Implementing Voice on Wireless LANs-

Michael Finneran

dBrn Associates, Inc.

Tel: (516) 569-4557
Email: mfinneran@att.net

The first article I wrote on the subject of carrying voice over wireless LANs was published in the January 2004 issue of *Business Communications Review*; surprisingly little has happened since then. While Voice over Wireless LAN (VoWLAN) or Voice over Wi-Fi (VoWi-FI) has been a hot topic among the analyst set, its acceptance among enterprise users has been minimal. Of the roughly 40 million Wi-Fi stations in use, less than a half million are voice devices. The vast majority of those are confined to a few vertical markets like health care and retailing. Given the flood of articles on the topic, that lack of success cannot be attributed to poor market awareness.

Given the limitations of the existing WLAN infrastructure in most enterprises and the capabilities of our current crop of VoWLAN handsets, deferring the implementation was probably a wise choice. However, 2006 should be a transition year for VoWLAN. Developments in WLAN switches should allow us to address the deficiencies in the WLAN infrastructure. Further, a new generation of WLAN handsets should finally provide the capabilities an enterprise IT department needs to deliver WLAN-based voice services that meet the users' expectations for quality, reliability, and availability.

In the meantime, many IT departments still struggle to assimilate WLAN technologies. Most of the initial networks had significant start-up problems and required considerable tweaking before they could be considered stable. Voice, by definition, is a mission critical application, and it requires virtually all of the newest features and standards in wireless LANs. So before setting out on that road, IT departments should be very sure they know what lies ahead.

Part 1- Segments of the VoWi-Fi Market

Despite the rather small installed base, the Voice over Wi-Fi (VoWi-Fi) market has already broken into three separate and distinct segments:

◊ ***Wi-Fi Cordless Phones:*** These are devices designed for home Wi-Fi networks or public Hot Spots, and allow the user to access public VoIP services. They generally do not have the features required for enterprise networks. UTStarcom's F1000 that supports access to Vonage's VoIP service would be an example.

◊ ***Enterprise VoWi-Fi Handsets:*** These are devices designed to be used in commercial installations in conjunction with a wired PBX system. SpectraLink dominates the market today, though Cisco, Vocera, RIM, Siemens, and Symbol Technologies also make products that serve this segment. These are the devices we will be focusing on primarily.

◊ ***Integrated Wi-Fi/Cellular Handsets***: Correctly implemented, an integrated WLAN/cellular capability would be the most functional solution as it would allow the user access to either the WLAN voice capability or a public cellular service.

Among the *Integrated Wi-Fi/Cellular Handsets, t*here are two different levels of functionality being provided:

- *Integrated Packaging:* This means that the WLAN and cellular capabilities are built into the same handset, but they are completely independent; there is no hand-off capability between the two networks. The user would have access to two separate networks, with two phone numbers, and a dual-personality handset that would allow them to access either service alternately.

- *Converged WLAN/Cellular Device:* In this case, the two devices are built into the same package and the handset can recognize if WLAN service is available. Further, when the user moves between the WLAN and cellular coverage areas, the call would be handed off. While this capability has been widely discussed, no products capable of providing a true cellular-WLAN hand-off are available in the US today.

> BT Telecoms' consumer-oriented *Fusion* service seems to be the only network in the world that delivers truly integrated public/private wireless network integration today.

An integrated WLAN/cellular capability with transparent two-way hand-offs would be the ideal solution; however implementing such a capability would require the cooperation of the cellular carriers. Thus far, the carriers have refused to allow any WLAN integration solution, even ones that require virtually no modification to their networks whatever. Until this impasse is resolved, the sole benefit of an integrated Wi-Fi/cellular handset is that it alleviates the need for a user to carry two devices. They would still have two phone numbers, two voicemails, and all of the inconvenience of dealing with two separate and distinct voice services. The WLAN portion of that integrated device would require the capabilities we describe below.

Part 2
The WLAN Infrastructure

If we are serious about supporting voice over our wireless LAN, the first issue to address is the WLAN infrastructure. Most organizations today have deployed "spot coverage" for WLANs with access in conference rooms, public areas, and other locations where we expect people to show up with laptops. Research tells us that better than 50% of WLANs cover only 30% of employees. Unfortunately, the market research only identifies the percentage of employees. The more meaningful measure, would be the percentage of floor space that is covered (i.e. "Ask a stupid question, …").

Voice users will wander wherever their feet may take them, and the WLAN will have to be available to them when they arrive. Voice service requires pervasive WLAN coverage (i.e. WLAN coverage throughout the facility). My own research indicates that fewer than 20-percent of large commercial facilities have that pervasive coverage today. The exceptions are small offices, where you only need one access point to cover the entire facility.

Among WLAN experts, it is widely recognized that the only way to build a large-scale, enterprise-grade wireless LAN is with a centrally controlled WLAN switch. These types of systems are sold by Cisco (particularly with the Airespace product line), Aruba, Trapeze, Meru, and others. The functionality provided is far more important than the architecture argument regarding the use of "thick" versus "thin" access points. The real issues are what capabilities the system provides and the overall cost. As enterprise customers begin rolling out WLANs in earnest, those centrally controlled systems will be the fastest growing segment of the WLAN market.

The first big decision regarding the infrastructure will be whether we support voice and data devices on the same or on different wireless LANs. While the idea of building a separate WLAN for voice was originally viewed as wasteful extravagance, switched WLANs are making this strategy more cost effective. A single WLAN controller can typically support both networks, and many commercial access points can be configured with two radios. As a result, much of the infrastructure can be shared. We refer to this type of deployment as a *dual overlay network*, and we would typically use a 2.4 GHz 802.11b/g network for data devices, and a 5 GHz 802.11a network for voice.

As we put that WLAN infrastructure in place, there are a few critical functions it will need in order to support voice:

◊ **802.11e Quality of Service**

WLANs operate on the principle of shared media, and IP-PBX vendors universally caution against using shared-media LANs for voice. Contending for a shared transmission channel invariably increases both latency and jitter. Miercom's testing shows that voice latency increases on the order of 20- to 30-msec when the call is carried on a WLAN (Ed Mier, Dave Mier and Robert Tarple, "Which IP PBX Rules?" *Business Communications Review*, January 2005, pp. 24-37).

If we intend to support both voice and data users on the same WLAN, it will be critical for vendors to support the IEEE's new 802.11e standard for Quality of Service (QoS) to prioritize voice access and minimize latency and jitter. When 802.11e-certified products begin to appear in mid-2006, the earlier and less-capable solutions like SpectraLink's SVP should start to disappear.

The 802.11e standard actually defines two distinct QOS options: Enhanced Distributed Control Access (EDCA) and Hybrid Controlled Channel Access (HCCA). From vendor reports it appears that only EDCA will be widely deployed. EDCA does not provide dedicated capacity for voice traffic, rather it gives voice users priority access to the shared channel. To understand how 802.11e works, it is important to understand a little about the operation of Wi-Fi's Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol.

All stations on a wireless LAN transmit and receive on the same channel. As a result, when a WLAN device is transmitting, it cannot hear other transmitters; hence there is no way to "detect" collisions as we do in a traditional wired Ethernet. To help *avoid* collisions, WLAN stations wait a defined interval before they transmit; that interval is called an Inter-Frame Spacing. If a collision occurs, the stations back off by a random amount before trying again.

In the original 802.11 CSMA/CA protocol, two waiting intervals were defined:

- DCF Inter-Frame Spacing (DIFS): The interval a station waits before sending a frame
- Short Inter-Frame Spacing (SIFS): The interval a station waits before sending a message acknowledgement or *ACK*. The SIFS interval is also user in some other WLAN operations like streaming and fragmentation.

As the SIFS interval is shorter, if one station is waiting to send a frame and another is waiting to send an ACK, the ACK will always be sent first.

The 802.11e Enhanced Distributed Control Access (EDCA) builds on that fundamental idea, and defines four levels of traffic priority called Access Categories. For higher priority traffic, the standard assigns shorter waiting intervals (called Arbitrated Inter-Frame Spacing or AIFS) and shorter back-off ranges.

802.11e Access Category	Description
Voice	The highest priority with the shortest intervals
Video	Lower priority than voice
Data	Uses the same DIFS interval and back-off range as current (i.e. pre-802.11e) WLAN devices
Background Data	The lowest priority for the least time-sensitive traffic

In essence, 802.11e defines two access categories that take precedence over existing devices, and one that has a lower priority. The beauty of this implementation is that pre-802.11e devices can be supported on the same network, and they will automatically be categorized as "Data". To take advantage of 802.11e's capabilities, any existing voice devices will require a software upgrade that will allow them to exercise their higher priority access to the channel.

Another important feature of 802.11e is streaming. In normal operation, a station gets to send one frame with each access opportunity; sending multiple frames would require vying for access to the network multiple times. Recognizing that voice traffic occurs in "bursts", streaming allows a device to send all of the frames it has accumulated on one access (Note: Each voice frame typically contains 20 msec of speech). Once the device gets access to the channel, subsequent frames are sent after a SIFS.

◊ **Call Access Control/Load Balancing**

While 802.11e will give voice users higher priority access to the channel, all voice users have the same access priority. That means a voice user should never collide with a data user; however, two voice users could still collide. In light of that, we still need a mechanism to prevent too many voice users from associating with the same access point (i.e., "protecting voice from voice"). If the access point doesn't have enough capacity to support another call, it has two options: deny or redirect.

Deny means that the AP simply returns a busy signal. Unfortunately, users don't like busy signals, so this strategy will not make us popular with the user community. The more functional approach would be to redirect that user to another, less congested access point. In a WLAN deployment for voice, we aim to have some degree of coverage overlap, so in most locations a user should have access to at least two access points.

Unfortunately, call access control and load balancing functions are not addressed in the standards. In deploying a VoWi-FI system, we will have to investigate the call control capabilities provided by the WLAN switch, above and beyond support for 802.11e.

◊ **Handoffs**

The other major attribute that distinguishes voice users from data users is mobility. Laptops are generally stationary when connected to the network, and data applications are not as time sensitive as voice connections. An essential requirement of a voice WLAN is the ability to support a fast handoff (i.e. <50 msec) that maintains the security relationship.

The IEEE 802.11r committee is developing a standard for fast, secure hand-offs, however, that standard is not expected until 2007. If we need to support hand-offs before 2007, an interim solution will have to be found. Fortunately, many WLAN switches have already demonstrated their ability to support sub-50 msec secure handoffs.

The 802.11r solution will give us a similar level of functionality along with the ability to mix different vendors' access points in a centrally controlled WLAN. However, if we intend to buy all of our WLAN switch components from the same vendor, we might very well elect to stay with our selected vendor's approach regardless of the status of 802.11r. We'd all love a standards-based handoff capability, but if you've got to deploy WLAN voice today, we're simply not getting it.

◊ **Security**

When we talk about security, there are two major areas to address: device authentication and privacy. If the authentication system is compromised, we could expose the network to toll fraud or theft of service (i.e. paying for a hacker's phone calls). If privacy were compromised, a hacker could eavesdrop on WLAN phone calls.

Authentication hacks are unlikely as most enterprise VoWi-Fi devices use 802.1x authentication. Further, the hacker would have to be within close proximity to the facility to place a call. Eavesdropping on WLAN voice conversations is a real concern, particularly if we're depending on static WEP encryption.

Voice handsets have clearly fallen behind in terms of security; SpectraLink and Cisco just introduced WPA (Wi-Fi Protected Access) support in 2005. Though there has been some reluctance among enterprise users to implement WPA, to date there have been no successful hacks against Enterprise WPA (i.e. WPA with 802.1x key generation). The 802.11i/WPA2 encryption would offer an even better degree of protection, but thus far only Symbol Technologies has deployed it in their MC70 Enterprise Digital Assistant (EDA). For the rest, we'll have to wait for the next generation of handsets. Of course, if we intend to support those 802.11i handsets on a shared voice/data WLAN, the lack of support for 802.11i on existing data devices may become a problem.

Part 3-
Handset Requirements

Most of the currently available WLAN handsets have been on the market for a few years, and lack many of the features an enterprise would need to deliver a stable, large-scale voice service. First, most current handsets support only the 11 Mbps 802.11b radio link. As of late 2005, the only exception to that was Siemens' optiPoint WL2, which can support the higher-speed 802.11g radio link (i.e. 54 Mbps, 2.4 GHz). The optiPoint is only supported on Siemens' systems, so the other PBX vendors had to make due with what they could get from SpectraLink, Vocera, or Cisco.

The choices for WLAN handsets would include three broad categories:

- ◊ Voice Handsets: Something that looks like a telephone and may include the capability to place calls on a cellular network as well.
- ◊ PDA-based Softphones: The success of RIM's Blackberry and the Palm Treo PDA/phone devices has clearly demonstrated that there is a market for an integrated PDA/phone. Some of the earliest VoWLAN

phones were actually softphones built into specialized PDA-type devices like barcode scanners.

◊ Laptop-based Softphones: While we could potentially build a softphone capability into a laptop and connect that device over a wireless LAN, you would have to ask why someone would bother to do that. The whole idea of WLAN voice centers on mobility, and who would want to drag a laptop around to make phone calls?

Enterprise VoWLAN Handset Manufacturers	
Company	**Web Site**
Cisco	www.cisco.com
Research in Motion (RIM)	www.blackberry.com
Siemens	www.siemens.com
SpectraLink	www.sprectralink.com
Symbol Technologies	www.symbol.com
Vocera	www.vocera.com

Regardless of the form factor and other capabilities, support for WLAN voice will require a basic set of capabilities. As of early 2006, most WLAN handsets available lacked the key features we need to support enterprise-grade voice. However, a new generation of WLAN handsets should be hitting the market in the first half of 2006. Symbol Technologies announced the first of those in January 2006 with their heavy-duty MC70 Enterprise Digital Assistant (EDA). Combining a GSM cell phone and a VoWLAN phone in the same unit, the MC70 is the first Wi-Fi handset to support 802.11a, b, and g radio links and 802.11i security. As we get ready for the new set of Wi-Fi handsets, here are the major features you should be looking for:

◊ **Quality of Service: 802.11e**
If the WLAN network will be supporting both voice and data devices, 802.11e support will be critical to minimizing latency and jitter for voice users. As we noted above, all voice devices will access the channel on an equal basis, so if we build a separate WLAN network exclusively for voice, 802.11e will provide little additional functionality.

◊ **Radio Links: 802.11g and a**
While 802.11b launched the wireless LAN market, it has become an albatross around our collective necks. By itself, 802.11b supports a maximum data rate if 11 Mbps, and when used in combination with 802.11g devices, it cuts the throughput for g devices substantially. A single 11 Mbps WLAN can support about six simultaneous voice connections. As a minimum, voice handsets should support the 54 Mbps 802.11g interface, but they should also support the 5 GHz 802.11a interface. The 802.11a interface provides 23- non-interfering channels (US implementation) versus 3- non-interfering channels in the 2.4 GHz band. The availability of additional channels is critically important in laying out a large-scale WLAN where channels must be reused in different parts of the facility.

IEEE 802.11 Radio Link Interfaces						
Standard	**Max. Bit Rate**	**Fallback Rates**	**Channel Bandwidth**	**Channels Provided**	**Transmission Band**	**Radio Technique**
802.11b	11 Mbps	5.5 M, 2 M, and 1 Mbps	25 MHz	3	2.4 GHz	DSSS
802.11g	54 Mbps	Same as 802.11a plus 2 M, an 1 Mbps	20 MHz	3	2.4 GHz	OFDM
802.11a	54 Mbps	48 M, 36 M, 24 M, 18 M, 12 M, 9 M, 6 Mbps	20 MHz	23	5 GHz	OFDM

Proposed 802.11n Data Rates									
		20 MHz Channel Data Rate (Mbps)							
Modulation	FEC	1 Stream		2 Streams		3 Streams		4 Streams	
		Guard Interval		Guard Interval		Guard Interval		Guard Interval	
		800ns	400ns	800ns	400ns	800ns	400ns	800ns	400ns
BPSK	1/2	6.5	7.2	13.0	14.44	19.5	21.7	26.0	28.9
QPSK	1/2	13.0	14.4	26.0	28.89	39.0	43.3	52.0	57.8
QPSK	3/4	19.5	21.7	39.0	43.33	58.5	65.0	78.0	86.7
16-QAM	1/2	26.0	28.9	52.0	57.78	78.0	86.7	104.0	115.6
16-QAM	3/4	39.0	43.3	78.0	86.67	117.0	130.0	156.0	173.3
64-QAM	2/3	52.0	57.8	104.0	115.56	156.0	173.3	208.0	231.1
64-QAM	3/4	58.5	65.0	117.0	130.00	175.5	195.0	234.0	260.0
64-QAM	5/6	65.0	72.2	130.0	144.44	195.0	216.7	260.0	288.9

Further, since the 802.11a channels are in the 5 GHz band, they create no interference for 802.11b/g devices. Support for 802.11a would give us the option of deploying a separate 802.11a network for voice devices while leaving the data devices on the 2.4 GHz b/g channels.

There is also a developing radio link standard designated 802.11n, the draft for which specifies that it will operate in both the 2.4 GHz and 5 GHz bands and support data rates up to 600 Mbps. While the draft has been accepted, the final standard is not scheduled for ratification until September 2007. Also, support for those very high data rates will require a new radio and a MIMO antenna system; that probably means a whole new handset. Given that schedule, we probably should not factor 802.11n into our immediate planning calculations.

◊ **Security- WPA, WPA2, 802.1x**

While the current crop of handsets is just getting around to WPA, as of mid-2006, all new Wi-Fi Certified devices will have to support 802.11i. Accordingly, we can safely assume that all of the new handsets will include 802.11i.

Unfortunately, that will put WLAN voice security a generation ahead of data devices. The vast majority of the installed laptop NICs cannot support 802.11i, nor can they be upgraded to support it. That means the ability to use 802.11i for voice security on shared WLANs may be impaired by the by the capabilities of the data devices.

Proposed 802.11n Data Rates									
		40 MHz Channel Data Rate (Mbps)							
Modulation	FEC	1 Stream		2 Streams		3 Streams		4 Streams	
		Guard Interval		Guard Interval		Guard Interval		Guard Interval	
		800ns	400ns	800ns	400ns	800ns	400ns	800ns	400ns
BPSK	1/2	13.5	15.0	27.0	30.0	40.5	45.0	54.0	60.0
QPSK	1/2	27.0	30.0	54.0	60.0	81.0	90.0	108.0	120.0
QPSK	3/4	40.5	45.0	81.0	90.0	121.5	135.0	162.0	180.0
16-QAM	1/2	54.0	60.0	108.0	120.0	162.0	180.0	216.0	240.0
16-QAM	3/4	81.0	90.0	162.0	180.0	243.0	270.0	324.0	360.0
64-QAM	2/3	108.0	120.0	216.0	240.0	324.0	360.0	432.0	480.0
64-QAM	3/4	121.5	135.0	243.0	270.0	364.5	405.0	486.0	540.0
64-QAM	5/6	135.0	150.0	270.0	300.0	405.0	450.0	540.0	600.0

◊ **WMM Power Save**

Battery life has been a major difficulty in VoWLAN handsets. Where cell phones routinely provide several hours of talk time and hundreds of hours of standby operation, Wi-Fi devices support a fraction of that. One very important feature to improve battery life is the Wi-Fi Multimedia (WMM) Power Save Feature. WMM is the Wi-Fi Alliance's interim QOS standard introduced in late-2004. Along with defining an EDCA-like mechanism for giving voice devices priority access to the LAN channel, WMM also includes a feature to improve battery life and reduce latency.

The original 802.11 standard has a Power Save feature that has the client "wake up" every 100 msec to listen for the access point's beacon message to determine if there is downstream traffic waiting in queue. If there is traffic in queue for it, the client must sends Power Save-Poll message to retrieve each individual frame.

WMM Power Save (WMM-PS) allows the user to tailor the wake-sleep cycle for each application. In WMM-PS, the voice handset wakes up on its own schedule (typically every 20 msec for voice devices) and sends a "trigger frame" to the access point; the trigger frame can also contain data. In response, the access point downloads all frames in queue (i.e. the client does not have to poll for each individual frame). As a result, the handset is awake for a shorter time and sends fewer polling messages. The Wi-Fi Alliance estimates this feature should improve power consumption 15- to 40-percent while improving latency for voice traffic.

◊ **Feature Integration**

Feature keys are one of the major conveniences in a business telephone system. As WLAN handsets are often provided by a third-party (i.e. not manufactured by the PBX vendor), the level of feature integration varies widely. So in selecting handsets, we can assume the ability to make and receive calls, but we must also assess the user interface and ease-of-use characteristics.

◊ **Form Factor/Accessories**

Management users will inevitably compare Wi-Fi handsets to their cell phones. The size of current WLAN handsets is akin to clunky residential cordless phones. Further, they typically do not support the range of accessories that users take for granted with cell phones (e.g. car chargers, holsters, wireless headsets, etc.). As WLAN voice has typically been deployed only to lower-level employees (e.g. nurses, maintenance staff, warehouse employees), this hasn't been a major issue. When we can deliver an enterprise-grade WLAN voice capability, demand among the executive ranks will skyrocket, and those folks will want a selection of clamshell phones, PDA phones, and all of the nifty accessories they get from their cellular carriers.

4. Traffic Monitoring and Network Management

Providing a WLAN voice capability is not simply a matter of picking some handsets, insuring that they adhere to a checklist of standards, and passing them out like campaign buttons. The primary responsibility of the IT department is to insure that we have an infrastructure in place that will provide the required service with the support features and tools we need to maintain that service and identify problems areas. Those functions are not covered in the standards, though they will be critical issues in selecting the equipment we need to implement the solution.

Network management involves all of the equipment, personnel, and procedures required to insure that we can deliver a reliable and cost-effective service on an ongoing basis. The key element in that definition is "an ongoing basis".

However well we plan a WLAN installation, we are still dealing with the major variable in any mobile network: mobility! While we can confirm that a user will be able to get a usable signal wherever they travel within the facility, what happens if too many users happen to congregate in the same place? As we noted above, our network might have a load balancing ability so those users could be distributed over multiple access points, but what if there is only one access point serving that congested area? In short, we will be making some important assumptions in the layout of our access points, and if we guess wrong, users will be getting busy signals.

Unpredictability is one of the "givens" in any mobile network design, so we have to insure that we include the capability to recognize and adjust to changing conditions. Further we have to plan for incidents like lost/stolen phones, areas with poor signal coverage, terminated employees, software upgrades for handsets, and all of the day-to-day headaches that go into providing a communication service.

Given the relative novelty of VoWi-Fi, little has been written on the practical realities of running a large-scale network. Even those of us who have been involved are still in a learning mode. Further, there are no all-encompassing tools we can buy that will address the full range of these requirements. So in shopping for a VoWi-Fi solution, we have to develop our own list of support requirements, analyze the capabilities of the various products in each of these areas, and develop procedures to use those features or develop work-arounds that will allow us to deliver what we've promised. Here are some of the major areas we should investigate:

◊ **Traffic Monitoring:** We will need a mechanism to determine if there is sufficient network capacity to accommodate normal and peak usage in all areas. Software that identifies the average and maximum number of users per access point, along with busy hour identification will be the starting point. However, we also need to know how many call attempts were denied or rerouted to a less-congested access point. If we are supporting voice and data on the same network, we also have to be able to gauge the impact of heavy voice traffic on data users. Most of the current systems provide very rudimentary information in this area, so we will likely have to develop our own "rules of thumb" to define acceptable thresholds until better management systems become available.

◊ **Identifying/Rectifying Coverage Problems:** Troubleshooting is inherently difficult in a wireless network, as you cannot "see" the radio signal. Anyone can spot a broken wire, but how do you determine why we have a good signal in one area but not another, particularly if they are the same distance from the access point? Given the vagaries of indoor radio propagation, you can have vastly different signal readings at points just a few inches apart! Training the Help Desk personnel to get accurate location information from wireless users will be the first step, but many of these problems require dispatching a technician with a test device to the area in an attempt to replicate the problem. When all is said and done, it could just be that the user's handset is faulty!

◊ **Security:** By themselves, VoIP and WLANs have proved to be headaches for network security, and now we will have to deal with both or them. Earlier we looked at the requirements for over-the-air encryption with WEP, WPA, and WPA2, but we must also insure that the overall solution operates in conjunction with our firewall and other IP security measures. Further, if we are using PDA-based softphones, there are a whole range of mobile device viruses that target both the Symbian and Windows operating systems. If we have a combined WLAN/cellular handset that has a Symbian OS and supports Bluetooth, we have assembled the single most vulnerable piece of computer equipment ever created.

◊ **Record Keeping:** We will also have to modify our ordering and record keeping systems to track our new class of mobile devices and define whether they will be assigned to individual users or shared by several people within one department.

Good-quality voice service requires the ability to recognize problems before the user calls us to complain (probably on a wired phone). These features are not defined in the standards, so we'll have to look at what capabilities are provided in the WLAN switch and the handsets to determine what additional tools and procedures will be needed to insure an adequate service level.

Part 5-
Do You Need Cellular With That?

A truly integrated WLAN/cellular capability would be the ultimate in mobile voice functionality. However, we do not have that capability with any enterprise-grade WLANs today. Virtually all of the major vendors of cell phone handsets (e.g. Nokia, Motorola, Samsung, etc.) have announced combined WLAN/cellular handsets, but again, it critically important that we identify the functionality that is being provided.

As we noted earlier, there are two levels of integration functionality:

- *Integrated Packaging:* Where WLAN and cellular capabilities are built into the same handset, but there is no ability to hand-off call between the two networks.
- *Converged WLAN/Cellular Device:* Where the two devices are built into the same package and the handset can recognize if WLAN service is available. Further, when the user moves between the WLAN and cellular coverage areas, the call would automatically be handed off.

While the converged WLAN/cellular capability would have great value and has been widely discussed, there are no deliverable products capable of providing it today. Further, the ability to deliver an integrated WLAN/cellular service is totally in the hands of the cellular carriers. To date, none of them has given any indication that they intend to provide this capability in the near term.

The solution that appears closest to market is the Avaya/Motorola Seamless Convergence, announced in June 2004. That capability remains in limbo because the cellular partner, Cingular Wireless, refuses to certify the Motorola CN620 WLAN/GSM handset. Cingular has not certified the GSM cellular capability in Symbol's MC70 either.

Most of the PBX vendors are planning offerings similar to the Avaya/Motorola plan, and there are a number of gateway products on the market from companies like Bridgeport and Kineto Wireless that cellular carriers could use to provide an even more functional convergence solution. In short, there is no doubt as to the obstacle to WLAN/cellular convergence- it's the cellular carriers.

From a business standpoint, if there's a capability that is completely outside of your scope of control, you put it on the "wish list" and get busy on something you can deliver.

Even in the absence of network convergence, there are lots of employees who need mobile voice within the facility, but do not qualify for a company-provided cell phone. This is one of the reasons WLAN voice has been successful in health care, distribution, and retail--the company is not providing cell phones for nurses and retail clerks. RIM has been trying to establish the term "Corridor Warrior" for employees who require mobile access but only within company facilities.

Of course, any employee who does have a company-provided cell phone and spends some time in company facilities would be a candidate for an integrated WLAN/cellular phone. For these users, even solutions that can't hand off between cellular and Wi-Fi networks would have the benefit of requiring one device rather than two. Of course, we also have to ensure that the integrated handset includes all of the VoWLAN functions we listed above.

When and if we get an integrated solution with transparent handoffs, it is important to recognize that the cost savings would not be instantaneous. Rather, it is unlikely we would see any savings until the next contract cycle. If we've signed a cellular contract that commits us to pay for a pool of minutes or a set number of minutes per user, the bill isn't going down until we renegotiate the contract, regardless of how many minutes we move off the cellular service.

The other idea being circulated is using the cellular service as our mobility solution (i.e. the Centrex version or WLAN voice). Ford Motor Company announced an arrangement of this type with Sprint PCS for one of their divisions. In this case, the only infrastructure that might be required is a distributed antenna system to insure adequate cellular coverage within the facility.

While the idea of outsourcing our mobile voice requirement may be appealing, but it is important to compare functionality along with the rest of the package. Cellular networks are designed to provide personal wireless communications to individuals. That means you don't have business features like a main list number for the company with an attendant to extend calls to station users. Also, you don't have capabilities like automatic call distribution or interactive voice response. Further, the cellular data services provide far less capacity than a wireless LAN. The bottom line is that you have to look at your full range of requirements in both the voice and data areas and then determine how you're going to address them.

Part 6- Conclusion: Do We Cost Justify WLAN Voice?

Now that we're getting ready to do WLAN voice seriously, we also have to determine what it's going to take to get this project approved. There is one school of thought that assumes it is necessary to compute a rate of return on the WLAN investment. Unfortunately, the underlying idea in that computation is that we can justify real dollar expenditures on assumed increases in productivity. For real decision makers, that type of justification falls in the realm of religious beliefs. The Wi-Fi Alliance has a WLAN Benefits Calculator on their Web site if you're interested, but you'd better get the boss's endorsement of this code of beliefs before you try it. Otherwise, this might be the *last* project request you'll be making at that company.

Viewed in the larger context, businesses no longer cost-justify copying machines, calculators, Internet access, or wired telephone systems. Business people simply understand that those are the tools people need to work in a modern office. No reasonable businessperson needs a spreadsheet to convince them that many employees can work more efficiently and be more accessible to their customers with a mobile voice capability. Today that mobile voice capability is a cell phone. If the management has already embraced cell phones, a more cost-effective solution that allows one-number access should be a fairly easy sell. If someone is asking you for a spreadsheet justification for something this obvious, they're either a little dense or just giving you a hard time. Those are management problems that are not solved with spreadsheets.

The decision on WLAN voice is simply whether we want to pay what it will cost to provide it. Of course, if management decides that WLAN voice is a capability our employees should have, we in the networking area had better be prepared to deliver a mobile voice service that really works.

Glossary of Acronyms

ACK	Acknowledgement
AIFS	Arbitrated Inter-Frame Spacing
AP	Access Point
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
DIFS	DCF Inter-Frame Spacing
EDCA	Enhanced Distributed Control Access
IT	Information Technology
HCCA	Hybrid Controlled Channel Access
LAN	Local Area Network
MIMO	Multiple Input-Multiple Output
PDA	Personal Digital Assistant
QoS	Quality of Service
SIFS	Short Inter-Frame Spacing
VoIP	Voice over Internet Protocol/Voice over IP
VoWi-Fi	Voice over Wi-Fi
VoWLAN	Voice over Wireless LAN
WEP	Wired Equivalent Privacy
WLAN	Wireless LAN
Wi-Fi	Wireless Fidelity
WPA	Wi-Fi Protected Access
WMM	Wi-Fi Multi-Media
WMM-PS	Wi-Fi Multi-Media Power Save
WPA2	Wi-Fi Protected Access 2 (i.e. 802.11i Compliance)

Summary of Some Important VoWLAN Standards
IEEE 802.11i/Wi-Fi Protected Access-2 An enhancement to the 802.11 MAC protocol to improve privacy protection; compatibility with 802.11i is defined by the Wi-Fi Alliance as *Wi-Fi Protected Access/2 (WPA2)*. The 802.11i security standard incorporates the Advanced Encryption Standard (AES), which is far superior to WEP's RC4-based 40-bit encryption. While 802.11i was in development, the Wi-Fi Alliance defined a short-term privacy fix called Wi-Fi Protected Access (WPA).
IEEE 802.11e Approved in October 2005, this enhancement to the 802.11 MAC allows wireless LANs to provide Quality of Service (QoS). In 802.11, four priority levels are defined, and higher priority voice and video traffic are given preferred access to the shared transmission channel. There is also mechanism to support real time services called Hybrid Controlled Channel Access, though it is not expected to be widely deployed.
IEEE 802.11n A standard for the next generation radio link for 802.11 wireless LANs that will support data rates up to 600 Mbps using multiple-input-multiple-output (MIMO) antenna technology. The IEEE approved a draft in early 2006, and the final standard should be ratified in late-2007.
IEEE 802.11r A developing standard to support fast, secure roaming between access points, particularly for voice users. The goal is to provide a secure handoff in <50 msec. This is a difficult to standard develop as security must be maintained during the hand-off process. The expected date is sometime in 2007.

dBrn Associates, Inc. is an independent network consulting firm specializing in wireless networks and technologies. References to unlicensed spectrum bands and service availability refer to the US market specifically.

All opinions expressed herein are based on independent research, and may not be quoted without written permission of the author.

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

Contact Information
dBrn Associates, Inc.
189 Curtis Road
Woodmere, NY 11598 (USA)
Tel. 516-569-4557