BUSINESS DATA COMMUNICATIONS

SECOND EDITION

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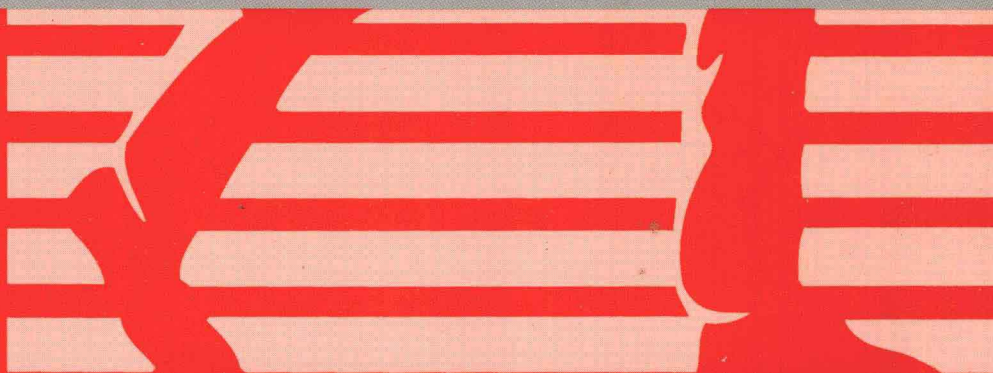
BUSINESS DATA COMMUNICATIONS

Second Edition

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IEEE	Institute of Electrical and Electronics Engineers
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
kbps	kilobits (thousands of bits) per second
LAN	Local Area Network
LATA	Local Access and Transport Area
LLC	Logical Link Control
MAC	Medium Access Control
Mbps	Megabits (millions of bits) per second
MIS	Management Information System
OAS	Office Automation System
OSI	Open Systems Interconnection
PAD	Packet-Assembler/Disassembler
PBX	Private Branch Exchange
PCM	Pulse-Code Modulation
PSK	Phase-Shift Keying
PTT	Postal, Telegraph, and Telephone
PM	Phase Modulation
RBOC	Regional Bell Operating Company
SNA	Systems Network Architecture
TDM	Time-Division Multiplexing
VAN	Value-Added Network

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HANDBOOK OF COMPUTER-COMMUNICATIONS STANDARDS VOLUME 3
THE TCP/IP PROTOCOL SUITE, SECOND EDITION

A description of the protocol standards that are mandated on all DOD computer procurements and are becoming increasingly popular on commercial local network products, including TCP, IP, FTP, SMTP, and TELNET. The network management standards, SNMP and CMOT, are also presented.

BUSINESS DATA COMMUNICATIONS

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To my loving wife, Tricia—W.S.

For Irene—R.V.S.

PREFACE

Background

Three 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 office, factory, and engineering environments.
- *The increasing use of distributed systems.* The dropping hardware costs have resulted in the increasing use of small systems, including minicomputers, microcomputer 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 break-up of AT&T, 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.

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

- *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, a 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 reader to understand the context of what is being discussed at any point in the text, and they motivate the material. Thus, readers will gain a *practical* understanding of business information communications.

An important element that helps to structure the presentation 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 responsibility. As a full-time job, some readers may have or plan to have responsibility for management of the company's telecommunications function. But virtually all managers and many staff personnel will need to have a basic understanding of business information communications to effectively perform their tasks.

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 both as a tutorial and a reference book for those already involved in business information communications.

Plan of the Text

This text deals with the broad and fast-changing field of information communications. It provides a survey of this field. 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 organization is as follows.

Part One, Requirements, defines the needs for information communications in the business environment. This part discusses the way in which various forms of information are used and the need for interconnection and networking facilities. It consists of two chapters:

- *Business Information:* Information is the key ingredient to the success of any business today. It is by far the most important resource of an organization. This chapter looks at the four types of information that, together, provide the basis for any business operation: voice, data

(text and numerical), image, and video. The issue of how these forms of information can be exploited in a business is examined.

- *Distributed Data Processing:* Business data processing support has moved from large centralized data processing centers to highly decentralized systems consisting of personal computers and other small and medium-size computers distributed throughout the organization. The motivations for a distributed approach are discussed, as well as potential pitfalls. The nature of distributed systems, from a user's point of view, is presented. Also, the key issue of micro-to-mainframe communications is introduced.

Part Two, Fundamentals, 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. It consists of three chapters:

- *Transmission and Transmission Media:* The most fundamental aspect of information communications technology is the actual transmission of electromagnetic signals that represent information. The characteristics of the transmission depends on the transmission medium used. The trade-offs among the various options are discussed.
- *Communication Techniques:* A variety of topics are covered in this chapter, including signal encoding, interfacing techniques, synchronous versus asynchronous transmission, error deduction and control, and link control.
- *Transmission Efficiency:* Transmission capacity remains an expensive resource and a major corporate cost item. To achieve efficiency in transmission, some form of line sharing, or multiplexing, is almost always used. This chapter looks at the various forms of multiplexing that are in common use. Another frequently-used technique for achieving efficiency is compression; this technique is also examined.

Part Three, Networking, examines the way in which communications facilities are organized into a network. There is a wide variety of options available to the manager and planner; this part intends to present the range of options and compare their strengths and weaknesses, so that the reader can make informed choices based on specific requirements. It consists of three chapters.

- *Wide-Area Networks:* Wide-area networks provide voice and data communications among geographically separated locations of a business and between that business and the rest of the world. The various public and private networking approaches that are available to the business are examined and compared. The chapter culminates with an examination of the integrated services digital network (ISDN).
- *Local-Area Networks:* An essential of any organization's data processing operation is a local-area network (LAN). A LAN is needed to interconnect equipment on the user's premises and to provide a

means to efficiently connect to outside services and other corporate sites. This chapter examines and compares the different technologies and products that provide local-area networking.

- *High-Speed Networking:* The reliance on traditional forms of wide-area networking to meet business needs is gradually giving way to these new high-speed alternatives. This chapter examines the key technologies and services becoming available, including frame relay, asynchronous transfer mode (ATM), and switched multi-megabit data service (SMDS). The chapter culminates with an examination of broadband ISDN (BISDN).

Part Four, Applications, deals with the specific business applications that require information communications facilities and networks. It consists of three chapters:

- *Open-Systems Interconnection:* To support the distributed applications discussed in this part, underlying communications software is needed. Increasingly, this software is being organized according to the Open Systems Interconnection (OSI) reference model and its related protocol standards. The key role of the Manufacturing Automation Protocol (MAP) and the Technical and Office Protocols (TOP) are explained. IBM's proprietary communications architecture, SNA, is also discussed.
- *Distributed Applications:* It is not sufficient to tie together data processing equipment with transmission lines or networks. Applications software is needed to provide key system-wide functions. This chapter looks at the most important of these applications, including electronic mail, file transfer, and document interchange.
- *Client/Server Computing:* Perhaps the most significant trend in information systems in recent years is the rise of client/server computing. This mode of computing is rapidly replacing both mainframe-dominated, centralized computing approaches and other distributed data processing approaches. Client/server computing at last provides the computing model that enables businesses to achieve productivity gains across all levels of the organization. This chapter provides an overview of the current state of client/server computing.

Part Five, Management Issues, examines some of the most important issues that confront the manager with respect to the in-house implementation or the purchase of networking and communications services. It consists of two chapters:

- *Network Management:* One of the most difficult tasks facing the manager is the management of networking facilities. This function is required even if these facilities are owned by another organization that leases capacity to the business.
- *Network Integrity:* Networks provide shared access. This immediately raises issues of security and privacy. This chapter looks at the

motivation for security mechanisms and examines the key approaches, including encryption and trusted systems.

Network Design and Performance Analysis: Effective design and analysis techniques are essential in planning, configuring, maintaining, and upgrading networks. This chapter describes procedures for setting up such processes.

Network Metrics: This chapter deals with how to measure success in the management activities discussed in this book and how to relate technology measures with measures of effective business function.

In addition, the book includes an extensive glossary, a list of frequently-used acronyms, and a bibliography. Each chapter includes problems and suggestions for further reading.

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 text itself 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 bold face in the chapter, and all of the new key terms for that chapter are listed at the end of the chapter. In addition, all new acronyms are highlighted and listed at the end of the chapter; this is important because the field of information communications, unfortunately, is loaded with acronyms. A glossary at the end of the book and list of acronyms in the end papers provide a handy summary of all key terms and acronyms. At the end of each chapter, there is a summary which 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, tables, and charts to enhance the 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 the concepts introduced prior to the case study.

Internet Services

An internet mailing list has been set up so that instructors using this book can change information, suggestions, and questions with each other and with the author. To subscribe, send a message to majordomo@prenhall.com with a message body of subscribe ws-bdc. To post a message, send to ws-lan@prenhall.com.

An errata list is available at hhtp://www.shore.net/~ws/welcome.html.

The Second Edition

In the 4 years since the first edition of this book, there have been many changes in the field of business data communications. In this new edition, we try to capture the most important of these changes, while maintaining a broad and comprehensive coverage of the entire field.

Two of the most significant developments, each of which is given an entire new chapter in this edition, are high-speed wide-area networks and client/server computing.

The availability of wide-area network services at very high data rates (ranging from 1 Mbps to hundreds of Mbps) constitutes a dramatic departure from the type of data networking facilities available until just a few years ago. Three new services—frame relay, switched multi-megabit data served (SMDS), and asynchronous transfer mode (ATM)—are providing the infrastructure to enable businesses to exploit the high-power personal computers and workstations and the high-speed local area networks (LANs) in such a way as to integrate data processing facilities on a national or even global level.

Perhaps even more important to business is the development of client/server computing. Despite the promise of widespread and significant productivity gains that were to come about as a result of the proliferation of personal computers and networks, those gains have been slow in arriving. Client/server computing has at last broken through the barriers that have prevented business users from truly exploiting information system technology. The result is that many organizations have transformed their way of doing business and achieved truly dramatic productivity gains in all areas of their companies.

Another significant change to the book is in Part 5, management issues. This portion of the book has been completely rewritten, reflecting the growing importance of such topics as network management and network security. In addition, the remainder of the book has been updated to reflect changes in the field.

Finally, the number of authors of this book has doubled! Our backgrounds and experience are complementary in many respects, and we are confident that this partnership has produced a book that is even more useful to the business reader than the first edition.

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