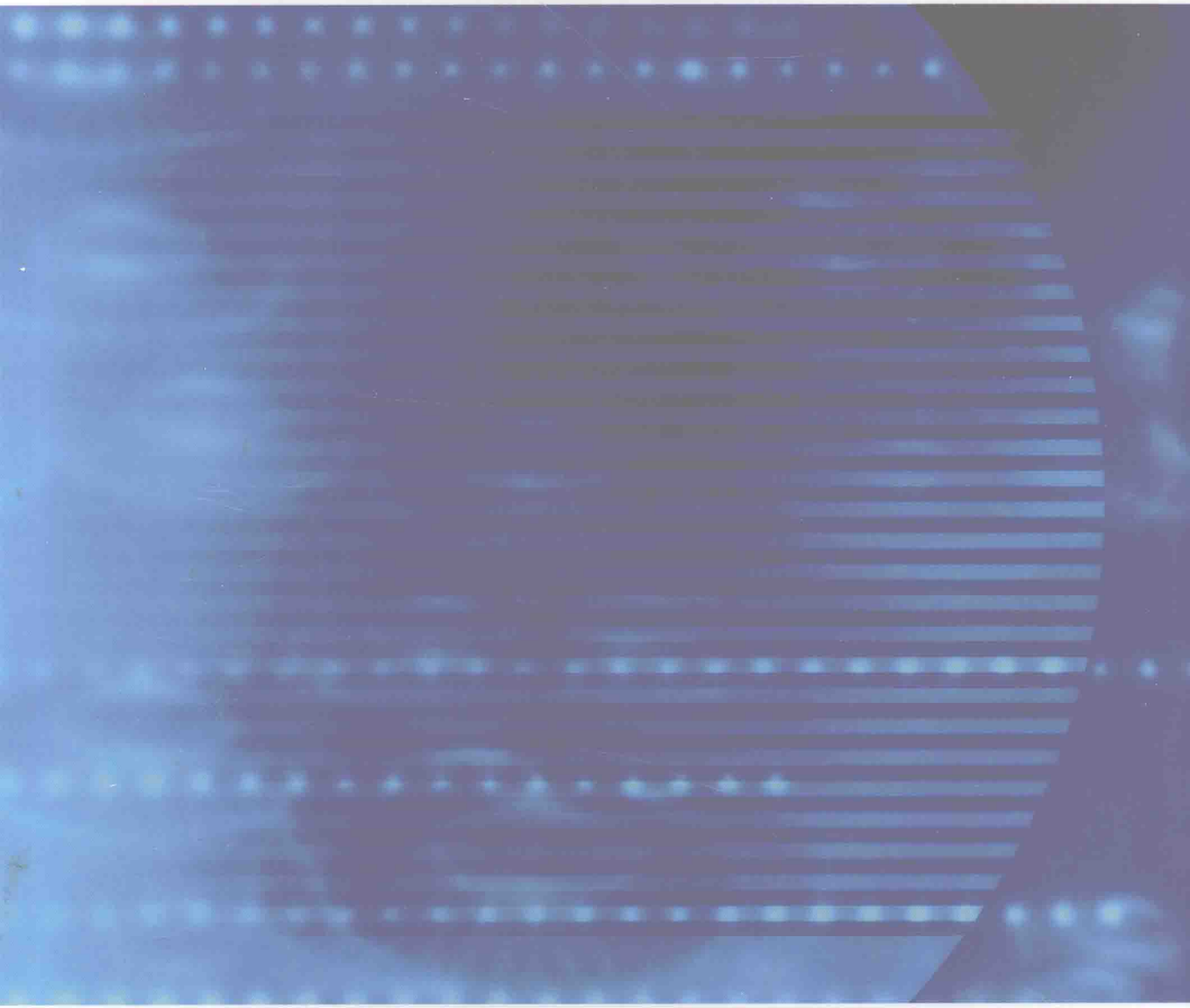
BUSINESS DATA NETWORKS AND TELECOMMUNICATIONS

SIXTH EDITION



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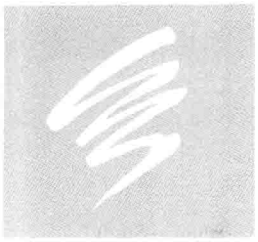

SIXTH EDITION

Business Data Networks and Telecommunications

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To Jon Fujiwara, who does all this stuff for real.

Preface for Teachers

THREE QUESTIONS

Teachers who are considering this book typically have three questions.

- What are the key reasons to select this book?
  - Job-Relevant Information
  - Great Teacher Support
  - Pedagogy
- How can I teach with it?
- What's new since the last edition?

WHY SELECT THIS BOOK?

Job-Relevant Information

The most important reason to select a textbook is the information it covers. This is especially important today because it is much harder for students to get jobs now than it was three or four years ago. Students need to achieve a higher level of content mastery.

In designing this and previous editions, the author talked extensively with working networking professionals and managers. He also got extensive market data on the technologies that corporations actually use. Many textbooks seem to be surprisingly market-blind. They spend time on technologies that were never adopted by the market or on technologies that have not been sold since the previous century—and, as a result, they do not cover important new developments. For example, Ethernet, which is now the only wired LAN technology in almost every firm, is no longer a simple technology. Students need to know about VLANs, STP, 802.1AE MACsec, and other advanced aspects of Ethernet.

Up-to-Date Content

Of course, the content needs to be up to date. The sixth edition has a completely new chapter on wireless LANs, a strong section on wireless metropolitan area networking (MAN), and information on many other important new areas. The sixth edition is not simply a minor update. Most chapters were completely or heavily rewritten to reflect changes since the fifth edition.

Market-Driven Content

Even more important, the book's content is strongly market-driven. Too many textbooks try to cover every technology that ever existed, even when its use today is almost nonexistent. As noted earlier, this leaves far too little time for today's critical technologies and emerging technologies. Students become historians, not market-ready

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graduates. In fact, some books seem to ignore market data. One recent textbook even called Frame Relay a new technology despite the fact that Frame Relay revenues were almost equal to those of private line revenues in the WAN market in the late 1990s and also despite the fact that Frame Relay is now considered to be a legacy technology in decline. Here are some examples of the book's market-driven content.

- *Wireless LANs.* The sixth edition chapter on wireless LANs (Chapter 5) looks at WLAN security and at the details of tradeoffs between different WLAN standards. It also looks at WLAN management.
- *Security.* As you would expect from an author whose security textbook is energizing security teaching in IS, security is pervasive throughout the text. One of the final chapters (Chapter 9) anchors the security information.
- *TCP/IP.* Above the physical and data link layers used in LANs and WANs, TCP/IP is consolidating its hold on upper-layer technologies. In the sixth edition, TCP/IP is pervasive. Chapter 1 introduces several core concepts; Chapter 2 introduces the basic elements of TCP/IP; and Chapter 8 goes into detail on advanced aspects of TCP/IP standards, including how routers make routing decisions. Chapter 10 discusses key topics in TCP/IP management. Module A covers a number of even more advanced aspects of TCP/IP. Also, the material in the book has been written to allow teachers to cover Chapter 8 after Chapter 3 or even Chapter 2. This allows routers to be handled much earlier.
- *Ethernet.* As noted earlier, Ethernet has won the LAN wars, but it is no longer a simple install-and-forget technology. The book has a full chapter on Ethernet (Chapter 4).

Job-Ready Detail

In the past, job interviews often asked students to name the OSI layers and stopped at that. Today, however, even job interviews for nonnetworking jobs grill job applicants on the details of networking. The days of feel-good "network appreciation" textbooks with far too little detail for job applicants should be over.

For example, in the Ethernet chapter (Chapter 4), the book goes well beyond basic topology and switch operation to look at VLANs, link aggregation, the Spanning Tree Protocol and the Rapid Spanning Tree Protocol, overprovisioning versus priority, and switch purchasing considerations. Detail has been beefed-up in other areas as well. The TCP/IP chapter (Chapter 8) takes a detailed look at how routers operate, while many other books cover this critical topic poorly or even incorrectly.

Great Teacher Support

Teaching networking is very difficult, so textbooks must provide strong teacher support.

Detailed PowerPoint Lectures

The book has full PowerPoint lectures created by the author—not just "a few selected slides." The PowerPoint lectures include builds for more complex figures. They also include new information since the book went to press. Students can download the lectures in full PowerPoint format. They can also download handouts with six slides per page in PDF format for faster downloading. Teachers can get annotated versions of the PowerPoint presentations to help them prepare and present lectures.

The PowerPoint slides are keyed directly to figures in the book. This is no accident. The book was designed so that almost all key points are covered in figures—including "study figures" that summarize key points in more complex sections. The PowerPoint lectures are created and updated by the author.

Website

The book's website, www.prenhall.com/panko, is rich in teacher resources. This is where teachers can go in order to download answer keys, test item file questions, and the latest versions of the PowerPoint lectures (which are updated once or twice a year). The website also is created and updated by the author.

Flexibility: An Eleven-Chapter Core

The book has eleven core chapters. In a three-credit one-semester course, this leaves one to two weeks for other material. The eleven core chapters—even without advanced information in boxes—form a complete course, so the additional time can be spent in enrichment activities. These may include hands-on activities (discussed later), additional TCP/IP material (or other material in the advanced modules), term projects, or whatever the teacher wishes to cover. In addition, many teachers cover only the eleven core chapters to ease the learning burden on students.

"Letter" Chapters and Advanced Modules

The book has two types of material beyond the eleven core chapters. These should be used judiciously. The book is not intended to be covered front-to-back. Even two or three letter chapters or one advanced module may be pushing it.

Several core chapters are followed by "letter" chapters. For example, after Chapter 1, there are Chapters 1a, 1b, and 1c. Three of these letter chapters are case studies (1a, 1c, and 7a.). Other letter chapters are designed for detailed hands-on learning (1b, 3a, 8a, and 9a).

Although neither 802.5 Token-Ring Networks or FDDI networks are used in corporations today, Chapter 4a gives an overview of ring topologies and token-passing.

There are three advanced modules. For teachers who really want to focus on TCP/IP, Module A has very detailed information about TCP/IP. Module C is designed for courses that focus on telecommunications. Chapter 6 looks at telecommunications from the viewpoint of corporate IS staffs. Module C looks at telecommunications from the carrier's point of view. Module B covers modulation in greater detail for teachers who feel that more information on telephone modems is needed.

Answer Keys and Test Item File

The chapters have test-your-understanding questions roughly once per page so that students can do a brain check on what they have just read. In addition, end-of-chapter thought questions, design questions, and troubleshooting questions help the student attain higher-level mastery of the material. Answer keys for all questions are available to teachers.

Multiple-choice test item file questions are keyed to specific chapter questions. This allows teachers who wish to be selective to specify specific questions that students should master, and it then allows them to develop tests that reflect those selected questions.

Mailing List

There is a low-volume mailing list that is used a few times per year to update adopters on new developments—most commonly new material at the website. The mailing list is also used to solicit adopter feedback on the text.

Pedagogy

Learning networking is difficult. Many students find that networking is the most conceptually difficult course in IS programs. Networking books need to have very strong pedagogy.

Clear Writing

All editions of this book have received accolades for clear writing—especially its ability to teach difficult and complex topics. Every chapter is classroom-tested.

Hands-On Opportunities

Students want opportunities to do things hands-on. With the sixth edition, they can.

- *OPNET IT Guru and ACE.* OPNET Technologies Inc. has kindly made the student versions of its IT Guru and ACE programs available to adopters—together with a series of lab exercises to reinforce key networking concepts. IT Guru is a powerful network simulation tool, while ACE focuses on application-level performance. (These exercises require 32-bit versions of Windows, so not everyone can run them.)
- *End-of-Chapter Hands-On Questions.* Chapters 1 and 10 in particular have hands-on questions to reinforce concepts. Chapters 1b, 3a, 8a, and 9a also offer hands-on experiences.
- *UTP.* Chapter 3a discusses how to cut and connectorize UTP. Teaching this material requires an investment of about $200, but undergraduate students love it.
- *Windows XP Networking and Security.* Windows XP is rapidly becoming the main client version of Windows, and it is not due to be replaced for some time. Chapter 1a shows students how to set up a Windows XP client for networking. If you have an understanding lab manager, students can go into your lab, set up a connection, set up a workgroup, and then undo what they have done. In turn, Chapter 9a shows students how to set up Windows XP security. Again, the chapter has material that you can have students do in your lab.

Running Case and Case Studies

Students like real-world scenarios because they help make complex concepts more concrete. The book has a running case—the First Bank of Paradise—which is a composite of several actual banks. (Much of the information presented is too sensitive for bank identification.)

Chapter 1 describes how a bank vice president set up a home PC network (a topic that most students will find interesting). In addition, several of the "a" chapters following the main chapters are case studies. Chapter 1a is a case study in the development of a small home network. Chapter 1c, in turn, is a case study in the development of a small SOHO PC network. Chapter 7a is a case study on the First Bank of Paradise's wide area networks (WANs).

Chapter Questions

The book gives the student many opportunities to check his or her knowledge. Approximately once per page, there are Test Your Understanding questions to help the student see if he or she has understood the material that was just read.

End of Chapter questions help the student integrate the material in the chapter. Thought questions help the student think more deeply about the material. Troubleshooting questions and Design questions also help students develop important troubleshooting and design skills, which are critical in networking. Some chapters also have Hands-on questions for your students to do at home.

As noted earlier, test item file questions are keyed to specific Test Your Understanding and End of Chapter questions.

Up Through the Layers/Familiar to the Unfamiliar

Like most books, the sixth edition takes an up-though-the-layers approach. However, this approach is significantly modified because most books that take this approach teach one layer at a time in isolation. Only at the end of the book does the student get the whole picture. During the process, students have only a cursory framework within which to integrate chapter knowledge.

- The book begins, in Chapters 1 through 3, with a strong framework to help students understand networking broadly so that when new knowledge appears, they understand its place. The difficult concept of layered network architectures is introduced early and is reinforced throughout the book.
- Chapters 4 through 7 deal with LAN, telecommunications, and WAN technologies. Every LAN and WAN technology is a mixture of Layer 1 (physical) and Layer 2 (data link) technologies. For this reason, this book covers Layer 1 and 2 technologies within the context of specific LAN and WAN technologies rather than individually (although Chapter 3 introduces specific physical layer information).
- Chapter 8 deals with internetworking, especially TCP/IP internetworking at Layer 3 (internet) and Layer 4 (transport). Once students understand LAN and WAN technologies, they can appreciate the need to interconnect them.
- Chapters 9 and 10 cover material that cuts throughout the layers—security and network management. These topics are introduced early, but a full discussion has to wait until students have a solid understanding of layer technologies.
- Chapter 11 covers the application layer (in OSI, application layers). It might seem better to cover this information after Chapter 8, but many schools cover applications in a separate course.

Synopsis Sections

Each chapter ends in a synopsis section that summarizes key points. In classroom testing of the sixth edition chapters, these synopsis sections were very popular with students.

TEACHING WITH THIS BOOK

As noted earlier, this book has eleven core chapters. They form a complete course.

Freshman and Sophomore Courses

For freshman and sophomore courses, it is good practice to stay with the eleven core chapters, going over chapter questions in class. If you want to do hands-on material, it is advisable to cut some material from the core chapters.

Junior and Senior Courses

With courses for juniors and seniors, covering the eleven core chapters (including "a" chapters that are case studies) will probably leave you with one or two semester weeks "free." As noted earlier, this leaves time for hands-on activities (discussed earlier), additional TCP/IP material (or other material in the advanced modules), a term project, or whatever you wish to cover. However, the entire book, including all hands-on material, should not be covered front-to-back in a semester.

Graduate Courses

Graduate courses tend to look a lot like junior- and senior-level courses but with greater depth. More focus can be placed on end-of-chapter questions and novel hands-on exercises, such as OPNET simulations. It is also typical to have a term project.

CHANGES SINCE THE FIFTH EDITION

The sixth edition generally follows the same basic flow as the fifth. The following table lists some specific changes.

Sixth Edition	Remarks Relative to the Fifth Edition (5e)
In General	Several of the chapters have been streamlined to make them easier to cover. In every chapter, new developments in the topic area are covered.
Chapter 1. An Introduction to Networking	Similar to Chapter 1 in the fifth edition but streamlined to reduce some concepts. In particular, the Pat Lee case becomes Chapter 1a for separate coverage.
Chapter 1a. Case Study: Pat Lee's Home Network	This case study was in Chapter 1 of the fifth edition.
Chapter 1b. Hands-On: Configuring Windows XP Home for Networking	This chapter complements the Pat Lee case study in Chapter 1a by discussing how to set up Windows XP for home networking and shared Internet access.
Chapter 1c. Case Study: XTR Consulting: A SOHO Network with Dedicated Servers	This chapter is a case study design exercise for how to set up a LAN in a small business with just under twenty workers. It is a good step beyond the Pat Lee home network.
Chapter 2. Network Standards	Similar to Chapter 2 in 5e but has a more streamlined structure. Some specifics, such as TCP session openings and closings, are moved to Chapter 8.
Chapter 3. Physical Layer Propagation: UTP and Optical Fiber	Similar to Chapter 3 in 5e. However, it has a more streamlined treatment of optical fiber, and it does not cover building wiring, which many adopters said was too detailed for an introductory text.

Sixth Edition	Remarks Relative to the Fifth Edition (5e)
Chapter 3a. Hands-On: Cutting and Connectorizing UTP	Unchanged from the fifth edition.
Chapter 4. Ethernet LANs	This chapter covers Ethernet, including the concepts needed for large Ethernet LANs. The switch purchasing information is moved into a box.
Chapter 5. Wireless LANs (WLANs)	Totally rewritten to focus on corporate decisions involving WLANs, especially the selection of standards and options for security. The chapter has a section on deciding where to place access points and on alternative technologies for management. This chapter is a bit longer than other chapters in the book.
Chapter 6. Telecommunications	Similar to Chapter 6 in 5e, but quite heavily rewritten. Focuses on telecommunications from the corporate viewpoint. Carrier information is covered in Module C. Chapter includes Internet access technologies.
Chapter 7. Wide Area Networks (WANs)	With Internet access technologies in Chapter 6, Chapter 7 focuses on corporate WANs using leased lines, public switched data networks, and VPNs for IP networking. Frame Relay is now a legacy technology for corporations.
Chapter 7a. Case Study: First Bank of Paradise's Wide Area Networks	Same as Chapter 7a in 5e.
Chapter 8. TCP/IP Internetworking	Somewhat streamlined, especially in its core treatment of how routers work. Adds ARP and a few other concepts not in the previous edition. The material in the book has been rewritten to allow teachers who wish to do so to teach Chapter 8 after Chapter 3 or even after Chapter 2. This is for teachers who expressed a desire to cover routers early in the course.
Chapter 8a. Hands-On: Packet Capture and Analysis with WINdump and TCPdump	Unchanged from 5e.
Chapter 9. Security	Streamlined from the fifth edition. Firewall section focuses heavily on stateful inspection, which dominates firewall filtering today.
Chapter 9a. Hands-On: Windows XP Home Security	Completely rewritten to deal with SP2 and other new developments.
Chapter 10. Network Management	Based on Chapter 10 in the fifth edition but with some information removed for streamlining.
Chapter 11. Networked Applications	Largely the same as in the fifth edition. Rewritten section on Web services under the name service oriented architecture (SOA).
Module A. More on TCP/IP	Unchanged from 5e.
Module B. More on Modulation	Unchanged from 5e. Now designed to be covered after Chapter 6.
Module C. More on Telecommunications	Covers telecommunications from the carrier's point of view.

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Preface for Students

PERSPECTIVE

Initially, information systems (IS) graduates had a single career track: programmer–analyst–database administrator–manager. Today, however, many IS graduates are going into the networking career track—often to their surprise. This course is an introduction to the networking track.

However, even programmers need a strong understanding of networking. In the past, programmers wrote stand-alone programs that ran on a single computer. Today, however, most programmers write networked applications that work cooperatively with other programs on other computers.

LEARNING NETWORKING

Networking Is Difficult

Networking is an exciting topic. It is also a difficult topic. In programming, the focus is on creating running programs. In networking, the critical skills are design, product selection, and troubleshooting. These rather abstract skills require a broad and deep knowledge of many concepts. Many IS students have a difficult time adjusting to these more cerebral skill requirements.

Employers Are Growing More Demanding

In the past, many teachers tried to deal with the complexity of networking by selecting what was in essence a "network appreciation" book—a feel-good book that lacked the detailed knowledge needed for actual networking jobs.

Today, however, employers demand—and get—much strong job readiness from new graduates. If you want to get a job in the IS field, you will need to have a competitive level of knowledge in every IS field you study. Even applicants for database jobs are grilled in networking knowledge (and networking applicants are grilled in database and other areas).

How to Study the Book

There are several keys to studying this book.

- Reading chapters once will not be enough. You will need to really study the chapters.
- Slow down for the tough parts. Some sections will be fairly easy; others difficult. Too many students study the harder stuff at the same speed they use to study the easier stuff.
- When you finish studying a section, do the Test Your Understanding questions immediately. If you don't get one of the questions, go back over the text.

Networking is strongly cumulative, and if you skim over one section, you will have problems with other sections later. Multiple-choice questions in the test item file are taken entirely from the Test Your Understanding questions and the End-of-Chapter questions.

- Later, in groups, go over the Test Your Understanding questions to see if you got the correct answers.
- Study the figures. Nearly every key point in the chapter is covered in the figures. If there is something in a figure you don't understand, you need to study that section.
- If several concepts—for instance, different network technologies—are presented in a section or chapter, do not just study them individually. You need to know which one to use in a particular situation, and that skill requires compare/contrast knowledge. Study figures that compare concepts, and make your own if the book does not have them.
- Study the Synopsis at the end of the chapter. The Synopsis summarizes the core concepts in the chapter. Be very sure you know them well. You might even study them before the chapter to get a broad understanding of the material.

Hands-On

One way to make networking less abstract is to do as many hands-on activities as possible.

- Be sure to do the hands-on exercises in Chapter 1, 4, and 10.
- If you have a Windows XP computer, do the work in Chapters 1b and 9a.
- To really understand TCP/IP, download WINdump and play with it. (See Chapter 8a.)
- If you can, do the OPNET exercises at the website, www.panko.net.

A NETWORKING CAREER

If you like the networking course and think you want a networking career, there are a number of steps you should take before graduation, even if your school does not have advanced networking courses.

- Most important, do a networking internship. Employers really want job experience—often preferring it to an absurd degree over academic preparation.
- Learn systems administration (the management of servers). Learn the essentials of Unix and Windows Server. You can download a server version of Linux and install it on your home computer in order to play with Unix commands and network management functions.
- Learn about security. Security and networking are now inextricably intertwined.
- Think about getting one or more industry certifications. In networking, the low-level CompTIA Network+ certification should be obtainable with just a bit more study after taking your core networking course. Cisco's CCNA (Cisco Certified Network Associate) certification, which focuses on switching and routing, will require substantially more study. Microsoft server certification is also valuable. Employers like applicants who are job-ready.

About the Author

Ray Panko is a professor of IT management at the University of Hawai'i's College of Business Administration. Before coming to the university, he was a research physicist at Boeing, where he flew on an early flight test of the 747 prototype, and was a project manager at Stanford Research Institute (now SRI International), where he worked for Doug Englebart (the inventor of the mouse). He received his B.S. in physics and his MBA from Seattle University. He received his doctorate from Stanford University, where his dissertation was conducted under contract to the Office of the President of the United States. In his spare time, he collects die-cast models and races in six-seat Hawai'ian outrigger canoes.

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