

Business Guide to Voice over Wireless LAN

Michael Finneran

dBrn Associates, Inc.

189 Curtis Road
Woodmere, NY 11598 USA

Tel: (516) 569-4557

Email: mfinneran@att.net

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Overview

Voice communications is taking an important new direction with the adoption of voice over IP (VoIP) technology as the foundation for both consumer and enterprise telephone services. In the consumer space, cable telephony and VoIP services from carriers like Vonage and Skype (now part of eBay) are demonstrating that IP is a viable and cost-effective alternative to traditional circuit-based voice networks. In enterprise communications, we are seeing a wholesale migration from traditional PBX systems to IP PBXs that rely on this same technology to reduce the cost and increase the functionality of business telephone systems.

In the IP PBX area, the most exciting development is the ability to provide enterprise users a mobile voice service by combining VoIP with wireless local area networks (WLANs) based on the IEEE 802.11 or Wi-Fi Standards. With mobile access, voice users no longer have to be out-of-touch when they are away from their desks. Sage Research reports that 52% of business users must use multiple methods to reach people. A caller may cycle through a series of attempts to the party's desk phone, cell phone, and possibly email to make a critical contact. The unpredictability of reaching users at their desks has led many mobile executives to rely on their cell phones as their primary voice communication tool. The result is increased cellular charges, the inconvenience of poor indoor cellular coverage, and the burden of retrieving voicemail messages from two separate systems.

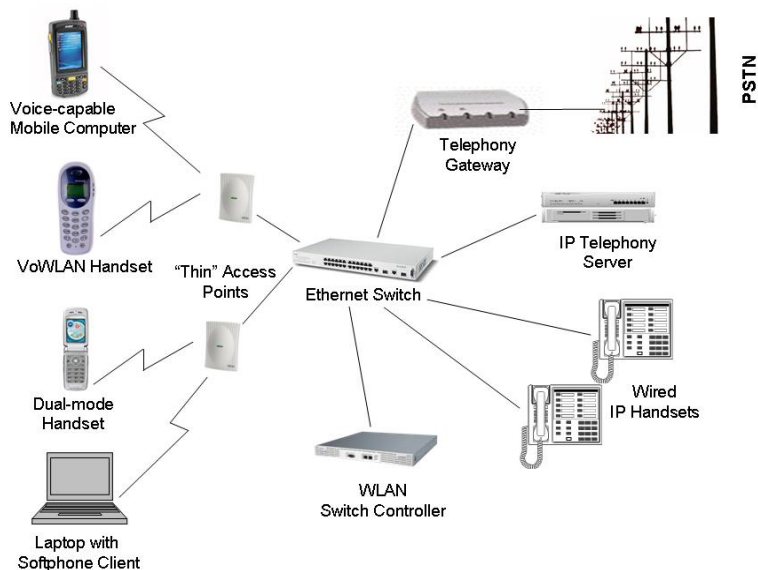
VoWLAN can provide a cost-effective way for users to stay connected while moving throughout the facility, or across campus; however, this application presents significant challenges in the design of the WLAN with regard to reliability, voice quality, and manageability. While the benefits of a mobile voice solution are easy to grasp, a successful implementation will require sound planning. The purpose of this white paper is to describe the configuration, applications, challenges, and potential benefits of an enterprise voice over WLAN system. Enterprise users have high expectations with regard to the quality and reliability of telephone communications, so great care must be taken in the design and implementation of a mobile voice solution to meet those expectations.

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What Is VoWLAN?

The basic idea of voice over WLAN is to support mobile voice communications over the same wireless LAN infrastructure that was implemented to support mobile data access. Unlike a cellular service where the carrier designs the network, with voice over WLAN the enterprise can control its own site coverage and provide continuous access to critical personnel regardless of where they are located throughout the premises.

There are four major elements in a VoWLAN system:



- *VoWLAN Endpoints:* The first element to consider will be voice-capable devices that support a Wi-Fi compatible radio interface. While most people associate "voice" with "handsets", enterprise users might also require access to email and "line of business" data applications along with voice. For those users, softphone clients on PDA's or rugged mobile computers can provide both traditional voice as well as push-to-talk or walkie-talkie service. When integrating mobile voice and data applications, it is critical to have a platform with high quality audio design and a systems integrator with experience in both areas. In any case, battery life will be a major concern in any voice-capable mobile device.
- *Telephony Server/Gateway:* Whether wired or wireless, IP networks do not inherently support telephone services. To provide telephony services, IP networks require telephony servers to coordinate connections and provide features, and gateways to connect to the wired telephone network. WLAN telephony systems initially used proprietary signaling mechanisms, but the trend in IP telephony today is toward standards-based signaling using the Session Initiation Protocol (SIP).
- *WLAN Infrastructure:* Given the transmission range of a Wi-Fi device, the wireless LAN for a home or small office will typically require only one access point and one WLAN channel. An enterprise WLAN on the other hand is more akin to an indoor cellular network. A number of WLAN access points will have to be distributed throughout the coverage area and interconnected through the wired LAN. Given the challenges involved in insuring adequate coverage and capacity throughout an expansive area, centrally controlled WLAN switches are highly recommended for any large-scale WLAN deployment.

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- *Management and Operating Systems:* While the handsets, telephony server, and WLAN infrastructure are the essential elements needed to provide WLAN voice service, systems to monitor performance, record traffic patterns, assist in troubleshooting, and plan for growth are also critical in delivering an enterprise-quality VoWLAN service. Networks do not run themselves, so you will also need a team of network professionals who are trained to design and maintain the wireless network, integrate applications, resolve problems, and plan for growth and upgrades. That team is typically comprised of internal IT professionals working in conjunction with equipment suppliers. Complex projects involving voice and data connectivity often involve a professional service partner who can help bring all of the elements of the solution together.

How Does VoWLAN Help the Enterprise?

VoWLAN is an efficient means of addressing recognized business needs. The fundamental idea is that when associates can communicate and collaborate in real time, they can be more productive and allow for faster decision making. Further, when associates are more accessible, that leads to better customer satisfaction and greater customer loyalty. While continuous mobile access might be achieved in any number of ways (e.g., cell phones, pagers, walkie-talkies, etc.), the promise of VoWLAN is that it could be accomplished more efficiently and cost effectively by leveraging the same mobile devices and the same wireless infrastructure that supports data access.

Key drivers in the business case for mobile voice/data are:

Efficiency

- Ability to visit other work areas while covering incoming calls
- Ability to return calls and check voicemails without returning to the wired desk phone
- Improving responsiveness by having more associates with continuous voice access
- Reducing the number of devices an associate needs for voice and data connectivity

Improved Customer Satisfaction

- Shorter time to reach a live person (avoiding voicemail or call backs)
- Having more associates available to provide assistance
- Improved customer service and responsiveness

Employee Effectiveness

- Associates can coordinate and collaborate immediately, such as parts replenishment on an assembly line
- Quicker response times to customer inquiries, such as stock checks in a retail store
- Faster time to decision, such as point-of-sale clerks getting manager approvals for returns

What Can I Do with It?

There are two major classes of voice service available through VoWLAN:

Wireless IP Telephony

This means having a wireless handset or a software client in a mobile computing device that serves as an adjunct to or a replacement for your desktop phone. The wireless solution can offer extension dialing and other PBX features like call transfer, call forward, and multiple line appearances along with access to the company's discounted long distance services and voicemail systems. The benefit of VoWLAN

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telephony is the ability to extend those capabilities to where the work gets done –the point of activity, whether helping customers, interacting with fellow associates, or performing other tasks – all while remaining accessible through your main number.

Peer-to-Peer / Push-To-Talk

The voice client can also provide an individual with the ability to contact another party or a group of associates instantly with a push-to-talk or walkie-talkie service. This capability would eliminate the need for traditional walkie-talkies within the WLAN coverage area, and provide a streamlined means for associates to work. With an integrated voice/data solution, a store clerk on the sales floor would need to carry only one device to perform store tasks like price checks and markdowns, and have the ability to contact the stockroom instantaneously to assist a customer.

VoWLAN Benefits

Users immediately recognize the benefit of mobility that a wireless telephone service provides. You can now have access to telephone service, as well as data and email access, even when you are away from your desk. Along with the convenience of making critical contacts on the go, a mobile telephone service means that people will be able to reach you. Tasks that require immediate action won't get sidetracked to voicemail or email. By carrying a voice-capable mobile device with a single number for contact, business users could greatly increase the odds of being reached, and on the first try.

Along with the productivity benefits, there may also be direct cost savings associated with a reduction in cellular usage. Most enterprise cellular calls today are placed in areas where WLAN service is available. Many outside sales and support personnel use their cell phone as their primary business phone, even when they are in their offices. Along with the unnecessary charges, cell phone service inside buildings can be poor. So the user is paying premium rates for unreliable service when there is a more reliable and more cost-effective alternative close at hand.

Those productivity benefits increase when email and data applications can be delivered through that same device. Relatively low-capacity cellular data services represent a significant additional cost, but a high capacity data service could be delivered along with voice over the WLAN. A VoWLAN solution also reduces costs of both network support and device management. As the user has only one device for both voice and data, there are fewer devices to support and manage. Further, having only one network to support will result in a lower cost of ownership and a faster return on investment.

Potential Voice over Wi-Fi Solutions

The key to making the most effective use of voice over WLAN technology is to consider the widest range of applications. Voice over WLAN is not just about the office worker and it's not just about voice. Getting information into the hands of a mobile user has the potential for improving any number of business processes.

General Office - Managers and Knowledge Workers

Managers are the key to controlling workflow, responding to problems, and coordinating business processes. Information is the lifeblood of an organization, and the people with the necessary expertise are often stretched to the limit. If the people with the information can't be reached, problems multiply, costs escalate, and customers are lost. Whether that communication comes in the form of a phone call, a text message, or an alarm generated by a critical production system, time is of the essence. Many managers are mobile beyond the boundaries of the office, so the solution for many of these may involve cellular or other wide area wireless

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technologies like WiMAX. Further, if their requirements call for voice and data access, the wide area solution must be able to support both regardless of where the party is at that moment.

Healthcare

Whether we are looking at hospitals, nursing homes, or assisted living facilities, healthcare has been a key market for mobile work solutions. A study by Forrester Research found that 65% of nurses said they spent between 20 and 60 minutes a day trying to reach staff, and 66% had to search more than one channel to make contact. Besides the communication efficiencies to be gained through a mobility solution, reducing the error potential of paper-based systems can have an enormous impact on service quality and patient safety. A well-designed system will allow a physician to prescribe a medication wirelessly, the pharmacy system to dispense it, and the nurse to verify the process at the bedside. The nurse can scan the bar code on the patient's admissions bracelet, scan their own badge, scan the bar code on the prescription, and the system will verify that the right medicine, in the right dose, is being given to the right patient, at the right time, and that there are no medication conflicts or allergies. If problems arise, the nurse can use the voice capability to contact the physician immediately. It is important to note that these systems will also require high levels of security, which are now mandated by such standards as HIPAA in the United States.

Mobile Nurse Call System

With this system, a patient can press their bedside call button to page a nurse, who might be helping another patient a few doors away. The nurse can get the page immediately on a rugged PDA and then speak directly with the patient. The nurse can then determine the criticality of each patient request, prioritize them, and let each patient know when they will be helped. Rather than going to each patient's room and then back-tracking to get what they need, the nurse can fill requests more quickly and with fewer wasted steps. The result is improved efficiency and increased patient satisfaction.

Retail

Modern shoppers are a fickle and demanding lot. They expect a store to have what they want, when they want it, and if they don't, there are plenty of other places to shop. A retail outlet that cannot respond to those demands and deliver a pleasant buying experience is not going to be successful. To make the sale and maintain the goodwill of the customer, it is essential that the retail clerk be able to determine quickly when the product will be available. Wirelessly connecting the salesperson to the inventory and customer service capabilities allows them to move about the store, interact with customers, and still remain in touch with the whole knowledge base of the company. This type of *total-presence marketing* improves customer satisfaction and increases the potential for add-on sales.

Mobile Retail Application

With a mobile retail system, a customer may ask a mobile sales assistant to locate a particular sale item. The sales assistant can check the store display, and if they can't find it, use their mobile terminal to determine if the item is in stock. They can also check the inventory at neighboring stores, and if they locate the item they can contact a sales associate at that location with the push of a key. They can arrange to ship the item to their store or directly to the customer's home, all without leaving the customer's side.

Manufacturing, Warehousing and Materials Handling

Mobile communications are also essential for the back-office personnel who are responsible for building product, maintaining stock, and filling customer orders. It is not surprising that the "uncarpeted areas" of the enterprise were where wireless data technologies first took hold. While many organizations still rely on paper-oriented fulfillment systems, the potential for using wireless bar code scanners, wireless pick-lists, and voice-directed order fulfillment is enormous. This type of core business application requires a reliable and robust wireless infrastructure, because if that network goes down, it can impact the company's ability to get product out the door.

Mobile Warehousing System

A production line operator may realize they are getting low on a critical assembly component, jeopardizing the workflow. With a mobile warehousing system, the operator can use the same rugged mobile terminal he uses for data capture, press a push-to-talk key, and call for assistance. The call goes directly to a forklift operator, who checks his onboard mobile computer, determines the item is in stock, responds with a voice confirmation, and then fills the request before the line has to stop.

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Business processes improvement involves getting information to the right person at the right time so that the customer is served in the best and most efficient manner. Mobile voice and data solutions allow that information to flow even while the critical people are on the move as they often are in a modern business. However, network professionals will have to develop the systems that insure that critical connection can be made.

The IP Voice Infrastructure

A WLAN voice solution is typically one element in an enterprise-wide strategy to IP-enable all voice and data communications. The idea of carrying information in addressed packets through high-capacity switches and routers has instituted a new model for cost and performance in business communications. The first step in that process typically involves replacing the traditional telephone switching system or PBX with an IP PBX. While WLAN voice systems can work in conjunction with traditional PBX systems, local telephone switching is already migrating to IP for cost and operational benefits. According to consulting firm TEQConsult, in 2005 more IP-compatible business phones were shipped than traditional PBX phones.

Extending IP Telephony to the WLAN

The key element in any enterprise scale VoWLAN system will be a centrally controlled WLAN switching system like those from Cisco, Symbol Technologies, Aruba or Trapeze. A WLAN switch network is comprised of a number of access points whose operations are coordinated by a central controller. The controller typically has built in mechanisms to auto assign channels and control transmit power levels to ensure optimal wireless performance.

The central WLAN controller is also key in managing security, collecting performance/usage statistics, and coordinating handoffs as callers move between access points. Voice users are highly mobile, so the network must be able to handoff calls to adjacent access points quickly and maintain the continuity of the voice path. On the security front, in addition to ensuring authentication and data encryption, one of the critical features is the controller's ability to monitor for unauthorized or "rogue" access point installed by users or contractors in violation of the organization's security policies.

The handsets or other WLAN voice-capable devices are the other major element in a VoWLAN network. While a voice user needs only a handset, other users may require email, bar code scanning, and access to other data applications. The ruggedized versions of those devices that are geared for retail, healthcare, warehouse and materials handling applications often include push-to-talk voice capability. Laptop users can install a softphone client, which allows them to make and receive voice calls as well.

VoWLAN Challenges

Capacity

The most fundamental design issue in a WLAN voice system is insuring that the network has sufficient capacity to support the total volume of voice and data traffic generated. Data applications can typically operate in an under-provisioned network, though user response times are likely to suffer. With voice service however, insufficient capacity will mean users experience poor voice quality, dropped calls, and no service conditions. High quality voice service requires good signal strength and adequate network capacity to insure high transmission rates and minimize

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retransmissions. A properly planned wireless network with pervasive coverage and a sufficient number of access points is the first ingredient to a successful WLAN voice deployment.

Quality of Service (QoS)

WLANs operate on a contention basis, which means that the access point and the clients all vie for access to a shared channel. When user transmissions collide, they will have to be resent. In the first generation WLAN standards, every station has an equal probability of seizing the channel. The delays introduced by channel contention and retransmissions are often transparent to data applications, but voice services are far less tolerant of delay and jitter. If both voice and data traffic are to be supported, the goal should be to give preferred access to voice users.

The IEEE 802.11e standard for WLAN Quality of Service (QoS) provides just such a mechanism; the Wi-Fi Alliance identifies compatibility with 802.11e's most typical implementation as Wi-Fi Multi-Media (WMM) Certified. WMM/802.11e defines four priority levels or Access Categories, and stations with higher priority traffic like voice and video are assigned shorter pre-transmission waiting intervals to access the channel. As a result, if a voice and a data user are both waiting to send, the voice user will always go first. Higher priority stations are also assigned a shorter range of back-off timers in the event of a collision.

Security

Security is the most often cited reason why enterprise customers defer implementation of wireless LANs. The fundamental problem with wireless security is that it is virtually impossible to constrain the radio signal to the desired coverage area. The only protection against eavesdropping is to insure that all WLAN transmissions are robustly encrypted and provisions made for strong user authentication. In voice applications, it is also important that the security relationship be maintained when a device roams from one access point to another.

The security concerns with early Wi-Fi networks came from the inadequate Wired Equivalent Privacy (WEP) based encryption defined in the original 802.11 specifications. Today there are two far more functional options designated Wi-Fi Protected Access (WPA) and Wi-Fi Protected Access- Version 2 (WPA2), either of which will provide enterprise-grade security. WPA was an interim step from the Wi-Fi Alliance that uses the same encryption technique as WEP, but changes the key on every packet to thwart brute force (i.e. trial and error) cracking; that key-changing technique is called the *Temporal Key Integrity Protocol (TKIP)*. WPA2, defined in IEEE 802.11i, is the preferred solution today as it uses the Advanced Encryption Standard (AES) encryption mechanism that has been adopted as the US Government's standard for encryption. The 802.11i specification also includes features for key caching that will help reduce roaming times.

Battery Life

The other major challenge in WLAN voice is battery life. Unlike cell phones that were designed with power conservation in mind, the initial WLAN protocols did not look to optimize battery life. The result was that many early WLAN handsets could not operate for an entire shift on a single battery charge. One important element in the 802.11e standards is a feature called Automatic Power Save Delivery (APSD) that can significantly improve battery life. Beyond that, WLAN switches often include additional features to increase both talk and standby times for WLAN voice devices.

In installations that require several types of VoWLAN equipment (e.g., handsets, PDAs, mobile computers), it is important to find partners with access to the widest range of devices to insure all of the users requirements can be met and that all of the different equipment options can be integrated in the WLAN solution.

VoWLAN Network Management

Providing a reliable mobile telephone service that operates in an indoor environment presents a number of technical challenges. Radio signals lose power at an exponential rate as the distance between the sender and receiver increases. Obstructions in the transmission path and multipath (i.e., the interference caused by receiving multiple images of the signal) can also diminish the signal strength. Further, interference from nearby WLAN installations can also affect your network performance. These factors can lead to dead spots, increased transmission delays, lower network efficiency, and areas where the wireless devices drop to their lowest transmission rate. From the user's standpoint, this means diminished voice quality, dropped calls, or no service available.

Given the unpredictability of indoor radio propagation, a successful WLAN voice network will require a comprehensive set of management and support systems to maintain the service and resolve problem conditions. Among the elements to include are:

RF Coverage Survey: Once the network is installed, a radio coverage survey should be conducted to document the quality of the radio coverage throughout the facility. That survey will be a valuable reference to help identify conditions that have changed and antenna or other problems that crop up later.

Call Access Control: WLANs support a maximum number of simultaneous calls, and if we allow additional calls to be set up, the quality for all of those calls will drop significantly. Further, if QoS is used, voice users will have preferred access, and data traffic could be squeezed out entirely. As part of the network design, you must estimate the number of callers who will be accessing the network in each area, and insure you have sufficient capacity to support them along with the expected data usage. Call access control describes the ability to limit the number of calls each access point will accept, and so insure the quality of those connections.

Load Balancing: If an access point is supporting its maximum call volume, call access control can deny additional call attempts. To avoid network busy signals, the preferred approach would be to steer those additional callers to an alternate access point that does have available capacity at that moment. There is a developing standard for load balancing designated 802.11u, but it is not expected before 2008. In the meantime, some WLAN switches do have some mechanism to implement this load balancing. WLAN switching systems from Symbol Technologies include a preemptive roaming capability that automatically transfers calls to access points with less traffic.

Statistics Collection: You will also have to collect statistics to monitor call volumes, assess overall network performance, and plan for upgrades. There are a number of information elements you will need to collect including:

- Calls per Access Point (Average and Maximum)
- Calls Denied/Load Balanced per Access Point
- Percent of Calls Dropped per Access Point
- Percent of Packet Retransmissions per Access Point
- Average Data Rate Used per Access Point
- Average and Maximum Handoff Times

Call Detail Recording: With the move toward standard SIP-based signaling, many WLAN switching systems can now monitor the SIP signaling exchange and produce call detail records that link to the calling and called numbers. Some can even produce a mean opinion score (MOS) to estimate the quality the user experienced on the connection. That information can be

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critical in responding to trouble reports made after the call is completed. Among the information elements to collect are:

- Date, Time, and Duration of the Call
- Called and Calling Parties
- Percentage of Dropped Calls
- Access Points Used, Handoff Times
- Percent of Packet Retransmissions
- Average Data Rate

All of the information in the world is useless if the help desk technicians are not trained in voice troubleshooting. They must know what information to collect from the caller (where were you using the Wi-Fi phone, was the problem continuous or sporadic, were you moving during the conversation, etc.) and how to retrieve and analyze the call detail and network monitoring information. One last point in assessing network management systems: the best network management system is not necessarily the one that produces the most statistics, but the one that helps get the problem resolved in the fastest and surest manner.

Looking Ahead- Fixed-Mobile Convergence

The major limitation of a WLAN voice solution is that coverage is limited to the company's facilities. A solution that would merge the capabilities of Wi-Fi with the coverage of a cellular telephone network would offer far greater functionality; that capability is now called Fixed-Mobile Convergence (FMC). When we consider a mobile voice/data network today, we should not limit our vision to employees who are located inside of our facilities, but rather look to address users who depend on cellular or other wireless services.

The ultimate in mobility would be a network that seamlessly merged the wireless LAN with a cellular service so a user could carry one device, with one phone number, with one voicemail, and have a consistent experience regardless of which network they were connected through. An FMC solution could also reduce cellular charges by redirecting some of that traffic to the wireless LAN. Further, the WLAN could provide better voice quality and higher data rates while the user has WLAN connectivity. That WLAN access could be found inside a company facility, at a public Hot Spot, or on a home-based WLAN network.

The US cellular carriers have been reluctant to embrace that type of integrated wireless vision, but that position is starting to change. T-Mobile is reportedly planning a consumer-oriented FMC service in the 2007 timeframe that would work with either home-based WLAN networks or their public Hot Spot locations. In Japan, NTT DoCoMo is already supporting over 50,000 Wi-Fi/cellular subscribers on its FMC service. In the UK, BT is offering a residential FMC service called *BT Fusion* that includes a dual mode cellular/Bluetooth handset and a home base station that hands calls off transparently between their cellular service and a Bluetooth accessible broadband VoIP service.

There are also FMC solutions that do not depend directly on the cellular carrier. Start-up DiVitas Networks builds a server that works with dual mode Wi-Fi/cellular handsets and allows voice calls to be transferred between the two networks. When a Wi-Fi voice user moves out of the coverage area of the WLAN, the DiVitas server instructs the wired PBX to call them on their cellular number. Once the cellular call is set up, the call is automatically transferred to the cellular connection. Special client software in the handset makes the exchange completely transparent to the user.

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As you can see, the initial FMC solutions are targeting traditional voice calls. Enterprise customers with push-to-talk or integrated voice/data applications will need a converged solution that addresses the full range of their requirements. The key will be to find partners with the necessary expertise and a wide range of products to address those multi-faceted requirements.

Conclusion

The adoption of Wi-Fi and VoIP technologies in enterprise organizations make their convergence almost inevitable. The ability to reach mobile users on the first try increases efficiency and provides the ability to speed critical business processes. That view is bolstered by the fact that carrying mobile voice calls on the wireless LAN can reduce cellular usage and provide better voice quality when users are in areas where WLAN coverage is available. To fully exploit the technology, users should also look to incorporate email and data access with voice to support core business applications; a configuration that can yield a solution with a far greater impact both in terms of cost savings and business process improvement.

Any VoWLAN solution requires careful planning, a robust and resilient infrastructure, and a set of management systems that will insure that the service can be maintained and supported. Buyers will be well advised to look for suppliers who on their own or through a network of partners and integrators can provide a full complement of VoWLAN solutions. A good network integrator should have access to the widest range of converged devices, wireless LAN infrastructure, management applications, and IP PBX systems along with the expertise to develop and deliver all of the elements of an integrated solution.

About dBrn Associates

dBrn Associates, Inc. is an independent network consulting firm specializing in wireless networks and technologies.

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Michael Finneran can be reached at mfinneran@att.net.

