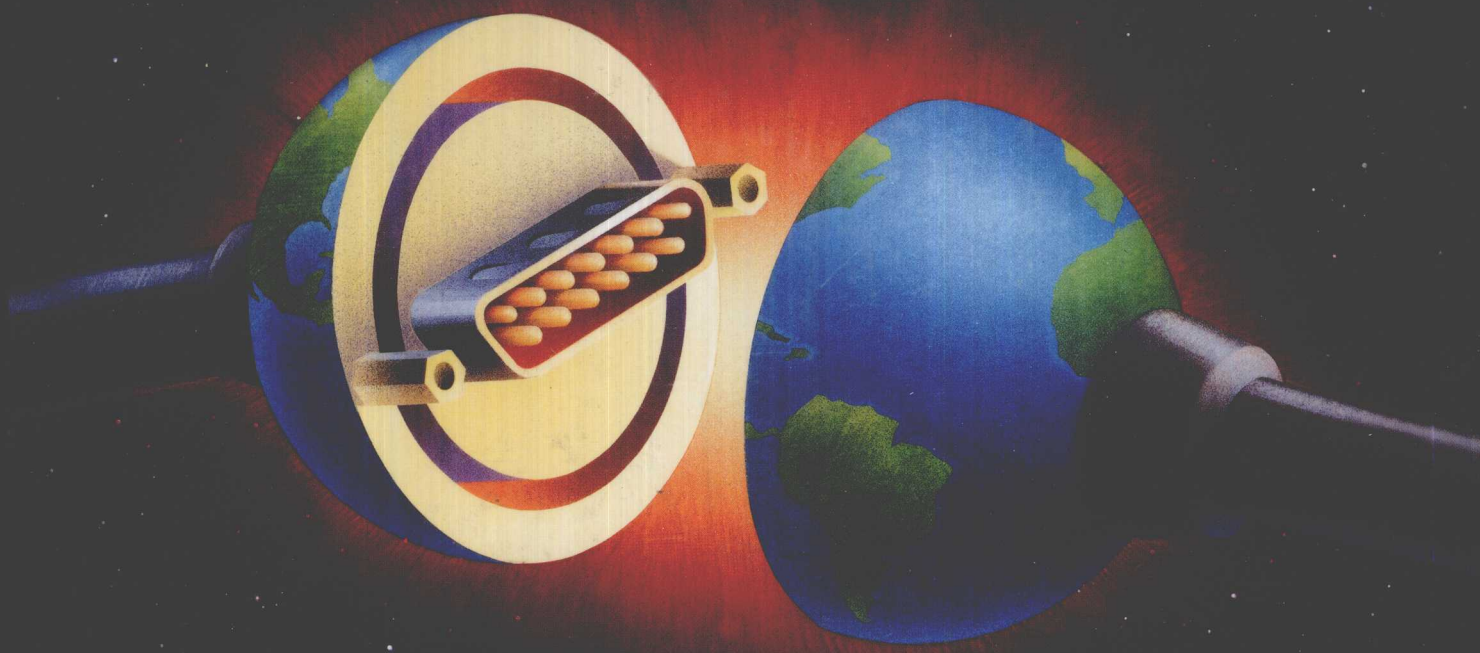
JAMES E. GOLDMAN ▪ PHILLIP T. RAWLES

APPLIED DATA COMMUNICATIONS

A BUSINESS-ORIENTED APPROACH



THIRD EDITION

APPLIED DATA COMMUNICATIONS

A Business-Oriented Approach

THIRD EDITION

James E. Goldman
Phillip T. Rawles
Purdue University

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PREFACE

NEW TO THE THIRD EDITION

The field of data communications continues to evolve at a rapid pace. To provide the reader with the most timely and important information possible, several changes have been made to the third edition while preserving those unique aspects of the first and second editions that contributed to its wide acceptance and popularity. Among the significant changes to the third edition are the following:

- All new case studies in every chapter.
- Increased technical depth as well as breadth of coverage throughout the text.
- Updated business implications of the Telecommunications Act of 1996.
- IT Economics orientation added to Chapter 11 (network development life cycle) including such topics as total cost of ownership, return on investment, and IT project portfolio management.
- Increased coverage of Unix including Linux.
- Increased coverage of wavelength division multiplexing and optical switching in Chapter 8 (WAN).
- Increased and updated coverage of wireless protocols (Bluetooth, WAP, 802.11, HiperLAN).
- More emphasis on organizing the entire text according to the OSI 7 layer model.

THE NEED FOR THIS BOOK

The field of information systems has undergone major paradigm shifts over the past several years from mainframe oriented, hierarchical information systems architectures through distributed, LAN-based, client-server information systems architectures, to browser/Internet-based information systems. However, this transition is far from complete as information systems architectures continue to evolve to include seamless integration with World Wide Web and Internet technologies such as application service providers as well as more transparent interoperability with legacy or mainframe systems. Today's resultant information systems architecture is comprised of a complicated array of interacting technologies combining elements of client-server, web-based, Internet, intranet, legacy applications, and database management systems. Data communications is the key building block to all of these interacting technologies.

Designing, implementing, and managing a successful data communications system requires sophisticated business-oriented analysis, design, and problem-solving skills. Furthermore, the collaborative computing and multimedia applications that are likely to be executed on these information systems are highly dependent on

properly designed networks for successful delivery of interactive content. The interdependency of application and network development required for successful deployment of distributed information systems is all too often overlooked by information systems professionals.

To effectively design today's highly integrated, distributed data communications networks, a comprehensive systems engineering approach that incorporated business analysis, application development, database systems integration, distributed network design, and structured technology analysis is required. Such a business-first, technology-last, top-down model was introduced in the first edition of *Applied Data Communications: A Business-Oriented Approach* by James E. Goldman of Purdue University. The highly successful second edition of *Applied Data Communications* and the subsequent texts *Local Area Networks* and *Client Server Information Systems* have solidified the top-down approach as the preferred design methodology for complex network-based information systems.

Unlike many of the currently available books and texts on data communications that seem to be either too broadly focused and conceptual or too narrowly focused and technical, this text strikes a balance between the two extremes while offering the reader a structured approach to data communications analysis and design from initial business considerations through final technology choices.

DESCRIPTION

Applied Data Communications: A Business-Oriented Approach, Third Edition, provides a thorough explanation of the analysis, design, integration, and technology choices involved with deploying, managing, and securing effective data communications systems, local area networks, internetworks, and wide area networks.

The text is flexibly organized so as to cater to a variety of course orientations. The general organization and key features of the text are as follows:

- Text is divided into four major sections to maximize flexible use by a wide variety of course orientations:
  - Part 1: Data and Voice Communications Fundamentals
  - Part 2: Local Area Networks
  - Part 3: Wide Area Networks and Internetworking
  - Part 4: Network Development and Administration
- Thirteen chapters of manageable length allow instructors to pick and choose chapters as appropriate for course content, focus, length, and intended audience.
- Written in a logical, problem-solving style applauded by both students and faculty from academia and industry.
- Text material is organized into overall architectures or models. By providing students with the "big picture" first, the text assists students in understanding how particular individual topics relate to other topics and to the overall scheme of things.
- Stresses analytical questioning and problem-solving skills as being key to successful design of information systems.

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- Provides working models into which students can organize their problem solving approach. These models are reinforced and used throughout the text. Examples include
  - Top down model
  - TCP/IP model
  - OSI model
- Business cases reprinted from professional periodicals are included in each chapter. Questions guide students toward development of analytical skills and business-oriented client-server information systems design capabilities.

The text equips students with real-world skills. In a fashion similar to Professor Goldman's previous texts, *Applied Data Communications: A Business Oriented Appraoch, Third Edition,* teaches students how to *do* data communications design rather than merely reading about it.

APPROACH

The reviews and current level of adoptions of the first two editions of *Applied Data Communications: A Business Oriented Appraoch,* the first two editions of *Local Area Networks: A Business Oriented Approach,* and *Client/Server Information Systems: A Business Oriented Approach* indicate that the same proven, practical approach should be applied to the third edition of this book. The text follows the top-down model, examining the many options, standards, interfaces, implications, advantages, and disadvantages in each of the top-down model's five layers:

- Business
- Application
- Data
- Network
- Technology

Concept roadmaps are located throughout the text that stress the relationship between chapters and their relationship to a data communications systems architecture as well as between topics within chapters.

Each chapter begins with an outline of new concepts introduced, previous concepts reinforced, and the learning objectives for that chapter.

Section and paragraph headings help students to organize and identify key concepts introduced in each chapter.

End of chapter material includes chapter summaries, key terms listings, abundant review questions, and activities and problems for active student learning.

As previously mentioned, business cases from professional periodicals are reprinted at the close of each chapter with associated analysis questions to be answered by students or used as the basis for classroom discussion.

A liberal use (two to three times as many as competing texts) of clear, concise diagrams add to the usability of the text and to the understanding of the students.

TARGET AUDIENCES/COURSES

Due to the modular nature of this text, a variety of audience/courses could be well served. Among the courses as potential adopters of this text are the following:

- An introductory level course on data communications: the practical nature of the text would be appealing as well as its broad coverage and architectural orientation. Advanced sections of the text could be easily avoided. This course could also serve as the foundation course for a concentration or degree program in data communications/telecommunications, and networking technology.
- A business-oriented course in data communications as part of an MBA program, especially those with concentration in MIS
- Continuing education or industrial seminars offered in data communications fundamentals for professional development.

SPECIAL FEATURES

Although some of these features have been mentioned previously, they are repeated here to stress the unique nature of this text as a purveyor of practical, business-oriented data communications analysis skills and problem-solving abilities rather than a mere collection of concepts and facts.

- Modular approach allows flexible use of text to fit instructor and course needs.
- Real business case studies stressing the business impact of data communications, thereby assisting students in sharpening their analysis and problem solving skills. Directed questions accompanying each case stimulate classroom discussion as well.
- "In Sharper Focus" sections highlight more detailed, more advanced, or background information for concepts introduced within a chapter. These sections can be included or excluded at the instructor's discretion.
- "Managerial Perspective" sections take a "bottom-line" approach to client server information systems analysis and design. The potential impact of management decisions in a variety of situations is highlighted in these sections that may be of particular interest to MBA audiences.
- "Applied Problem Solving" sections of chapters focusing on the use of analytical models for applied problem-solving activities are highlighted for the benefit of both instructors and students. By stressing problem-solving activities, students can be assured of learning how to *do* data communications analysis and design.
- Emphasizing the practical nature of the text, instances of practical advice or warnings are highlighted to call the reader's attention to important but often overlooked information.

OSI NETWORK REFERENCE MODEL ORGANIZATION

Previous editions of *Applied Data Communications* have attempted to strike a balance between stressing a systems integration approach to teaching data communications against a strict organization of material according to the seven layers of the OSI network reference mode. The authors feel that the key to comprehending data communications lies in the understanding of the interfaces between OSI layer components rather than in the categorization of components according to OSI layer. As a result, although the material in the text is loosely organized according to the layers of the OSI model, the key theme to the overall organization of the text is the appreciation of how data communications components must be integrated to produce a functional end-to-end system. As an aid for those instructors wishing to organize their course according to the OSI model, the table below provides a cross-reference.

OSI Model Layer	Topics	Chapter(s)
Layer 1-Physical	Media, signaling, modulation	3, 4, 6
Layer 2-Data Link	LAN architectures	5
Layer 3-Network	LAN protocols and NOS	7
Layer 4-Transport	LAN protocols, internetworking	7,9
Layer 5-Session	LAN protocols and NOS	7
Layer 6-Presentation	LAN protocols and NOS	7
Layer 7-Application	LAN protocols and NOS	7

SUPPLEMENT PACKAGE

A CD-ROM containing the Instructor's Resource Guide and PowerPoints is provided to adopters. The IRG contains thorough answers to all review questions featured at the end of each chapter, solutions to case study questions, and an abundant selection of additional questions in a variety of formats for each chapter. In addition, all illustrations are in PowerPoint format to expedite the production of transparencies and class notes to accompany the text.

ACKNOWLEDGMENTS

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CHAPTER 1

THE DATA COMMUNICATIONS INDUSTRY

Concepts Introduced

- Interacting Components of the Data Communications Industry
- Regulatory Process
- Deregulation and Divestiture
- Standards-Making Process
- Top-Down Model
- Data Communications as a Profession
- Data Communications and Information Systems
- OSI Model
- Internet Suite of Protocols Model
- I-P-O Model
- Protocols and Compatibility
- Job Skills
- Career Opportunities

OBJECTIVES

Upon successful completion of this chapter, you should:

1. Understand today's data communications industry as a system of interacting components.
2. Understand the current state of the data communications industry as well as the major issues facing each of the industry's constituent components.
3. Understand the challenges and solutions to business oriented data communications analysis.
4. Understand the importance of structured models such as the top-down model, the OSI model, and the I-P-O model to successful business oriented data communications analysis.
5. Understand the relationship of network analysis and design to information systems analysis and design.
6. Understand career opportunities in data communications and the job skills required to succeed in this field.

INTRODUCTION

Data communications is a field of study and an industry in a most rapid state of change. This chapter familiarizes the reader with the current state of the data communications industry and introduces the reader to a series of models or thinking frameworks. These frameworks provide a mechanism to organize thoughts, facts, requirements, solutions, and technology to overcome the challenges faced by today's data communications professionals. By mastering these thinking models, the reader will be developing a business-oriented, technology-independent process for the analysis and design of data communications systems. These models are used extensively throughout the remainder of the text to further familiarize the reader with them.

To better appreciate the wonderful professional opportunities available in data communications, it is important to understand how network analysis relates to information systems analysis in general, as well as the types of skills required for success in this most exciting field.

THE BEST WAY TO APPROACH DATA COMMUNICATIONS

Since the field of data communications is in a state of constant change—some would even refer to it as chaos—how can you study data communications and keep your sanity? The primary points to remember are the first two of Goldman's laws of data communications. (For a full listing of Goldman's laws, see Appendix A.)

- **Law 1:** You will never know all there is to know about data communications.
- **Law 2:** Be honest with yourself concerning what you don't know.

If you can accept these laws as facts, you will be well on your way to survival in this most exciting and rewarding field.

What, then, can you expect to master in a one-semester course in data communications based on this textbook? After successful mastery of the material contained in this text, you should be able to:

1. Hold an intelligent conversation on a variety of data communications topics.
2. Analyze networking requirements, evaluate networking options, ask appropriate networking questions, and know where to seek answers to those questions.

Understand, however, that you will not necessarily possess all of the answers. Nor will you necessarily be qualified to design networks. However, you will possess enough information to ask the essential questions and to keep yourself from getting in over your head.

What Is Data Communications?

Data communications can be viewed as a foreign language. Just as the mastery of any foreign language requires practice in speaking and writing that language, so it is

with data communications. As when learning a foreign language practice is a key factor for success. Try to speak the language as often as possible. Don't be afraid of making mistakes. Form informal study groups if possible and review key concepts by forcing yourself to speak data communications. You will be pleasantly surprised at the speed at which you become comfortable with this new language.

A classic definition of **data communications** might be "the encoded transmission of data via electrical, optical, or wireless means between computers or network processors." Traditionally, data communications is viewed as a subset of **telecommunications,** which encompasses the transmission of voice, data, and video. Throughout the text we'll see that the fields of telecommunications and data communications are becoming so intertwined that it's difficult, if not impossible, to differentiate between them. Voice, video, image, and fax transmission all currently fall within the domain of the data communications analyst.

In truth, any functional definition is really just a goal or outcome of a much larger process of interacting system components collectively known as the data communications industry. By breaking down a system-oriented representation of the data communications industry into constituent components, interaction among components and the resultant state of the data communications industry can be more easily understood.

THE DATA COMMUNICATIONS INDUSTRY

To be an effective participant in the data communications industry, it is important to understand the industry forces at work behind the scenes. In this manner, enlightened professionals can be proactive in their decision making rather than being at the mercy of an industry that at times seems to be beyond reason and out of control.

Figure 1-1 shows one way of breaking the complex world of data communications into a group of interacting components. As can be seen from the diagram, data

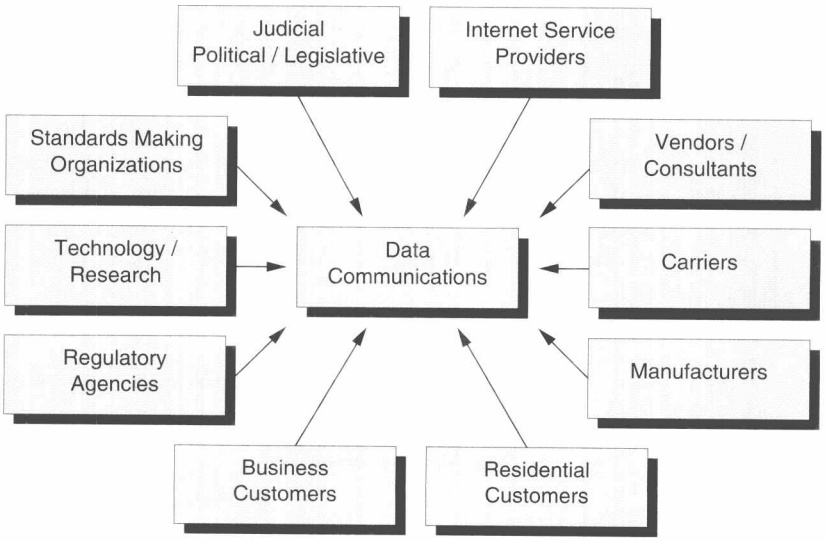

Figure 1-1 The Data Communications Industry: A Series of Interacting Components

communications is the sum total of the interacting components outlined. There is no distinct beginning or end. No single component is more important than another.

The Regulatory Process

Two tightly dependent components in a constant and ongoing state of change are the **regulatory** and **carrier** components. The regulatory component represents local, state, and federal agencies charged with regulating telecommunications, while the carrier component represents companies such as telephone and cable TV companies that sell transmission services.

To fully understand these two important components of today's data communications environment, we must focus on their interaction, those forces that join them and influence their present status. This interaction is a rather formal process of a series of proposals, also known as tariffs. Tariffs are submitted to state and federal regulatory agencies by carriers, and rulings and approvals are issued in return. This relationship is illustrated in Figure 1-2.

Basic Telecommunications Infrastructure To understand the changing regulatory relationship between different phone companies and their associated regulatory agencies, it is important to understand the physical layout of a basic telecommunications infrastructure and the names of the interacting components and service boundaries contained therein. Figure 1-3 illustrates the major components of the **public switched telephone network (PSTN)** required to support long distance dial-up service for data communications.

Local access transport areas (LATA) were established as a result of the breakup of AT&T to segment long-distance traffic. Originally all phone traffic within a LATA (intra LATA traffic) was reserved for the local phone company, also known as a **local exchange carrier (LEC).** Although recent rulings and legislation have made the distinction between intra-LATA and inter-LATA calls less significant, the LATA structure is still important to the overall telecommunications architecture.

A LATA is sometimes, but not always, equivalent to the geographic region covered by a given area code. However, there can be several LATAs per area code. Another key difference between LATAs and area codes is that a LATA can cross state boundaries, but an area code cannot. Figure 1-4 illustrates both the area codes and LATAs for the state of Indiana.

Residences or businesses are connected to the PSTN via circuits known as **local loops.** Local loops run between the residence or business location and the local **central office (CO),** a facility belonging to the local phone company in which calls are switched to their proper destination. Any phone traffic destined for locations outside of the local LATA must be handed off to the long-distance or **inter-exchange carrier**

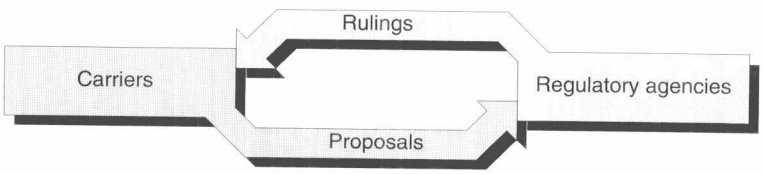

Figure 1-2 Systems Relationship of Regulatory Agencies and Carriers

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