Preface

*The mind is not a vessel that needs filling,
but wood that needs igniting.*
—PLUTARCH

This text is designed for a one-semester undergraduate course in Business Data Communications. Data Communications is one of the growth areas of the economy because information exchange is becoming an increasingly important part of people's lives. This book focuses on providing working knowledge of data communication concepts and technologies that most students are likely to encounter within the first five years after graduation.

This book tries to most effectively utilize the time frame of a semester-long undergraduate class with about 40 hours of instruction time. Unlike many other information systems classes, which typically have a unifying theme—for example, SQL in database development, or the Waterfall model in Systems Analysis and Design—the data communications class easily transforms into developing familiarity with an alphabet soup of technologies—QAM, ASK, 802.3, IP, TCP, UDP, HTTP, SMTP, IMAP, DHCP, DNS, NAT, ARP, RFC 1918, subnetting, BGP, and 802.11, to name a few. The challenge in this class is to develop a unifying theme to help a student who is new to these technologies, so that the student is able to see how all these technologies are components of a unified system that enables data communications. All the design choices made while developing this text are based on this single goal.

The goal of the text is to help students, the future innovators of business and technology in our society, to understand the common principles underlying computer networks. In pursuit of this goal, at every possible occasion, the book addresses *why* networking technologies are designed to work in their current form. Hopefully, this focus on *why* will help students recognize opportunities for profitable innovation in their careers, even in contexts that are unrelated to data communications.

Key features

The book incorporates a number of features to improve student comprehension. These include:

- *Reinforcement of a unifying theme throughout the book—"efficiency of network resource utilization."* Research suggests that the brain assimilates new ideas better when these new ideas are linked to existing ideas in the brain. The unifying theme

helps build these connections. All modern data communication technologies are motivated by the need to most efficiently utilize the extremely expensive network infrastructure—cables, bandwidth, routers, exchange points, even IP addresses. If at first a technology makes no sense to a student, they should be encouraged to please step back for a minute and try to assess how this technology improves network resource utilization. Network operators would not invest in using a technology unless the technology was absolutely necessary to improve the utilization of network resources in some way. This idea of improving resource utilization is reinforced in almost every chapter. Examples include multiplexing in Chapter 2, broadcast in Chapter 3, IP addressing in Chapter 4, flow control in Chapter 5, address reuse in Chapter 7, point-to-point communication in Chapter 10, bandwidth utilization in Chapter 11, and frequency reuse in Chapter 12.

- *A focus on describing why technologies have been designed to work the way they do.* When students understand why a technology works, it helps improve comprehension, long-term recall, and, potentially, helps the idea in other contexts. Resource utilization efficiency (as described above) is the most common explanation for data communication technology design. But other factors are important too. Examples in the book include layered architectures in Chapter 1, signaling in Chapter 2, multi-part addressing in Chapter 4, three-way handshake in Chapter 5, hierarchical naming in Chapter 7, and modulus operation in Chapter 13.

- *A focus on covering a core set of data communication technologies.* Trying to cover every possible networking concept within one class, particularly at the undergraduate level, hinders student comprehension. Accordingly, the book takes the minimal set of technologies that are absolutely necessary to enable computer networking in organizations—Ethernet, TCP/IP, ARP, NAT, DNS, DHCP, routing, subnetting, and security—and focuses on showing what each of these technologies does, why each of these technologies is necessary, and how each technology works. Focusing on the most essential topics enables more detailed coverage of essential topics such as packetization, IP addresses, subnetting, route aggregation, and DNS. Every topic that has been covered is discussed in reasonable detail so students feel confident in their abilities to apply them at work and to discuss them with professional experts in the industry and in job interviews.

- *Hands-on exercises with every chapter.* Students repeatedly state that they understand more from hands-on exercises than from lectures. Every chapter in this book has hands-on exercises that help students use and understand the networking concepts covered in the chapter. All personal computers come with easy-to-use networking utilities that students can use to learn more about the capabilities of their computers. Many exercises are based on these utilities. Examples include tracert in Chapter 1; ipconfig in Chapter 3, 4, and 8; ping in Chapter 4; netstat in Chapter 5; and nslookup in Chapter 7. There are also spreadsheet exercises that help students understand amplitude modulation (Chapter 2) and CDMA (Chapter 12). Finally, some end-of-chapter hands-on exercises use other interesting software. These include Wireshark (Chapters 6, 11, and 13), OPNET (Chapters 10 and Chapter 14), and BGPlay (Chapter 9).

Some of these hands-on exercises are unique to the book. For example, the Wireshark exercise in Chapter 11 uses wireless packets captured using AirPCap, so

that students can see the fields in the radio header to see the transmission frequency channel selected. The spreadsheet exercises demonstrate technical concepts such as modulation and multiplexing using simple spreadsheet exercises.

- *Business case in each chapter.* To show students the business use for the technologies covered in the book, each chapter ends with a case study that shows the business or social impact of the technology covered in the chapter.

- *Network design case integrated throughout the text.* To help students see how all the technologies covered in the book integrate with each other in an enterprise network, there is a network design case that runs throughout the book. In each chapter, students make design choices to meet user requirements for the technology covered in the chapter. The finished exercise can also be included in students' portfolios for job interviews.

Book outline

The book may be seen to have four parts: (1) introduction, (2) technology layers, (3) supporting technologies and systems, and (4) managerial issues.

The introduction (Chapter 1) provides a high-level overview of the book, the need for computer networks, and their evolution to their current form. It describes why layering and packetization are done to deliver information. Part 2 (Chapters 2–6) covers each of the five layers in the TCP/IP technology stack in detail. Since upper layers in all layered systems depend upon services from the lower layers, it is easier to understand the operations of lower layers than that of upper layers. Hence the book uses a bottom-up approach, starting from the lowest layer (Chapter 2) and ending in the topmost layer (Chapter 6). Part 3 (Chapters 7–13) covers the supporting data communication technologies such as WANs, routing, and subnetting. Finally, Part 4 (Chapter 14) covers managerial issues in networking, such as standardization, legal issues, and network design.

Supplements

The following supplements are available to help instructors and students:

- PowerPoint slides are available for all the chapters. These slides include all the figures used in the book and can be used to highlight the key points in the chapters.

- There is a companion website for the book, which is referenced at various places in the text. The companion website includes technology standards, particularly the easy-to-read RFCs such as IP, TCP, HTTP, SMTP, and NAT. There are also articles from the mainstream media that are relevant to the class. The goal of the companion website is to get students to devote a meaningful amount of time outside class hours going over the assigned readings and to get a broader understanding of data communications. I assign 3–4 readings from the website for every meeting and devote about 20 minutes at the beginning of each class to discuss the assigned readings for the day. A side benefit of this approach is that by the end of the class, students become comfortable reading these kinds of technical articles and reports.

- There is an Instructors' Manual with answers to the end-of-chapter questions and about 20 multiple choice or true-false questions per chapter for use in tests.

This text is the result of my own adaptations over the years of material covered in existing data communications texts. The result seems to work well for my students, and hopefully will work for everyone who uses the book.

Acknowledgment

I would like to acknowledge three people who are especially important in planting the seeds for this book and for giving me the confidence to write it. My PhD advisor, Prof. H. R. Rao, at the University at Buffalo, encouraged me to teach Business Data Communications when it was time for me to teach a class while doing my PhD. Without that start, I probably would have never taught this topic. Over the years at USF, Joe Rogers, the university's network expert, has been very patient in sharing his expertise with me and responding to my questions about computer networking. Joe also went over the book to help remove technical errors. Finally, a friend from college and former McKinsey consultant, Bhasker Natarajan, gave me the idea to write a book when I asked him for productive ideas to keep busy in my spare time. He assured me that it was easier than it appears and would not take longer than two weeks to complete the first draft. That encouragement was enough to get me started, though it certainly took longer than two weeks to complete the first draft of the book.

I am grateful to Beth Lang Golub, the Information Systems editor at Wiley, for having faith in me, a first-time textbook author, when I approached her with the idea of a new text in Business Data Communications.

Special thanks are due to my department chairs, Stan Birkin and Kaushal Chari for their constant encouragement. Finally, I would like to thank the reviewers of this book, who gave very constructive feedback and pointed out errors in earlier drafts. The book is better because of their efforts.

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About the colophon[1]

It is unlikely that a single book can teach everything worth learning in any subject. An approach that tries to fill a "bucket of knowledge" is therefore necessarily futile. A more productive approach is to recognize the boundless potential and spirit of inquiry of the human brain. Recognizing this, at every opportunity, this book tries to show why Internet technologies work the way they do—what the challenges were and how the adopted solutions solve these challenges. It is hoped that this approach will ignite students' curiosity, motivate them to look for common principles underlying computer networking, and maybe even improve the ways we currently operate and use computer networks. Maybe some ideas from the technologies discusses in the book could even be usable in entrepreneurial ventures.

Notations

Definitions are in italics.

> Remarks are in shaded boxes

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[1] A colophon is a brief comment, usually located at the end of the text, providing finishing touches to the text.

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