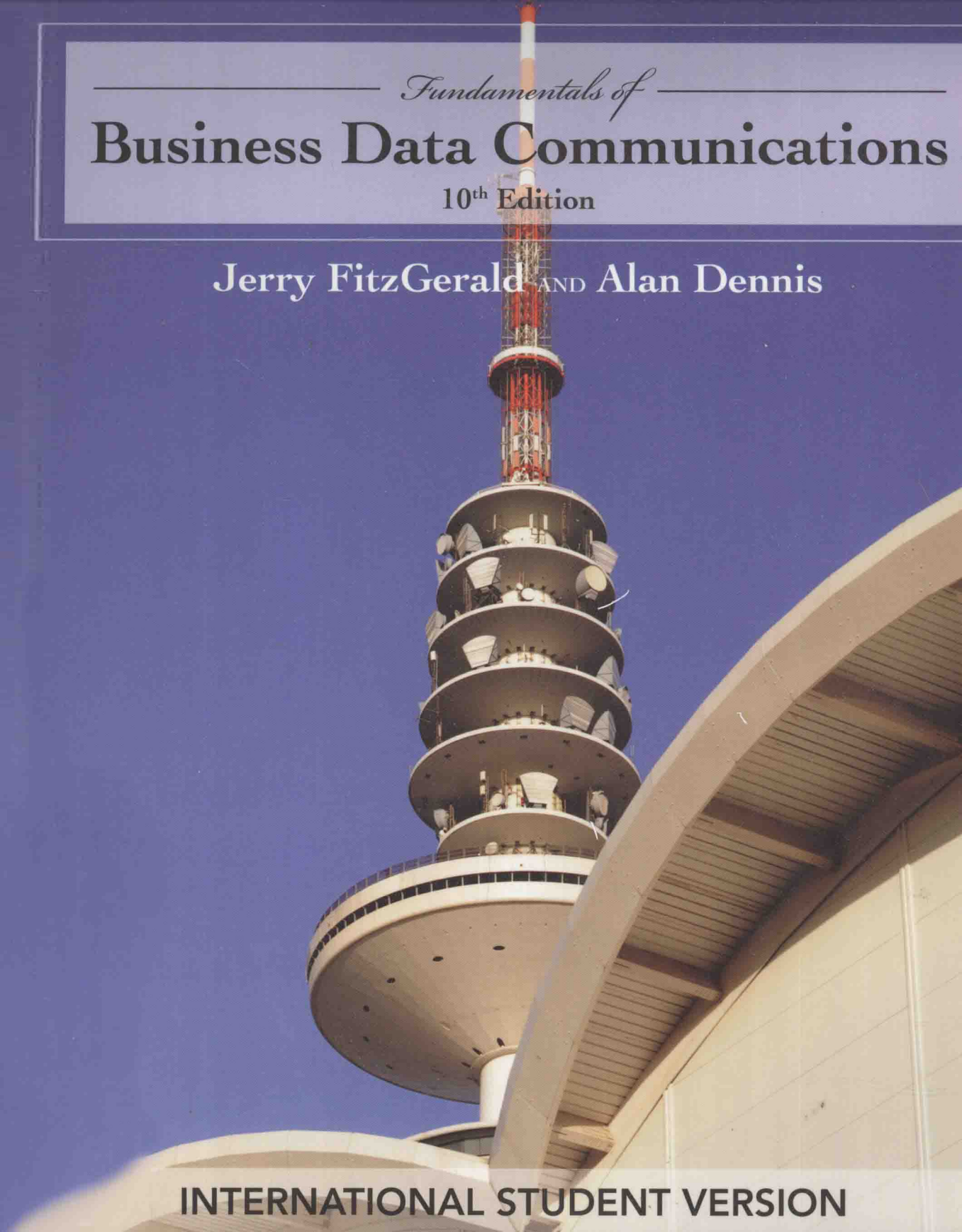
*Fundamentals of*

# Business Data Communications

10th Edition

Jerry FitzGerald AND Alan Dennis



INTERNATIONAL STUDENT VERSION

TENTH EDITION

# FUNDAMENTALS OF BUSINESS DATA COMMUNICATIONS

## International Student Version

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*Jerry FitzGerald & Associates*

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*To Kelly and Alec*



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# ABOUT THE AUTHORS

Professor Alan Dennis is professor of information systems in the Kelley School of Business at Indiana University and holds the John T. Chambers Chair in Internet Systems. The Chambers Chair was established to honor John Chambers, president and chief executive officer of Cisco Systems, the worldwide leader of networking technologies for the Internet.

Prior to joining Indiana University, Professor Dennis spent nine years as a professor at the University of Georgia, where he won the Richard B. Russell Award for Excellence in Undergraduate Teaching. Professor Dennis has a bachelor's degree in computer science from Acadia University in Nova Scotia, Canada, and an MBA from Queen's University in Ontario, Canada. His Ph.D. in management of information systems is from the University of Arizona. Prior to entering the Arizona doctoral program, he spent three years on the faculty of the Queen's School of Business.

Professor Dennis has extensive experience in the development and application of groupware and Internet technologies and developed a Web-based groupware package called Consensus @nyWARE, now owned by SoftBicycle Corporation. He has won seven awards for theoretical and applied research and has published more than 100 business and research articles, including those in *Management Science, MIS Quarterly, Information Systems Research, Academy of Management Journal, Organization Behavior and Human Decision Making, Journal of Applied Psychology, Communications of the ACM,* and *IEEE Transactions of Systems, Man, and Cybernetics.* His first book was *Getting Started with Microcomputers,* published in 1986. Professor Dennis is also an author (along with Professor Barbara Wixom of the University of Virginia and Professor Robby Roth of the University of Northern Iowa) of *Systems Analysis and Design: An Applied Approach,* also available from Wiley. Professor Dennis is the cochair of the Internet Technologies Track of the Hawaii International Conference on System Sciences. He has served as a consultant to BellSouth, Boeing, IBM, Hughes Missile Systems, the U.S. Department of Defense, and the Australian Army.

Dr. Jerry FitzGerald is the principal in Jerry FitzGerald & Associates, a firm he started in 1977. He has extensive experience in risk analysis, computer security, audit and control of computerized systems, data communications, networks, and systems analysis. He has been active in risk-assessment studies, computer security, audit reviews, designing controls into applications during the new system development process, data communication networks, bank wire transfer systems, and electronic data interchange (EDI) systems. He conducts training seminars on risk analysis, control and security, and data communications networks. Dr. FitzGerald has a Ph.D. in business economics and a master's degree in business economics from the Claremont Graduate School, an

MBA from the University of Santa Clara, and a bachelor's degree in industrial engineering from Michigan State University. He is a certified information systems auditor (CISA) and holds a certificate in data processing (CDP). He belongs to the EDP Auditors Association (EDPAA), the Institute of Internal Auditors (IIA), and the Information Systems Security Association (ISSA). Dr. FitzGerald has been a faculty member at several California universities and a consultant at SRI International.

His publications and software include *Business Data Communications: Basic Concepts, Security and Design,* 4th edition, 1993; *Designing Controls into Computerized Systems,* 2nd edition, 1990; RANK-IT: A Risk Assessment Tool for Microcomputers; CONTROL-IT: A Control Spreadsheet Methodology for Microcomputers; *Fundamentals of Systems Analysis: Using Structured Analysis and Design,* 3rd edition, 1987; *Online Auditing Using Microcomputers; Internal Controls for Computerized Systems;* and over 60 articles in various publications.

# PREFACE

Over the past few years, many fundamental changes have occurred in data communications and networking that will shape the future for decades to come. Networking applications such as the Internet and World Wide Web have exploded into the business world. High-speed modems providing megabit data rates (millions of bits per second) over regular telephone lines and cable TV circuits are widely available. New local area network (LAN) and backbone technologies providing gigabit (billions of bits per second) speeds are now available. Metropolitan area network (MAN) and wide area network (WAN) technologies providing terabit (trillions of bits per second) to petabit (quadrillions of bits per second) speeds are on the horizon. The integration of voice and data communication is moving rapidly.

Perhaps the most important change has been the recognition of the strategic importance of communications and networking in both the public and private sector. Today, almost all computers are networked. As we look back on the 1990s, we realize that the importance of the computer was surpassed by the importance of the network.

## PURPOSE OF THIS BOOK

Our goal is to combine the fundamental concepts of data communications and networking with practical applications. Although technologies and applications change rapidly, the fundamental concepts evolve much more slowly; they provide the foundation from which new technologies and applications can be understood, evaluated, and compared.

This book has two intended audiences. First and foremost, it is a university textbook. Each chapter introduces, describes, and then summarizes fundamental concepts and applications. Management Focus boxes highlight key issues and describe how networks are actually being used today. Technical Focus boxes highlight key technical issues and provide additional detail. Mini case studies at the end of each chapter provide the opportunity to apply these technical and management concepts. Moreover, the text is accompanied by a detailed Instructor's Manual that provides additional background information, teaching tips, and sources of material for student exercises, assignments, and exams. Finally, our Web page will continue to update the book.

Second, this book is intended for the professional who works in data communications and networking. The book has many detailed descriptions of the technical aspects of communications, along with illustrations where appropriate. Moreover, managerial, technical, and sales personnel can use this book to gain a better understanding of fundamental concepts and trade-offs not presented in technical books or product summaries.

## WHAT'S NEW IN THIS EDITION

The tenth edition has five major changes from the ninth edition. First, it includes numerous updates to technologies that have evolved and changed since the last edition went to press. The biggest change has been to the chapter on wireless LANs, as this has undergone major changes in just 2 years.

Second, we have added new hands-on activities to each chapter. The activities are designed to reinforce the key concepts in each chapter, as well as to provide an interesting, practical use of network technology. These activities could be used as demonstrations in class, lab exercises, or activities given as homework. In any event, we believe they will help students better understand key concepts.

Third, this edition includes updates to examples, questions, and exercises throughout the book. We believe these items help to improve students' understanding of key topics. We've also revised three crossword puzzles to the book because we've found that students enjoy puzzles, even those that help them learn.

Fourth, the chapter on network security has been reorganized and updated. This edition focuses on the two major aspects of security (business continuity and intrusion prevention) as well as risk analysis. The topics within the two major aspects have been reorganized to make them easier to understand and easier to teach.

Finally, what is just as important as what has been added is what has been removed. As new technologies arrive it is important to reduce complexity and bulk by removing older technologies that are fading from use. This edition has omitted legacy technologies such as ATM in the backbone, and has reduced the coverage of dial-up modems in favor of cable modems and DSL modems.

## Online Animations www.wiley.com/go/global/fitzgerald

For students and instructors, we're offering online animations that help students visualize basic data communications processes. These animations can be used in the classroom or as a study aid for students. To access the animations, go to the Student Resources site.

## Lab Exercises www.wiley.com/go/global/fitzgerald

This edition includes an online lab manual with many hands-on exercises that can be used in a networking lab. These exercises include configuring routers and servers and other additional practical topics. This edition also includes a series of OPNET labs; OPNET is a network simulation tool.

## Online Supplements for Instructors www.wiley.com/go/global/fitzgerald

Instructor's supplements include an Instructor's Manual that includes teaching tips, war stories and answers to end of chapter questions and Lecture Slides in PowerPoint for classroom presentations. Both are available to instructors adopting this text.

## ACKNOWLEDGMENTS

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# CONTENTS

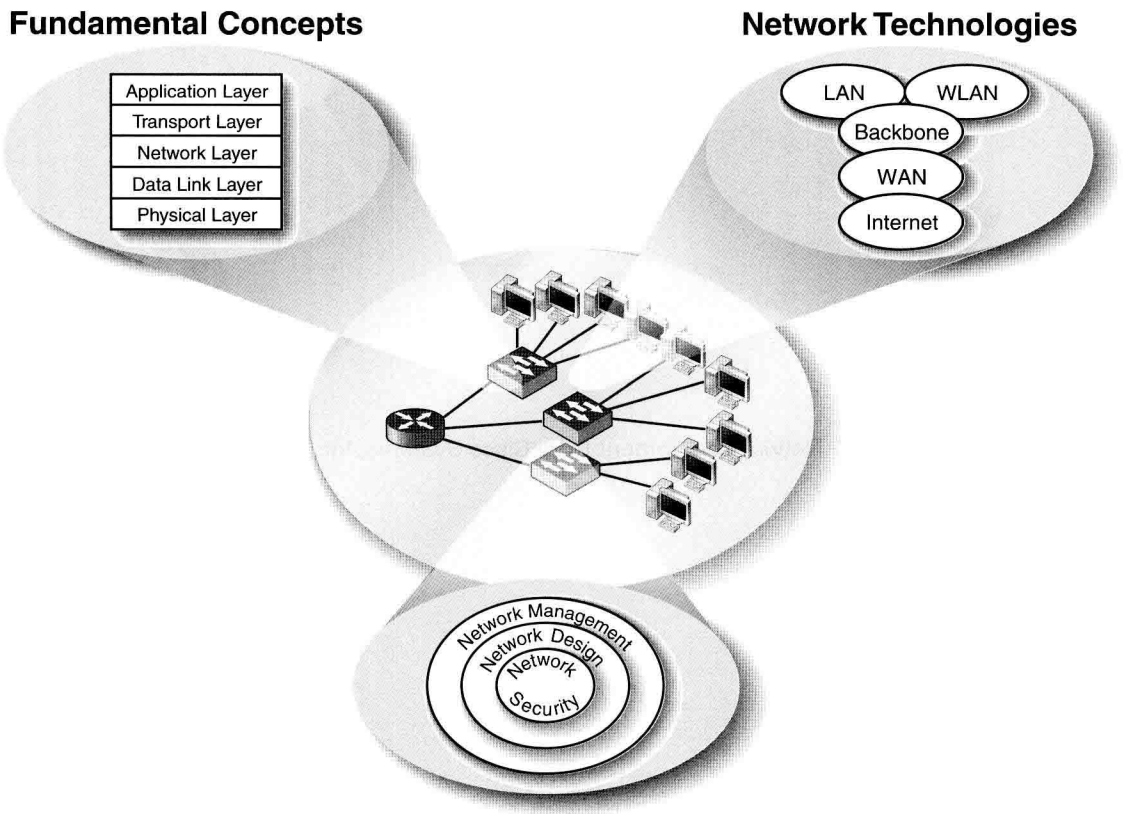
PART ONE

# INTRODUCTION

Courtesy Cisco Systems, Inc.

Network equipment from Cisco Systems, Inc.

# CHAPTER 1
# INTRODUCTION



THIS CHAPTER introduces the basic concepts of data communications and shows how we have progressed from paper-based systems to modern computer networks. It begins by describing why it is important to study data communications and how the invention of the telephone, the computer, and the Internet has transformed the way we communicate. Next, the basic types and components of a data communication network are discussed. The importance of a network model based on layers and the importance of network standards are examined. The chapter concludes with an overview of three key trends in the future of networking.

## OBJECTIVES ▼

- Be aware of the history of communications, information systems, and the Internet
- Be aware of the applications of data communication networks
- Be familiar with the major components of and types of networks
- Understand the role of network layers
- Be familiar with the role of network standards
- Be aware of three key trends in communications and networking

## CHAPTER OUTLINE ▼