MTP
MACMILLAN TECHNICAL PUBLISHING U·S·A

MACMILLAN NETWORK ARCHITECTURE & DEVELOPMENT SERIES

WIRELESS LANs

Implementing Interoperable Networks

Jim Geier

Wireless LANs

Implementing Interoperable Networks

Jim Geier

Wireless LANs: Implementing Interoperable Networks

FIRST EDITION

International Standard Book Number: 1-57870-081-7

Library of Congress Catalog Card Number: 98-85498

2001 00 99 98 4 3 2 1

Interpretation of the printing code: The rightmost double-digit number is the year of the book's printing; the rightmost single-digit, the number of the book's printing. For example, the printing code 98-1 shows that the first printing of the book occurred in 1998.

Composed in Bergamo and MCPdigital by Macmillan Computer Publishing

Printed in the United States of America

Trademark Acknowledgments

All terms mentioned in this book that are known to be trademarks or service marks have been appropriately capitalized. Macmillan Technical Publishing cannot attest to the accuracy of this information. Use of a term in this book should not be regarded as affecting the validity of any trademark or service mark.

Warning and Disclaimer

This book is designed to provide information about wireless LAN technology. Every effort has been made to make this book as complete and as accurate as possible, but no warranty or fitness is implied.

The information is provided on an as-is basis. The authors and Macmillan Technical Publishing shall have neither liability nor responsibility to any person or entity with respect to any loss or damages arising from the information contained in this book or from the use of the discs or programs that may accompany it.

Feedback Information

At Macmillan Technical Publishing, our goal is to create in-depth technical books of the highest quality and value. Each book is crafted with care and precision, undergoing rigorous development that involves the unique expertise of members from the professional technical community.

Readers' feedback is a natural continuation of this process. If you have any comments regarding how we could improve the quality of this book, or otherwise alter it to better suit your needs, you can contact us at `networktech@mcp.com`. Please make sure to include the book title and ISBN in your message.

We greatly appreciate your assistance.

Publisher
Jim LeValley

Executive Editor
Linda Ratts Engelman

Managing Editor
Caroline Roop

Acquisitions Editor
Karen Wachs

Development Editor
Thomas Cirtin

Project Editor
Laura N. Williams

Copy Editor
Keith Cline

Indexer
Tim Wright

Proofreader
Julie Searls

Acquisitions Coordinator
Amy Lewis

Manufacturing Coordinator
Brook Farling

Book Designer
Gary Adair

Cover Designer
Sandra Schroeder

Production Team Supervisor
Tricia Flodder

Production
Eric S. Miller

About the Author

Jim Geier is an internationally known consultant, author, and speaker on wireless LAN technologies and implementation strategies. He is currently the director of Network and Software Systems at Monarch Marking Systems, an international leader in providing bar code system solutions. Jim's department develops wireless system tools and application software for companies and organizations worldwide.

Jim is the author of *Wireless Networking Handbook* (1996, New Riders Publishing) and *Network Reengineering* (1996, McGraw-Hill), as well as numerous articles in leading publications, including *Network Magazine* and *Byte*. Jim has instructed courses internationally on computer-related topics, including wireless networking, software development, and project management, for George Washington University and Technology Training Corporation. He speaks regularly at conferences and tradeshows held throughout the world.

Jim served as chairman of the Institute of Electrical and Electronic Engineers (IEEE) Computer Society, Dayton Section, and chairman of the IEEE International Conference on Wireless LAN Implementation. He was an active member of the IEEE 802.11 working group, responsible for developing international standards for wireless LANs.

Jim's past 20 years of experience include a variety of consulting and management positions. At Wright-Patterson Air Force Base in Ohio, Jim managed the design and operational support of numerous LANs and a wide area network that supports over 10,000 users. For the base, he evaluated the effectiveness of wireless network technologies for use in mobile and portable office environments. He led the development of a tool to aid engineers in the installation of wireless networks and evaluated commercial network technologies for use with U.S. government mobile sensor systems.

He was the principal investigator for a small business innovative research grant to develop an automated software tool that assists engineers in planning, upgrading, and maintaining information systems. He managed a test team responsible for testing computer networks throughout the world. He has developed corporate information system standards for companies migrating from mainframe to client/server systems.

Jim holds a B.S. degree from California State University, Sacramento, and an M.S. degree from Air Force Institute of Technology, both in electrical engineering with emphasis in computer networks. As part of his master's thesis, he developed and implemented an adaptive automatic routing algorithm for a worldwide packet radio network.

Jim's hobbies include sailing and amateur radio (KC8KQH). He resides with his wife and four sons in Yellow Springs, Ohio. You can reach him at `jimgeier@aol.com`.

About the Technical Reviewers

These reviewers contributed their considerable practical expertise to the entire development process for *Wireless LANs*. As the book was being written, these folks reviewed all the material for technical content, organization, and flow. Their feedback was critical to ensuring that *Wireless LANs* fits our readers' need for the highest quality technical information.

D. Ed Lamprecht is a Senior Systems Engineer at Monarch Marking Systems with 15 years of programming experience in applications and operating systems. He received a bachelor's degree in 1983 from the University of Northern Iowa and started his career with NCR Corporation programming operating systems in assembly for retail computing systems. It was during this time that Ed also developed applications for other platforms, including UNIX and DOS.

In 1988, Ed joined Monarch Marking Systems, a company specializing in bar code printers and labels. Here he developed bar code applications for MS-DOS and Microsoft Windows 2.0 and later, including PC drivers and TSRs and connectivity software. Since 1996, Ed has been involved in data collection systems providing wireless network connectivity solutions of handheld printers and data collection terminals for retail, industrial, manufacturing, and health care markets.

At Monarch, Ed has developed client/server applications, visited customer sites for analysis and problem solving, and provided international training on products and wireless connectivity. Ed holds six patents in bar code software and handheld printer and data collectors.

Ed lives with his wife, Michelle, and his son, Colin, in Dayton, Ohio. When not tinkering with PCs and networks at home, he enjoys model railroading, railroad memorabilia collecting, golfing, traveling, and spending time with his son.

Peter Rysavy is a consultant specializing in wireless communication and other technologies related to personal and mobile communication. His firm, Rysavy Research, assists clients with market research, product and business development, and technology assessment. Peter is the chairman of the standards committee of the Portable Computing and Communications Association (PCCA), a standards group that produces wireless-data standards.

Since 1993, Peter has worked as a consultant with numerous clients on projects involving mobile and wireless communication. Clients include cellular carriers, communications software companies, network hardware companies, investment firms, automotive electronics companies, research organizations, and universities. He also teaches seminars and writes articles about wireless communication.

Dedication

I dedicate this book to my wife, Debbie, for her loving support of my writing efforts.

Acknowledgments

When writing this book, I was fortunate to work with an excellent team at Macmillan Technical Publishing, whose contributions vastly improved the presentation of this book. In particular, Tom Cirtin, development editor, did an outstanding job guiding me through the revision of the text. Tom's ideas and his editing enhanced this book's readability and use as a tool for implementing wireless LANs.

I'd also like to give special thanks to Ed Lamprecht for performing the technical review of the book's manuscript. Ed's valuable suggestions greatly refined this book.

Peter graduated with an MSEE from Stanford University in 1979, where he was involved in several collaborations between academia and industry. Joining Fluke Corporation in 1979, he designed communications hardware and software for data-acquisition products. From 1981 to 1983, he designed ethernet networking hardware at Time Office Computers in Australia. He rejoined Fluke, and until 1988 managed the development of a family of communication-oriented touch terminals. From 1988 to 1993, Peter was VP of Engineering and Technology at Traveling Software (makers of LapLink). His last major project was LapLink Wireless. He also managed the development of LapLink and connectivity solutions for a broad variety of mobile platforms.

Contents at a Glance

Contents

Introduction

Wireless LAN technology is rapidly becoming a crucial component of computer networks, and its use is growing by leaps and bounds. Thanks to the finalization of the IEEE 802.11 wireless LAN standard, wireless technology has emerged from the world of proprietary implementations to become an open solution for providing mobility as well as essential network services where wireline installations proved impractical. Now companies and organizations are increasingly investing in wireless networks to take advantage of mobile, real-time access to information.

Most wireless LAN suppliers now have 802.11-compliant products, allowing companies to realize wireless network applications based on open systems. The move toward 802.11 standardization is lowering prices and enabling multiple-vendor wireless LANs to interoperate. This is making the implementation of wireless networks more feasible than before, creating vast business opportunities for system implementation companies and consultants.

Many end-user companies and system integrators, however, have little knowledge of, and experience in, developing and implementing wireless network systems. In many cases, there is also confusion over the capability and effectiveness of the 802.11 standard. The implementation of wireless networks is much different from traditional wired networks. In contrast to ethernet, a wireless LAN has a large number of setup parameters that affect the performance and interoperability of the network. An engineer designing the network and the person installing the network must understand these parameters and how they affect the network. To address wireless installation issues, this book is full of implementation notes, especially regarding 802.11-compliant solutions.

To optimize the operation of wireless systems, you need to be familiar with software options for interfacing wireless handheld appliances to application software and databases located on the network. Terminal emulation, direct database connectivity, and middleware are alternatives that provide connectivity depending on system requirements. This book describes each of these in detail, and explains how to choose one over the others.

Altogether, this book provides a practical overview of wireless network technologies, with emphasis on the IEEE 802.11 wireless LAN standard and implementation steps and recommendations.

Who Will Benefit from This Book?

This book is primarily intended for readers having knowledge of networking concepts and protocols. Readers should be familiar with basic communications protocol handshaking processes and ethernet network infrastructures, for example. Readers should also be conversant with basic computer terminology, such as *local area network*, *client/server*, and *application software*. Project managers can also benefit from the book by learning important project-planning steps for wireless network implementations.

This book is aimed at the following audience:

- Information system (IS) staff and system integrators involved with analyzing, designing, installing, and supporting wireless LANs
- Engineers developing wireless LAN products and solutions
- Managers planning and executing projects for developing wireless products or implementing wireless LAN systems

Key Features of This Book

This book contains the following features that make it a practical guide for developing and implementing wireless LANs:

- Roadmaps at the beginning of each chapter clearly summarize the topics addressed in the chapter.
- Various case studies throughout the book anchor the reader in real-life examples.
- Implementation notes provide practical instruction in the concepts described in this book.
- Diagrams throughout the book illustrate technical issues and procedures.
- Tables convey crucial technical information at a glance.

- The glossary defines terms related to wireless network systems. It is a handy reference to use when reading this book or working on a wireless network project.
- A list of all the case studies (on the inside of the cover of this book) provides a handy reference to the examples of real-world implementation.

The Organization of This Book

To expedite the learning process required in mastering wireless LAN technology, this book follows a three-part sequence of related topics—beginning with explanations of essential concepts and culminating in solid implementation procedures. The book's organization is described in detail in the following sections.

Part I: Wireless Networks—A First Look

The first part of this book addresses introductory material as a basis for understanding the remaining elements. This portion will help the reader understand the concepts, benefits, and issues dealing with radio network systems, clearing up confusion of competing wireless solutions.

If you are already familiar with wireless networks, you might want to skip Chapter 1, "Introduction to Wireless Networks," and Chapter 2, "Wireless Network Configurations." In any case, be sure to read Chapter 3, "Overview of the IEEE 802.11 Standard," if you need an introduction to the standard for wireless LANs.

Part II: Inside IEEE 802.11

Part II is more challenging and contains in-depth coverage of the medium access and physical layers of the IEEE 802.11 standard. Chapter 4, "Medium Access Control (MAC) Layer," describes MAC operations and frame structures, and Chapter 5, "Physical (PHY) Layer," explains PHY operations and frame structures and helps readers select the type of 802.11 physical layer that best fits their needs.

Engineers designing wireless LAN solutions will find this part useful for understanding design options and tuning of an 802.11 network. Engineers developing 802.11-compliant products will find the coverage of the 802.11 standard beneficial when specifying new 802.11-compliant products. IS operational support staff will also find this part most useful to understand frame formats when troubleshooting network behavior.

Part III: Deploying Wireless LANs

The final chapters contain all the steps necessary to deploy a wireless LAN. Chapter 6, "Wireless System Integration," explains the technologies and components needed in addition to what 802.11 covers, such as MobileIP and application connectivity software. Chapter 7, "Planning a Wireless LAN," and Chapter 8, "Implementing a

Wireless LAN," describe the steps you should follow when planning, analyzing, designing, and installing a wireless system. A single case study, threaded throughout Chapters 7 and 8, provides details of a real project that help you understand how to implement the ideas presented in the chapters' step-by-step procedures.

In addition, special implementation notes throughout the chapters of Part III enable readers to directly apply what they have read in earlier chapters to solving the needs for wireless networks within their companies or organizations. IS staff, system integrators, and project managers can strongly benefit by using this part of the book as a practical guide that is based on the experiences and lessons learned from many wireless network projects.

Appendices

The appendices provide supplementary information related to wireless networks. Appendix A, "Automatic Identification and Data Capture (AIDC)," gives the reader an understanding of implementing bar code systems—a primary application of wireless LANs.

Appendix B, "Products, Companies, and Organizations," principally identifies the wireless network product suppliers and system integration companies. This appendix is useful to people looking for products and services when implementing a wireless network. It is also a quick reference for the organizations mentioned in this book.

CHAPTER 3

Overview of the IEEE 802.11 Standard

- The importance of standards
  This chapter begins with an introduction to the types of LAN standards and the primary organization that makes the standards: the Institute for Electrical and Electronic Engineers (IEEE). You learn the important benefits of using the IEEE 802.11 wireless LAN standard.
- IEEE 802 LAN standards family
  It is important to know how the IEEE 802.11 standard fits into other LAN protocols to ensure proper interoperability. An overview of the 802 series of LAN standards describes the operation of the 802.2 Logical Link Control that directly interfaces with 802.11.
- Introduction to the IEEE 802.11 standard
  An explanation of the scope and goals of the 802.11 standard provides an understanding of the basic functionality of 802.11. Learn the peculiar wireless network issues that were addressed when developing the standard.
- IEEE 802.11 topology
  An overview of the physical structure of 802.11-compliant LANs provides an understanding of 802.11 topology. Understand how basic physical 802.11 elements, such as Basic Service Sets (single-cell wireless LANs) and access points, form integrated, multiple-cell wireless LANs that support a variety of mobility types.
- IEEE 802.11 logical architecture
  Coverage of the main elements of the 802.11 protocol stack provides an overview of how the 802.11 protocol works. Learn the main functionality of each of the following 802.11 protocol layers: MAC Layer and individual PHY (Physical) Layers (frequency hopping, direct sequence, and infrared).

- **IEEE 802.11 services**
  802.11-compliant LANs function based on a set of services that relate to stations and distribution systems. Discover how these services offer security equivalent to wired LANs.
- **Implications of the IEEE 802.11 standard**
  Although the long-awaited 802.11 standard offers several benefits over using proprietary-based wireless LANs, the 802.11 standard still has shortcomings that implementors should be aware of. Learn some of the 802.11 implications, such as relatively low data rates and lack of roaming.
- **IEEE 802.11 standard compliance**
  The compliance with 802.11 depends on those having the need for wireless networks. Become aware of how vendors are complying with 802.11, what end users need to do to be compliant, and how different regions of the world comply with 802.11 radio frequencies.
- **IEEE 802.11 Working Group operations**
  Involvement in IEEE 802.11 standards development is open to anyone with a desire to participate, but you need to understand the membership requirements and types of 802.11 members.
- **Future of the IEEE 802.11 standard**
  When making decisions about wireless LANs, be sure to include what the future holds for the 802.11 standard. Discover the projects IEEE 802.11 members are working on to increase the performance of 802.11-compliant wireless LANs.

The Importance of Standards

Vendors and some end users initially expected markets to dive headfirst into implementing wireless networks. Markets did not respond as predicted, and flat sales growth of wireless networking components prevailed through most of the 1990s. Relatively low data rates, high prices, and especially the lack of standards kept many end users from purchasing the wire-free forms of media.

For those having applications suitable for lower data rates and enough cost savings to warrant purchasing wireless connections, the only choice before 1998 was to install proprietary hardware to satisfy requirements. As a result, many organizations today have proprietary wireless networks for which you have to replace both hardware and software to be compliant with the IEEE 802.11 standard. The lack of standards has been a significant problem with wireless networking, but the first official version of the standard is now available. In response to lacking standards, the Institute for Electrical and Electronic Engineers (IEEE) developed the first internationally recognized wireless LAN standard: IEEE 802.11.

Types of Standards

There are two main types of standards: official and public. An *official standard* is published and known to the public, but it is controlled by an official standards organization, such as IEEE. Government or industry consortiums normally sponsor official standards groups. Official standards organizations generally ensure coordination at both the international and domestic level.

A *public standard* is similar to an official standard, except it is controlled by a private organization, such as the Wireless LAN Interoperability Forum. Public standards, often called *de facto standards*, are common practices that have not been produced or accepted by an official standards organization. These standards, such as TCP/IP, are the result of widespread proliferation. In some cases, public standards that proliferate, such as the original ethernet, eventually pass through standards organizations and become official standards.

Companies should strive to adopt standards and recommended products within their organizations for all aspects of information systems. What type of standards should you use? For most cases, focus on the use of an official standard if one is available and proliferating. This will help ensure widespread acceptance and longevity of your wireless network implementation. If no official standard is suitable, a public standard would be a good choice. In fact, public standards can often respond faster to changes in market needs because they usually have less organizational overhead for making changes. Be sure to avoid nonstandard or proprietary system components, unless there are no suitable standards available.

Case Study 3.1: 802.11 Versus Proprietary Standards

A large retail chain based in Sacramento, California, had requirements to implement a wireless network to provide mobility within their 10 warehouses located all over the United States. The application calls for clerks within the warehouse to utilize new handheld wireless data collectors that perform inventory-management functions.

The company, already having one vendor's data collection devices (we'll call these brand X), decides to use that vendor's brand Y proprietary wireless data collectors and their proprietary wireless network (the vendor doesn't offer an 802.11-compliant solution). This decision eliminates the need to work with additional vendors for the new handheld devices and the wireless network.

A year passes since the installation, and enhancement requirements begin to pour in for additional mobile appliances that are not available from the brand X

continues

continued

vendor. This forces the company to consider the purchase of new brand Z appliances from a different vendor. The problem, however, is that the brand Z appliances, which are 802.11-compliant, don't interoperate with the installed proprietary brand Y wireless network. Because of the cost associated with replacing their network with one that is 802.11 compliant (the brand Y wireless network has no upgrade path to 802.11), the company can't cost effectively implement the new enhancement.

The company could have eliminated the problem of not being able to implement the new enhancement if it would have implemented the initial system with 802.11-compliant network components, because most vendors offer products that are compatible with 802.11, but not all the proprietary networks. The result would have been the ability to consider multiple vendors for a wider selection of appliances.

Institute for Electrical and Electronic Engineers (IEEE)

The IEEE is a nonprofit professional organization founded by a handful of engineers in 1884 for the purpose of consolidating ideas dealing with electro-technology. In the last 100 plus years, IEEE has maintained a steady growth. Today, the IEEE, which is based in the United States, has over 320,000 members located in 150 countries. The IEEE consists of 35 individual societies, including the Communications Society, Computer Society, and Antennas and Propagation Society.

The IEEE plays a significant role in publishing technical works, sponsoring conferences and seminars, accreditation, and standards development. The IEEE has published nearly 700 active standards publications, half of which relate to power engineering and most others deal with computers. The IEEE standards development process consists of 30,000 volunteers (who are mostly IEEE members) and a Standards Board of 32 people. In terms of LANs, IEEE has produced some very popular and widely used standards. The majority of LANs in the world utilize network interface cards based on the IEEE 802.3 (ethernet) and IEEE 802.5 (token ring) standards, for example.

Before someone can develop an IEEE standard, he must submit a Project Authorization Request (PAR) to the IEEE Standards Board. If the board approves the PAR, IEEE establishes a standards working group to develop the standard. Members of the working groups serve voluntarily and without compensation, and they are not necessarily members of the institute. The working group begins by writing a draft standard, and then solicits the draft to a balloting group of selected IEEE members for review and approval. The ballot group consists of the standard's developers, potential users, and other people having general interest.

Before publication, the IEEE Standards Board performs a review of the Final Draft Standard, and then considers approval of the standard. The resulting standard represents a consensus of broad expertise from within IEEE and other related organizations. All IEEE standards are subjected to review at least once every five years for revision or reaffirmation.

Note

In May 1991, a group of people, led by Victor Hayes, submitted a Project Authorization Request (PAR) to IEEE to initiate the 802.11 Working Group. Victor became Chairman of the working group and led the standards effort to its completion in June 1997.

Benefits of the 802.11 Standard

The benefits of utilizing standards, such as those published by IEEE, are great. The following sections explain the benefits of complying with standards, especially IEEE 802.11.

Appliance Interoperability

Compliance with the IEEE 802.11 standard makes interoperability between multiple-vendor appliances and the chosen wireless network type possible. This means you can purchase an 802.11-compliant PalmPilot from Symbol and Pathfinder Ultra handheld scanner/printer from Monarch Marking Systems, and they will both interoperate within an equivalent 802.11 wireless network, assuming 802.11 configuration parameters are set equally in both devices. Standard compliance increases price competition and enables companies to develop wireless LAN components with lower research and development budgets. This enables a greater number of smaller companies to develop wireless components. As a result, the sales of wireless LAN components should boom over the next few years as the finalization of the IEEE 802.11 standard sinks in.

As shown in Figure 3.1, appliance interoperability avoids the dependence on a single vendor for appliances. Without a standard, for example, a company having a non-standard proprietary Symbol network would be dependent on purchasing only appliances that operate on a Symbol network. This would exclude appliances such as ones from Telxon that only operate on proprietary Aironet networks. With an 802.11-compliant wireless network, you can utilize any equivalent 802.11-compliant appliance. Because most vendors, including Symbol and Telxon, have migrated their products to 802.11, you have a much greater selection of appliances for 802.11 standard networks.

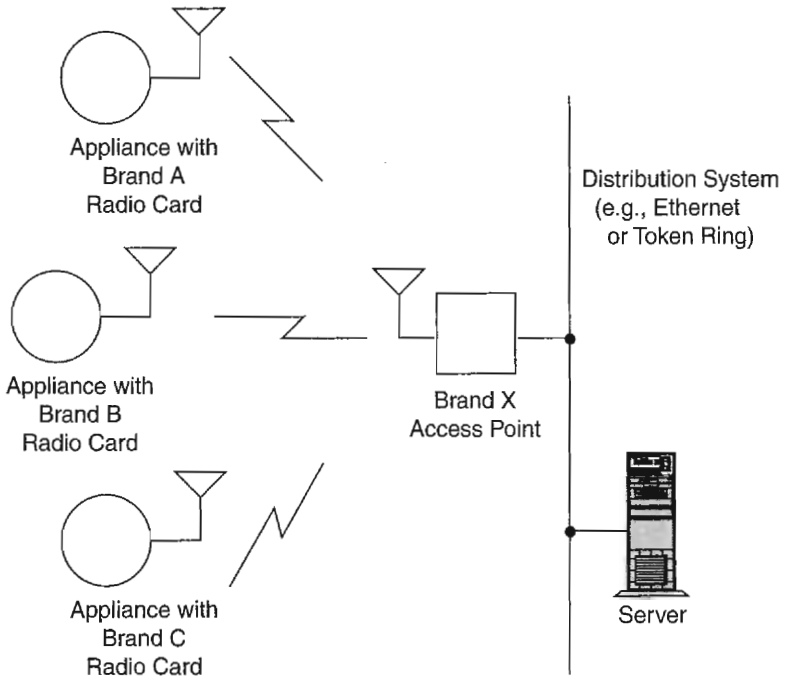

FIGURE 3.1 *Appliance interoperability ensures that multiple-vendor hardware works within equivalent wireless networks.*

Fast Product Development

The 802.11 standard is a well-tested blueprint that developers can use to implement wireless devices. The use of standards decreases the learning curve required to understand specific technologies because the standard-forming group has already invested the time to smooth out any wrinkles in the implementation of the applicable technology. This leads to the development of products in much less time.

Stable Future Migration

Compliance with standards helps protect investments and avoids legacy systems that must be completely replaced in the future as those proprietary products become obsolete. The evolution of wireless LANs should occur in a similar fashion as 802.3, ethernet. Initially, ethernet began as a 10 Mbps standard using coaxial cable media. The IEEE 802.3 Working Group enhanced the standard over the years by adding twisted-pair, optical-fiber cabling, and 100 and 1000 Mbps data rates.

Just as IEEE 802.3 did, the 802.11 Working Group recognizes the investments organizations make in network infrastructure and the importance in providing migration paths that maximize the installed base of hardware. As a result, 802.11 will certainly ensure stable migration from existing wireless LANs as higher performance wireless networking technologies become available.

Price Reductions

High costs have always plagued the wireless LAN industry; however, prices should drop significantly as more vendors and end users comply with 802.11. One of the reasons for lower prices is that vendors will no longer need to develop and support lower-quantity proprietary subcomponents, cutting design, manufacturing, and support costs. Ethernet went through a similar lowering of prices as more and more companies began complying with the 802.3 standard.

Avoiding Silos

Over the past couple of decades, MIS organizations have had a difficult time maintaining control of network implementations. The introduction of PCs, LANs, and visual-based development tools has made it much easier for non-MIS organizations, such as finance and manufacturing departments, to deploy their own applications. One part of the company, for example, may purchase a wireless network from one vendor, and then another part of the company may buy a different wireless network. As a result, *silos*—noninteroperable systems—appear within the company, making it very difficult for MIS personnel to plan and support compatible systems. Some people refer to these silos as *stovepipes*.

Acquisitions bring dissimilar systems together as well. One company having a proprietary system may purchase another having a different proprietary system, resulting in noninteroperability. Figure 3.2 illustrates the features of standards that minimize the occurrence of silos.

Case Study 3.2:

Problems with Mixed Standards

A company located in Barcelona, Spain specializes in the resale of women's clothes. This company, having a MIS group without much control over the implementation of distributed networks in major parts of the company, has projects underway to implement wireless networks for an inventory application and a price-marking application.

Non-MIS project managers located in different parts of the company lead these projects. They have little desire to coordinate their projects with MIS because of past difficulties. As a result, both project managers end up implementing noncompatible proprietary wireless networks to satisfy their networking requirements.

The project managers install both systems: one that covers the sales floorspace of their 300 stores (for price marking) and one that encompasses 10 warehouses (for doing inventory functions). Although the systems are noncompatible, all is fine for the users operating the autonomous systems.

The issues with this system architecture, however, are the difficulty in providing

continues

continued

operational support and inflexibility. The company must maintain purchasing and warranty contracts with two different wireless network vendors, service personnel need to acquire and maintain an understanding in the operation of two networks, and the company cannot share appliances and wireless network components between the warehouses and the stores.

As a result, the silos in this case make the networks more expensive to support and limit their flexibility in meeting future needs. The implementation of standard 802.11-compliant networks would have avoided these problems.

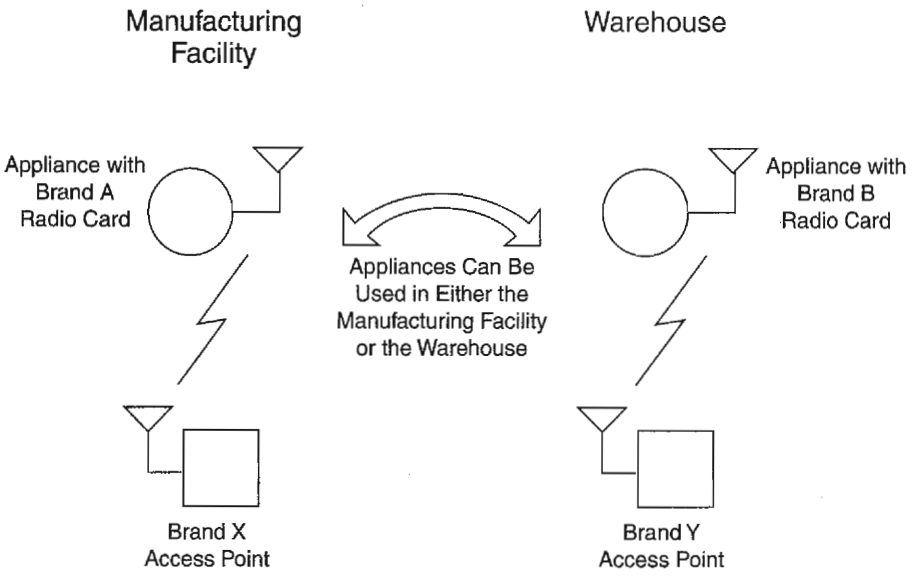

FIGURE 3.2 *Compliance with the IEEE 802.11 standard can minimize the implementation of silos.*

IEEE 802 LAN Standards Family

The IEEE 802 Local and Metropolitan Area Network Standards Committee is a major working group charted by IEEE to create, maintain, and encourage the use of IEEE and equivalent IEC/ISO standards. IEEE formed the committee in February 1980, and has met at least three times per year as a plenary body since then. IEEE 802 produces the series of standards known as IEEE 802.x, and the JTC 1 series of equivalent standards are known as ISO 8802-nnn.

IEEE 802 includes a family of standards, as depicted in Figure 3.3. The MAC and Physical Layers of the 802 standard were organized into a separate set of standards from the LLC because of the interdependence between medium access control, medium, and topology.

Implications of the IEEE 802.11 Standard

As with any technologies and standards, one must be aware of the implications surrounding the implementation of wireless networks based on the IEEE 802.11 standard. Chapter 1, in the section "Wireless Network Concerns," discusses the general issues of implementing wireless networks. In addition to these problems, the following are a couple of implications specifically related to the IEEE 802.11 standard:

- *Relatively low data rates:* As mentioned before, the 802.11 standard currently supports data rates up to 2 Mbps. Some end users and vendors claim this data rate is too low. In some cases, this is true; but in other cases, it is not true. Video transmissions, for example, may require higher data rates if applications need frame rates, pixel depth, and resolutions that require greater amounts of bandwidth. Large data block transmissions may also require higher data rates to keep transmission delays tolerable.

  On the other hand, bar code applications, such as receiving, inventory, and price marking, generally work well under the 2 Mbps limitation of the current 802.11 standard.

- *Lack of standard roaming across multiple-vendor access points:* The 802.11 standard does not define the protocols necessary to move 802.11 frames within the distribution system because it falls outside the scope of 802-type LANs. The Network and Transport Layers are left to address distribution system protocols. As a result, the 802.11 standard does not define communications *between* access points.

  Currently, it is up to the access point vendors to define the protocols necessary to support roaming from one access point to another. To be safe, you should consider purchasing access points from a single vendor, although you can mix-and-match radio cards in the appliances. Chapter 6, "Wireless System Integration," discusses industry standards, such as the Inter Access Point Protocol (IAPP) specification, that are beginning to define multiple-vendor roaming protocols.

IEEE 802.11 Standard Compliance

No standard is worthwhile unless vendors and end users comply with it. The following sections describe activities taking place to ensure compliance with 802.11.

Vendor Compliance

Most wireless LAN vendors (that is, manufacturers of the hardware) are releasing initial radio cards and access points throughout 1998 and 1999 that comply with the official 802.11 standard. Before deeming their devices as 802.11 compliant, they must follow the protocol implementation compliance procedures that the 802.11 standard specifies in its appendix. The procedures state that the vendor shall

complete a Protocol Implementation Conformance Statement (PICS) proforma. The structure of the PICS proforma mainly includes a list of fixed questions that the vendor responds to with yes or no answers, indicating adherence to the standard. The PICS can have the following uses:

- A checklist that helps the vendor reduce the risk of failure to conform to the standard
- For the vendor and system implementor to better understand what 802.11-compliancy means
- As a basis for designing an interface between the 802.11 device and another network or system
- As the basis for developing protocol conformance tests and simulations

To ensure proper compliance, vendors test their products at the InterOperability Laboratory located at the Leavitt Center on the campus of The University of New Hampshire. In March 1997, for example, Aironet Wireless Communications, Inc.; Breezecom Wireless Communications; Netwave Technologies, Inc.; Proxim Inc.; Raytheon Electronics; and Symbol Technologies performed joint interoperability testing to advance customer adoption of wireless technology. In some cases, users can upgrade their existing proprietary radio cards to be 802.11 compliant by just reinstalling NIC interface software on their appliances.

Note

Vendors are easing the transition to 802.11-compliant radio networks by offering relatively simple ways to upgrade existing radio LAN devices. Symbol, Inc., for example, offers a firmware upgrade to your existing Symbol 2.4 GHz (Spectrum 24) networks, avoiding the purchase of new network adapters.

The InterOperability Laboratory, founded in 1988, performs research and development work and is used by more than 100 vendors to verify the interoperability and conformance of their computer communications products. The University of New Hampshire encourages vendors to conduct interoperability testing by providing facilities for a multiple-vendor test environment. The goal of the laboratory is to provide complete testing for all networking products, including ethernet, ADSL, ATM, fast ethernet, FDDI, FDSE, Fibre Channel, gigabit ethernet, IP/Routing, Network Management, and Wireless.

Note

Be aware that in 1997 some vendors released "802.11-compliant" wireless LAN radio cards and access points that were not certified as compliant with the final 802.11 standard. These products may or may not operate within the final official standard.

WLI Forum

The Wireless LAN Interoperability Forum (WLI Forum), a not-for-profit corporation founded in March 1996, promotes the growth of the wireless LAN market by delivering interoperable products and services. The Forum consists primarily of appliance suppliers/vendors (such as Hewlett-Packard, Fujitsu, Monarch Marking Systems, and Handheld Products) having products that operate on the WLI Forum's OpenAir™ wireless network. The Forum provides certification via an independent third-party test lab to ensure proper compliance.

The OpenAir™ specification describes a MAC and radio frequency Physical Layer, similar in scope to the 802.11 specification. The OpenAir™ network is based on Proxim's RangeLAN2 protocol, employing frequency hopping spread spectrum technology in the unlicensed 2.4 GHz ISM band. The OpenAir™ operates at a data rate of 1.6 Mbps per channel, with 15 independent channels (hopping patterns) available. This architecture enables up to 15 wireless LANs to overlap independently in the same physical space, providing up to 24 Mbps of aggregate network bandwidth.

The WLI Forum wrote the OpenAir™ specification to motivate third-party development of compatible products. At the time, with no official IEEE standard on wireless networking, the Forum decided to base its specification on Proxim's product. Soon after the release of the 802.11 specification in June 1997, the WLI Forum announced its support for the adoption of the IEEE 802.11 standard and urged the supplier community to move toward conformance. As a result, the WLI Forum is likely to establish conformity to the IEEE 802.11 standard as well.

The WLI Forum is a worldwide organization, and is completely self funded through membership dues and fees. Membership is open to all companies that develop, manufacture, or sell wireless LAN products or services. For more information on the WLI Forum, visit their Web site located at `http://www.wlif.com`.

End-User Compliance

Throughout 1999 and beyond, end users should begin widespread implementations of 802.11-compliant LANs. As an end user, do you need to purchase and use products that comply with the 802.11 standard? Of course the answer is no, but you should carefully consider the advantages and disadvantages of implementing 802.11-compliant networks. Most likely, complying with 802.11 will be favored over the use of proprietary networks unless extenuating circumstances prevail. If the decision is to go with 802.11, you will be starting with one of the following scenarios:

- No existing implementation of wireless LANs
- Existing implementation of proprietary wireless LANs

If you are an end user with no existing installation of wireless networking components, compliance with the 802.11 standard is easy. Right? Actually, it is not as sim-

ple as it seems. The 802.11 standard is not as Plug and Play as the 802.3 ethernet standard. With 802.11, you must first decide which version of 802.11 best satisfies your needs. You might consider the following questions:

- *What type of modulation do I need?* Do I have radio interference implications that lean toward using the infrared PHY? Does the application require wider area coverage that may depend on the longer range capability of one of the spread spectrum PHYs? If the choice is spread spectrum, should I use direct sequence or frequency hopping?
- *Will the application require roaming across BSS cells interconnected by access points of different vendors?* If yes, you will need to think about how to provide roaming between access points.
- *Does the network require the optional WEP security?* If the answer is yes, be sure to choose wireless devices having WEP available.
- *Do the appliances I need to comply with have the 802.11 options I have chosen?* If not, you need to choose options that comply with the appliance, or you must choose different appliances.

Answers to the preceding questions define the options you need to consider when planning to purchase radio cards and access points complying with 802.11.

If proprietary wireless LANs already exist, you will need to either upgrade or replace the existing network to make it compliant with 802.11. Many of the vendors offer free upgrades to make your existing wireless LANs (if they are of a recent enough version) compliant with 802.11. BreezeCOM, for example, guarantees software upgrades to the IEEE 802.11 standard for its BreezeNET PRO product line.

If it is not possible or feasible to upgrade your existing wireless LAN, then of course you must perform a complete replacement if benefits outweigh the expenses. The replacement of the network will be difficult to cost-justify; however, it may become necessary as proprietary wireless components become obsolete.

International Electromagnetic Compliance

The 802.11 standard specifies operation in the 2.4 GHz band; however, electromagnetic compatibility requirements vary from one country to another. Operating frequencies, power levels, and spurious levels differ throughout the world.

Regional and national regulatory administrations of each individual country demand certification of wireless equipment. The 802.11 standard, however, identifies the minimum technical requirements for interoperability and compliance based on established regulations for Europe, Japan, and the North America. Therefore, wireless LAN vendors must be aware of all current regulatory requirements prior to releasing a product for sale in a particular country. The following agencies and

documents specify the current regulatory requirements for various geographical areas:

Canada

- *Approval standards:* Industry Canada (IC)
- *Documents:* GL36
- *Approval authority:* Industry Canada

Europe

- *Approval standards:* European Telecommunications Standards Institute
- *Documents:* ETS 300-328, ETS 300-339
- *Approval authority:* National Type Approval Authorities

France

- *Approval standards:* La Reglementation en France por les Equipements fonctionnant dans la bande de frequences 2,4 GHz "RLAN-Radio Local Area Network"
- *Documents:* SP/DGPT/ATAS/23, ETS 300-328, ETS 300-339
- *Approval authority:* Direction Generale des Postes et Telecommunications

Japan

- *Approval standards:* Research and Development Center for Radio Communications (RCR)
- *Documents:* RCR STD-33A
- *Approval authority:* Ministry of Telecommunications (MKK)

Spain

- *Approval standards:* Supplemento del Numero 164 del Boletin Oficial del Estado (published 10 July 91; revised 25 June 93)
- *Documents:* ETS 300-328, ETS 300-339
- *Approval authority:* Cuadro Nacional De Atribucion De Frecuesias

The United States of America

- *Approval standards:* Federal Communications Commission (FCC)
- *Documents:* CFR47, Part 15, Sections 15.205, 15.209, 15.247
- *Approval authority:* FCC

Operation in countries within Europe and other areas outside Japan or North America may be subject to additional regulations.

IEEE 802.11 Working Group Operations

The 802.11 Working Group is a part of the IEEE LAN MAN Standards Committee (LMSC), which reports to the Standards Activity Board (SAB) of the IEEE Computer Society. IEEE 802.11 meetings are open to anyone. The only requirement to attend is to pay dues, which offset meeting expenses. Most of the active participants are representatives from companies developing wireless LAN components. The IEEE bylaws explain that to vote on standards activities, however, you must become a member by participating in at least two out of four consecutive plenary meetings. Then, you must continue to attend meetings to maintain voting status. The 802.11 Working Group meets three times a year during the plenary sessions of the IEEE 802 and three times a year between plenary sessions.

The IEEE 802.11 Working Group consists of about 200 members; membership falls into the following categories:

- *Voting members:* Those who have maintained voting status.
- *Nearly members:* Those who have participated in two sessions of meetings, one of which being a plenary session. Nearly members become voting members in the first session they attend following their qualification for nearly membership.
- *Aspirant members:* Those who have participated in one plenary or interim session meeting.
- *Sleeping voting members:* Those who were once voting members, but have chosen to discontinue.

Future of the IEEE 802.11 Standard

What is the future of IEEE 802.11? Will end users eventually fully comply with the standard? Will the 802.11 Working Group solve implications revolving around the standard? Only time will tell for certain. It is known today, however, that all major wireless LAN vendors are releasing 802.11-compliant wireless LANs throughout 1998, and these vendors are making it fairly easy for end users to upgrade their existing systems. This, combined with the advantages of standardization, should proliferate the use of 802.11-compliant networks.

To solve implications of the current release of the standard, the IEEE 802.11 Working Group is actively working on the following projects that will aid the widespread acceptance of the standard:

- *802.11rev: Revision of IEEE Standard 802.11-1997:* This project was charted to rectify a number of errors in the current standard and to accommodate input from the JTC1 review to result in a single JTC1/IEEE standard.

- *802.11a: Extension of the IEEE Standard 802.11-1997 with a higher data rate PHY in the 5 GHz band:* This project was initiated to develop a high speed (about 20 Mbps) wireless PHY suitable for data, voice, and image information services in fixed, moving, or portable wireless local area networks. The project concentrates on improving spectrum efficiency and will review the existing 802.11 MAC to ensure its capability to operate at the higher speeds.

  The IEEE 802.11 Working Group will actively correspond with regulatory bodies worldwide to encourage spectrum allocations that match these frequencies.

- *802.11b: Extension of the IEEE Standard 802.11-1997 with a higher data rate PHY in the 2.4 GHz band:* The purpose of this project is to extend the performance and the range of applications of the existing 802.11 standard. The header of the two existing radio-based PHYs can support data rates up to 4.5 Mbps for frequency hopping and up to 25.5 Mbps for direct sequence. This project will investigate ways to exploit these data rate capabilities and analyze the capability of the existing 802.11 MAC to support higher data rates.

  The actual data rates targeted by this project are at least 3 Mbps for the frequency hopping PHY and at least 8 Mbps for the direct sequence PHY. As with project 802.11a, IEEE 802.11 will correspond with regulatory bodies worldwide to ensure that the proposed extension will be applicable as widely as possible.

In addition to the preceding official projects, the 802.11 Working Group is actively studying the needs for standardization of wireless communications of wearable computing devices. The study is examining the requirements for Wireless Personal Area Networking (WPAN) of devices that are worn or carried by individuals. The objectives of the study group are as follows:

- Review WPAN requirements.
- Determine the need for a standard.
- If a standard is necessary, draft a PAR for submittal.
- Seek appropriate sponsorship within 802.

The study group is soliciting industry input on market requirements and technical solutions for a WPAN with 0-to-30–foot range, data rates of less than 1 Mbps, low power consumption, small size (less than 0.5 cubic inches), and low cost relative to target device.

As mentioned in this chapter, the 802.11 wireless LAN standard certainly has benefits that an organization should consider when selecting components that provide LAN mobility. IEEE 802 is a solid family of standards that will provide much greater multiple-level interoperability than proprietary systems.

Wireless LANs conforming to 802.11 provide interoperability between radio cards and access points. The 802.11 standard has the backing of IEEE, having an excellent track record of developing long-lasting standards, such as IEEE 802.3 (ethernet) and IEEE 802.5 (token ring). When designing a wireless LAN, definitely consider the use of 802.11-compliant products, but ensure that the data rates of 802.11 will support your application and that the chosen components support roaming between access points.

With 802.11, system implementors have several choices. You will need to choose the type of physical medium, for example: frequency hopping spread spectrum, direct sequence spread spectrum, or infrared light. This concept is similar to choosing between twisted-pair, optical-fiber, and coaxial cable in an ethernet LAN. You will also need to determine how to interface wireless devices with server operating systems and applications. In defining these elements, be sure the resulting network supports all requirements.

MACMILLAN NETWORK ARCHITECTURE AND DEVELOPMENT SERIES

WIRELESS LANs

Implementing Interoperable Networks

Jim Geier holds B.S.E. and M.S.E. degrees in electrical engineering, with an emphasis in computer networks. He was an active member of the IEEE 802.11 Working Group, responsible for developing international standards for wireless LANs. Jim has served as chairman of the Institute of Electrical and Electronic Engineers (IEEE) Computer Society, Dayton Section, and chairman of the IEEE International Conference on Wireless LAN Implementation. Jim has 18 years of experience providing information system consultation to companies worldwide, and has instructed many courses internationally on topics such as wireless networking, software development, and project management. He is currently the director of Data Collection Solution Development at Monarch Marking Systems. Jim is also the author of the *Wireless Networking Handbook* (1996, New Riders Publishing) and *Network Reengineering* (1996, McGraw-Hill), as well as numerous articles in leading publications, such as *Byte* and *Network Magazine*.

The *Macmillan Network Architecture and Development Series* is a comprehensive set of guides that provide computing professionals with the unique insight of leading experts in today's networking technologies. Each volume explores a technology or set of technologies that is needed to build and maintain the optimal network environment for any particular organization or situation.

MTP
MACMILLAN TECHNICAL PUBLISHING U·S·A

CATEGORY: Networking

Wireless local area networks can provide unique benefits to many organizations, but require specific support and tools for maintaining network integrity. Based on the most recent developments in the field, *Wireless LANs*, gives network engineers, designers, and architects vital information on how to plan, configure, and implement wireless networks, including

- Coverage of the implications of migrating from proprietary solutions to the 802.11 standard
- Explanation of critical issues, such as maximizing interoperability between existing and future system infrastructure
- Authoritative advice on how to address common problems, such as radio frequency interference
- Discussion on how to realize significant cost savings through wireless LAN implementation for data collection systems
- Case studies and implementation notes, which provide real-world insight into the best practices of deploying a wireless LAN

This book provides both a context for understanding how an enterprise can benefit from the application of wireless technology, and the proven tools for efficiently implementing a wireless LAN. Designers and implementors will learn the considerations that must be addressed at each stage of the process, and find authoritative information on

- Primary wireless LAN applications, such as barcode scanners, data collectors, and printers
- The features and functionality of the IEEE 802.11 standard
- The details of upgrading from existing 902MHz to 2.4GHz networks
- Selecting the type of spread spectrum (direct sequence or frequency hopping) that best fits the needs of their particular networking environment

$40.00 USA / $57.95 CAN

ISBN 1-57870-081-7

6 19472 70081 5

9 781578 700813 94000