Deploying Voice over Wireless LANs

The definitive guide to planning, architecting, deploying, supporting, and creating Voice over Wireless LAN solutions

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Jim Geier is the founder of Wireless-Nets, Ltd., and the company's principal consultant. His 25 years of experience includes the analysis, design, software development, installation, and support of numerous wireless network-based systems for enterprises, airports, homes, retail stores, manufacturing facilities, warehouses, hospitals, and cities worldwide.

Jim has been active within the Wi-Fi Alliance, responsible for certifying interoperability of 802.11 (Wi-Fi) wireless LANs. He has also been active with the IEEE 802.11 Working Group, responsible for developing international standards for wireless LANs. He served as Chairman of the IEEE Computer Society, Dayton Section, and Chairman of the IEEE International Conference on Wireless LAN Implementation. Jim is an advisory board member of several leading wireless LAN companies.

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Dedication

This book is dedicated to Madison and Kimberlyn.

Acknowledgments

I would like to give special thanks to Shawn Merdinger and Joseph Roth for offering their technical wisdom during the editing process. Their feedback was extremely useful and enabled the creation of a great book.

Also, I would like to thank the entire production team for their time and effort with this book. I had most contact with Christopher Cleveland and Dan Young; these guys are incredibly professional and fantastic editors. As with other books that I have written for Cisco Press, the production team never ceases to amaze me. Thanks for a job well done!

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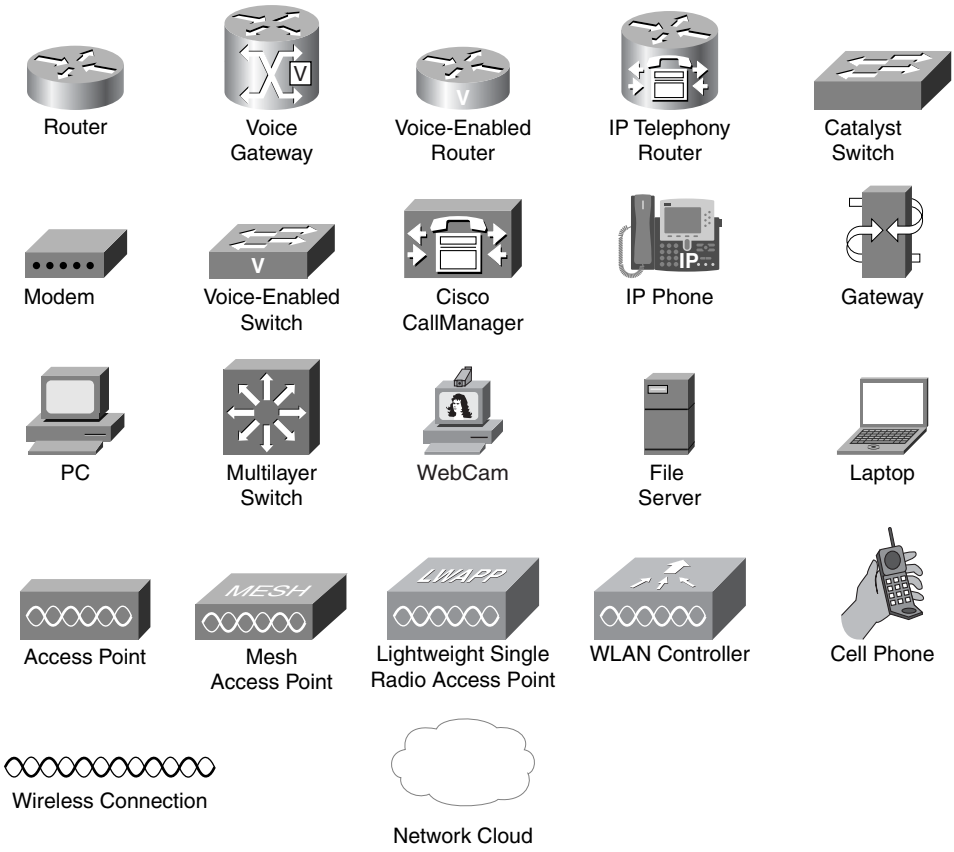


Command Syntax Conventions

The conventions used to present command syntax in this book are the same conventions used in the IOS Command Reference. The Command Reference describes these conventions as follows:

- **Boldface** indicates commands and keywords that are entered literally as shown. In actual configuration examples and output (not general command syntax), boldface indicates commands that are manually input by the user (such as a **show** command).
- *Italic* indicates arguments for which you supply actual values.
- Vertical bars (|) separate alternative, mutually exclusive elements.
- Square brackets [ ] indicate an optional element.
- Braces { } indicate a required choice.
- Braces within brackets [{ }] indicate a required choice within an optional element.

Introduction

This book focuses on technologies and implementation strategies for deploying voice over wireless LANs. Companies have been deploying wireless LANs for more than a decade, but recent advancements in data rates and quality of service mechanisms are enabling companies to effectively make integrated voice and video communications (along with common data applications) over wireless LANs a replacement for traditional, relatively costly wired telephone and video surveillance systems. The significantly lower support costs, combined with mobility, make voice and video killer applications. The deployment of a wireless voice and video system is much different from traditional wired and wireless networks. As a result, this book is necessary to educate readers on how to deploy voice and video systems. This book is based on practical experience that the author has gained through related real-world projects.

Who Should Read This Book?

This book is intended for readers having moderate knowledge of networking concepts and protocols. For example, the reader should be familiar with communications protocols, handshaking processes, and Ethernet network infrastructures. Readers should also be conversant with computer terminology, such as local-area network, client/server, and application software.

The following constitutes the book's intended audience:

- Information technology (IT) staff and system integrators involved with analyzing, designing, installing, and supporting wireless voice and video systems.
- Engineers developing voice and video products and solutions.
- Technical project managers planning and executing projects that develop or install wireless voice and video products or systems.
- University professors and students learning details of wireless voice and video systems in undergraduate or graduate-level courses.

How This Book Is Organized

Although this book could be read cover to cover, it is designed to be flexible to allow you to easily move between chapters and sections of chapters to cover just the material that you need more work with or more information on. The chapters cover the following topics:

- **Part I—Fundamental Elements**
  - **Chapter 1, "VoWLAN Applications and Benefits"**—This chapter defines all components that are part of a wireless voice and video system, such as phones, client software, and voice encoders/decoders. Examples of actual components are given, with emphasis on Cisco products. Descriptions of how multimedia integrates with existing systems found in enterprise settings are also given.

- — **Chapter 2, "VoWLAN System Components"**—This chapter defines all components that are part of a wireless voice system, such as phones, client software, and voice encoders/decoders. Examples of actual components are given, with emphasis on Cisco products. Descriptions of how multimedia integrates with existing systems found in enterprise settings are also given.
- — **Chapter 3, "VoWLAN Signaling Fundamentals"**—This chapter provides an overview of the primary elements of voice communications, such as voice signal characteristics, analog-to-digital conversion, compression techniques, and so on.

- **Part II—Critical Technologies**
  - — **Chapter 4, "Wireless LAN Technologies"**—To effectively design a wireless LAN that supports voice applications, it is important that readers fully understand the 802.11 standard. This chapter describes standard elements, such as MAC layer frames and physical layer options, and how these elements impact multimedia operation. Special attention is given to options that govern the behavior of a multimedia system.
  - — **Chapter 5, "VoWLAN Security Solutions"**—Wireless voice systems have unique security implications that solution providers must realize and offer applicable countermeasures. This chapter explains security issues related to voice systems and describes effective methods to provide security that meets relevant requirements.
- **Part III—Implementation Steps**
  - — **Chapter 6, "Analyzing VoWLAN Requirements"**—Before designing a wireless LAN that supports voice applications, you must fully understand requirements, such as number of users, existing data traffic, roaming needs, security needs, and anything else that will provide a basis for the design. A designer uses these requirements when deciding which technologies to use and how to configure the network. This chapter describes each type of requirement that needs definition to implement a quality multimedia system. The chapter offers plenty of real-world examples and methods for determining requirements.
  - — **Chapter 7, "Designing a VoWLAN Solution"**—This chapter discusses the technical elements that need consideration when designing a wireless LAN for voice applications. This includes determination of technology, mechanisms for providing required capacity, optimum 802.11 configuration settings, roaming, and integration with cellular systems. The chapter provides examples of which technical elements to consider, with specific requirements in mind.
  - — **Chapter 8, "Installing, Configuring, and Testing a VoWLAN System"**—This chapter defines all necessary installation steps and provides real-world tips that minimize risks when installing the system. The chapter describes details on the various types of tests that should be run to verify and validate that the system is meeting requirements and needs of the users.
  - — **Chapter 9, "Supporting a VoWLAN System"**—Wireless voice systems require unique support practices and tools. This chapter discusses these elements and provides examples of tools and methods that are effective at supporting the system.

PART

Fundamental Elements

Objectives

Upon completing this chapter, you will be able to

- Understand the role of Voice over Wireless LANs (VoWLAN).
- Define VoWLAN applications.
- Determine ROI of a VoWLAN solution.

CHAPTER 1

VoWLAN Applications and Benefits

This chapter describes various applications of Voice over Wireless LAN (VoWLAN) systems. Real-world examples and case studies provide you with a solid understanding of how VoWLAN can benefit a company. Details are also given about tangible benefits and expected return on investment (ROI).

The Role of VoWLAN Solutions

VoWLAN systems are an extension to wired Voice over Internet Protocol systems and an alternative to traditional analog and digital voice communications. VoWLANs offer significant benefits of providing mobility and wirelessly converging voice with data applications. With VoWLANs, hospitals, enterprises, retail stores, warehouses, and home owners can reduce telephony costs and enable mobile applications.

Examples of the systems that VoWLANs can replace include the following:

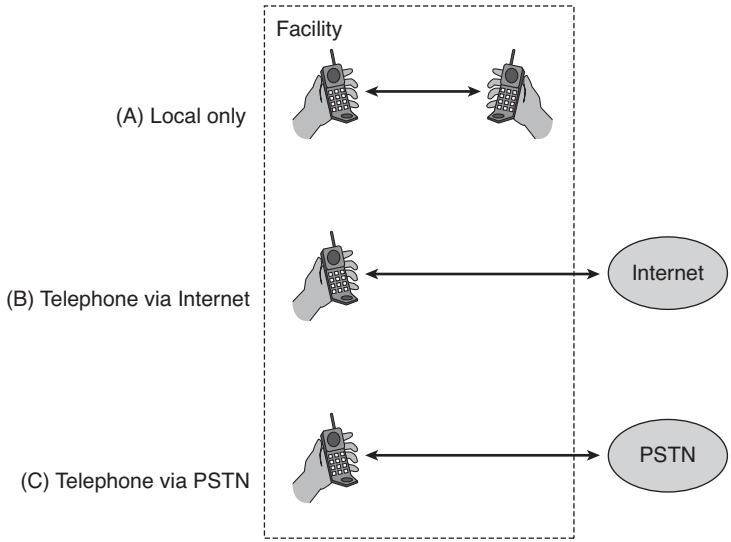
- Wired telephones
- Cellular telephones
- Two-way radios

With VoWLANs, people can use VoWLAN phones to communicate by voice wirelessly with others inside and outside a facility. The experience is very similar to using a traditional wired telephone, except the user is free to move about the building. Furthermore, a VoWLAN phone can operate from many of the growing Wi-Fi hotspots, enabling a person to make use of the same mobile phone while within or away from the office or home. Some cellular phones incorporate VoWLAN capability, which enables users to make calls over traditional cellular networks when no wireless local-area network (wireless LAN) is available.

Figure 1-1 shows the basic usage models of a VoWLAN system. The optimum approach depends on user requirements and existing telephone hardware.

The local-only configuration (part A of Figure 1-1), which is similar to two-way radios, consists of a wireless LAN that merely enables a user to talk to other users directly connected to the network. This supports a mix of wireless and wired VoIP telephones. For example, a clerk looking for a part in a warehouse may use a VoWLAN handset to communicate with a manager sitting at a desk and using a wired VoIP phone.

Figure 1-1 *VoWLAN Usage Models: (A) Local Only, (B) Telephone via Internet, and (C) Telephone via PSTN*



More advanced VoWLAN systems (Parts B and C of Figure 1-1), however, allow users to place actual telephone calls from their VoWLAN handsets. The telephone traffic can travel over the Internet or the Public Switched Telephone Network (PSTN). With these two models, the use of the system is virtually the same as a traditional telephone. For example, a sales agent in her home office in Ohio may dial a phone number on her VoWLAN phone to call a customer in California.

The primary benefit of VoWLAN solutions is cost savings. For instance, according to recent studies, federal, state, and local agencies could achieve savings of $4.5 billion annually by making telephone calls over the Internet. In addition, VoWLAN systems are easier to deploy and allow flexible communications. VoWLAN plays a critical role in realizing these savings by mobilizing the workforce.

History of VoWLANs

The two primary technologies of VoWLANs are wireless LANs and VoIP. Both have been evolving over the past decade and are now stable enough to support wireless voice communications.

VoIP

The earliest indication of VoIP systems was in the mid-1990s, when Vocaltec, Inc. released Internet Phone Software. This software ran on PCs and translated voice signals into digital packets that could be sent over the Internet. Both the sending and receiving callers must use

the same software. Sound quality was not as good as traditional telephones, but long distance calls could be made for free.

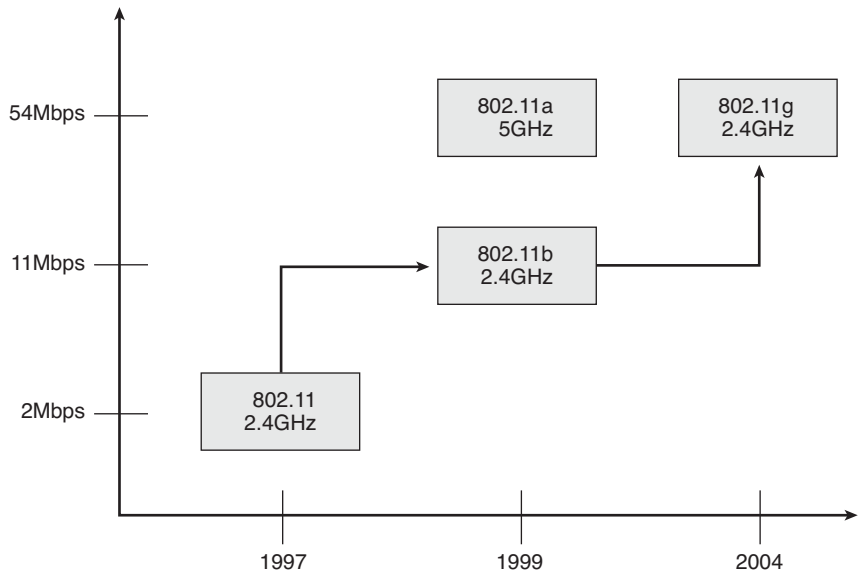
Throughout the late 1990s, entrepreneurs began establishing gateways and switches to allow people to make free phone calls over the Internet using standard telephones. The users had to utilize a PC to set up the call, but then they were free to talk from standard wired telephones connected to a PC. With these systems, the VoIP market began evolving. Many companies, including Cisco, began selling VoIP equipment about the year 2000 to enterprises to converge voice and data and provide mobility.

Wireless LANs

In the early 1990s, the first wireless LAN products, NCR WaveLAN and Motorola Altair, appeared on the market. At this time, there were no applicable standards and prices were relatively high, at around $1,500 per wireless adapter. As a result, only companies having applications with significant benefits from wireless connectivity, such as inventory management and price marking, could afford to deploy wireless LAN solutions.

Figure 1-2 summarizes the evolution of the 802.11 standard. In 1997, the Institute of Electrical and Electronics Engineers (IEEE) ratified the first version of the 802.11 wireless LAN standard. 802.11 at this point provided up to 1Mbps and 2Mbps data rate operation in the 2.4GHz frequency band using direct sequence and frequency hopping, which are both spread spectrum technologies. The capacity of these first 802.11 solutions was not good enough to effectively support voice applications.

Figure 1-2 *Evolution of the 802.11 Standard*



To enhance the performance of wireless LANs, the IEEE ratified the 802.11a and 802.11b standards in 1999. 802.11a provides up to 54Mbps data rates in the 5GHz band using orthogonal frequency division multiplexing (OFDM). 802.11b extends the maximum data rates of the initial 2.4GHz direct sequence 802.11 standard to 11Mbps. Later, in 2004, IEEE released 802.11g, which further extends data rates in the 2.4GHz band to 54Mbps using OFDM. The higher data rate 802.11 standards, 802.11a, 802.11b, and 802.11g, offer adequate capacity for supporting VoWLAN applications. 802.11a, however, provides the highest capacity, mainly because the Radio Frequency (RF) channels in the 5GHz band do not overlap with each other as they do in the 2.4GHz band. 802.11n, which will offer 100Mbp or more performance, is nearing ratification.

Other recent improvements to the 802.11 standard include security (802.11i), which includes much stronger encryption and authentication mechanisms than the initial standard. The use of Temporal Key Internet Protocol (TKIP) and Advanced Encryption Standard (AES), along with 802.1i protocols, makes wireless LANs very secure. Also, the ratification of the 802.11e standard in 2006 offers quality of service important for VoWLAN applications.

Within the past couple of years, the prices for wireless LAN adapters have decreased to well under $100 each. This dramatic drop in prices has fueled the proliferation of wireless LANs for a variety of applications in all markets. The Wi-Fi Alliance has also been actively promoting wireless LANs through the Wi-Fi brand and mandating interoperability testing.

Because of the proliferation of wireless LANs, VoWLAN solutions are also proliferating. Companies offering VoIP equipment, such as Cisco, have been marketing VoWLAN phones that interface with their digital telephony systems. Even service providers, such as Vonage, now offer Wi-Fi phones that interface with their Internet Protocol (IP) telephony service.

Healthcare

Hospitals were one of the first users of VoWLAN solutions, such as Vocera, mainly because of the significant need for effective communication among high-valued medical staff. The ability for doctors and nurses to respond quickly with verbal instructions is crucial for saving the lives of patients. For example, Children's Hospital in Madera, California, uses a VoWLAN system to support push-to-talk features on its VoWLAN phones to broadcast Code Blue alerts that summon emergency teams. Patients receive a higher level of care, which leads to faster recovery. VoWLAN systems allow hospital staff to not waste time looking for a phone to use.

An issue with deploying VoWLANs in hospitals, though, is the difficulty in providing adequate wireless LAN coverage. Hospitals include x-ray rooms surrounded by lead, irregular metal objects, and unpredictable traffic flows of people. These factors lead to significant signal impairments. In addition, RF interference from other wireless systems

operating in the 2.4GHz band, such as frequency-hopping spread spectrum devices, can cause degradation in performance. As a result, installers must conduct thorough RF site surveys when identifying optimum placement of wireless access points.

Hospital in Northeast U.S. Benefits from VoWLAN Solution

Doctors and nurses at this hospital, as in others, are always on the move, taking care of patients. To do this effectively, the doctors and nurses must be capable of contacting each other immediately as emergencies arise, which is fairly often. For example, a nurse may find that a particular patient develops complications a few hours after surgery and needs immediate attention from a doctor. Before VoWLAN systems, the nurse would try calling the doctor on a cell phone. Cell coverage in the hospital was not very good, and the call would go immediately to the physician's voice mail. If the nurse could not make immediate contact with the doctor over the cell phone, which was about 75 percent of the time, the nurse would then call the doctor's pager. Pager coverage was very good throughout the hospital. The physician would receive the page and then find a wired phone to call the nurse. This task added significant delays because a phone could not always be found quickly, and the nurse would have to wait around a phone for the doctor to call (taking the nurse away from the patients needing assistance).

The hospital deployed a wireless LAN that supports the use of VoWLAN phones, enabling doctors and nurses to stay in immediate contact with each other. Now when a nurse needs a doctor's attention to help an ailing patient, the nurse can simply call the doctor directly using the VoWLAN phone. All calls go through because the wireless LAN was installed in a manner that provides signal coverage in all parts of the hospital. This solution significantly reduces communications delays, and patients receive immediate attention and care.

The hospital installed 120 wireless LAN access points to provide signal coverage for the VoWLAN phones. To determine optimum access point installation locations, the hospital conducted an RF site survey. Ensuring high enough signal strength and cell overlap throughout the hospital is very important to maintain effective operation of the phones and roaming.

Enterprises

Enterprises are taking advantage of VoWLAN applications to provide mobility to workers and reduce costs through a common network infrastructure for voice and data. In many cases, enterprises implementing VoWLAN are doing so as an extension to wired VoIP systems. A company, for example, can equip the majority of the employees with a wired VoIP desk phone, and VoWLAN handsets are given to the employees needing mobility. Certainly the benefit of going wireless is that users can carry their phone with them throughout the facility, which enables them to respond faster to customer needs and

functions within the company. The use of VoWLAN phones also eliminates the costs associated with rewiring telephone lines when employees change offices.

Enterprise executives making the decision to spend money on the necessary hardware and services need solid numbers before committing funds. An issue with deploying VoIP, and especially VoWLAN, in enterprises, however, is accurately predicting ROI. Assessing the returns a company will achieve by enabling faster response to customer needs, for example, is difficult. A company must be capable of achieving significant productivity benefits before moving forward with a VoWLAN deployment.

Executive Management Team at Corporate Headquarters Benefits from VoWLAN Solution

A particular enterprise, as with most other companies, has an executive management team located in a centralized location of the company's headquarters facility. All of these executives are infrequently in their offices—they manage by walking around and keeping tabs on their various departments. For example, the IT manager is generally visiting with technicians distributed in various parts of the facility, making sure that projects, such as PC hardware upgrades, are going smoothly. The problem is that when issues arise, the technicians have no way of contacting the IT manager immediately. The technicians use a phone in the office where they are working to call the manager's office, and 90 percent of the time must leave a voice message. In most cases, hours would pass before the manager would receive the message.

The solution to this problem was for this company to make use of an existing wireless LAN and deploy VoWLAN phones to the managers. This solution enables just about anyone to reach an appropriate manager within seconds, without experiencing the delays of voice mail.

Universities

A university environment is highly mobile, with teaching staff and students moving among different classrooms, libraries, and offices. The use of VoWLANs at a university offers tremendous benefits by enabling university staff to stay in touch from anywhere on campus. This capability makes teachers more accessible to students, and the learning environment is much safer. A teacher, for example, can report safety issues as they occur, rather than having to wait until a class ends.

A challenge of deploying a VoWLAN system at a university is that coverage must include a wide variety of buildings and outdoor areas. An extensive RF site survey is very important to take into account the varying facility construction and obstacles blocking radio waves. Even after installing the system, reevaluating coverage from time to time is generally necessary to determine whether student traffic and campus functions offer major signal attenuation.