The Future of Wireless LANs will be Multimode

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A Multimode Future

With the emergence of a converged standard for wireless local area networks (WLAN), the stage is set for a multimode marketplace. Much like its wired predecessor, wireless Ethernet (802.11) will flourish in an environment characterized by multimode operation. Converging the separate 10- and 100-megabit per second technologies of wired Ethernet into the now familiar 10/100 networks accelerated the market's acceptance of wired Ethernet. The same should be expected of WLAN technology and the merging of the 802.11b and 802.11a versions of the standard into 802.11g.

Two sets of dynamic forces argue for a multimode WLAN environment. First, it can be stated with some surety that not all standards are created equal. Each of the several versions of the wireless Ethernet standard, 802.11b, 802.11a and 802.11g, have their own strengths and advantages. Each version of the standard has its own set of operational and economic characteristics. A multimode model ensures that the strengths of all of the modes of operation will persist in the market place.

Second, the various market segments, such as the enterprise, the so-called hot-spot or public access segment, and the home and embedded market segments each have a distinct set of demands and requirements that differ from each other. Again, a multimode model of operation is best suited to meeting all of these needs across the broad spectrum of a diverse WLAN marketplace.

The Evolution of WLAN standards

In 1997, the first wireless Ethernet standard, just plain 802.11, was adopted and published by the IEEE. This unified standard provided several modes of operation and data rates up to only two megabits per second (Mbps). Work soon began on improving the performance of 802.11. The eventual results were two new but incompatible versions of the standard, 802.11b and 802.11a. The "b" version operated in the same frequency range as the original 802.11, the 2.4 GHz Industrial-Scientific-Medical (ISM) band, but the "a" version ventured into the 5 GHz Unlicensed National Information Infrastructure (U-NII) band.

802.11b mandated complementary code keying (CCK) for rates of 5.5 and 11Mbps, and included as an option Packet Binary Convolutional Coding (PBCC™) for throughput rates of 5.5 and 11 Mbps, and additional range performance. It also supported fallback data rates of 2 Mbps and 1 Mbps, using the same Barker coding used in the original 802.11 standard. 802.11a turned to another multi-carrier coding scheme, Orthogonal Frequency Division Multiplexing (OFDM), and achieved data rates up to 54 Mbps.

Because 802.11b equipment was simpler to develop and build, it arrived in the marketplace first. 802.11b technology soon established a foothold in the market and proved the viability of WLAN technology in general. Some market experts have estimated that there are currently more than 20 million users of 802.11b wireless networks. When initial 802.11a equipment was brought to market, users and system manufacturers were forced to decide between two incompatible and non-interoperable standards. The result was confusion about where WLAN technology was heading.

In March of 2000, the IEEE 802.11 Working Group formed a study group to explore the feasibility of extending the 802.11b standard to data rates greater than 20 Mbps in the 2.4 GHz spectrum. For a year and a half, this group, which came to be known as the Task Group G (TGg), studied several technical alternatives until it finally adopted a hybrid solution that included the same OFDM coding and provided the same physical data rates of 802.11a. But this version of the draft standard, 802.11g, occupied the 2.4 GHz band of the original 802.11 standard. Several optional coding schemes were incorporated into 802.11g, including CCK-OFDM and PBCC, the latter of which provides alternative data rates of 22 and 33 Mbps.

The 802.11g standard, which is expected to be approved by May 2003, provides for true multimode operations because it converges two technical solutions that had been totally separate and quite incompatible. The 802.11g standard requires backward compatibility with the 802.11b standard. As the WLAN marketplace transitions to true multimode operations over the next few years, decision makers in the various market segments will analyze the characteristics of the various modes of operation. The results of this analysis will affect when full multimode capabilities will be adopted by each particular end application. These characteristics include the following:

- *Cost*

Cost is always a critical factor as new technologies are evaluated. When the 802.11g standard was first published in draft form, some in the market expressed concern that a hybrid solution might increase the cost to users, especially at a time when the cost of 802.11b networks had dropped considerably. In response, system manufacturers have forecast that equipment for "g" networks will be at a cost level similar to that of "b" networks. In addition, multi-standard equipment capable of 802.11b, 802.11g and 802.11a operations has been forecast at a cost comparable to "a" only equipment. Clearly, the cost factor favors multimode operations.

- *Transmission Speeds*

The market's transition to the higher data rates of the "g" and "a" standards will have to accommodate an installed base of some 20 million users of 802.11b networks. In fact, during a transitional period, many WLANs could support high-speeds as a first option and lower speeds as an alternative when traffic or client equipment dictates the use of slower speeds. In addition, some market segments, like the enterprise, will place greater importance on an average guaranteed throughput per user. In contrast, the home networking segment will emphasize the transmission rate among devices within the home, procurement cost, ease-of-use and ease-of-installation. Therefore, the availability of various transmission speeds inherent in multimode operations suggests that multimode operations will meet the needs of the marketplace in the future.

- *Power Consumption*

Battery-operated embedded applications like cell phones, smartphones, laptop computers and wireless personal digital assistants (PDAs) place a high premium on power consumption over other factors like the high data rates of 802.11g and 802.11a. Some WLAN components have responded to the need for low power consumption. For example, TI's TNETW1100B 802.11b WLAN processor for embedded applications has slashed power consumption in standby mode by a factor of 10 over competitive chipsets. The new TNETW1130 802.11a, b, g WLAN processor features enhanced low power (ELP) technology that is similar to that of the TNETW1100B device. The discrepancy in power consumption among the various WLAN modes suggests that multimode operations will be needed to accommodate the requirements of battery-driven systems as well as those types of systems that enjoy a practically unlimited supply of power.

- *Range*

Because signal fading is more significant in the 5 GHz band than in the 2.4 GHz band, 802.11g has extended range (Figure 1) over 802.11a. At the same time, 802.11g has the same high data rates as 802.11a. In some applications, such as the enterprise and public place 'hot spots' like airports, hotels and restaurants, the range of a WLAN access point (AP) will have a decided effect on the cost of deployment. With greater range, fewer APs must be deployed. At the same time though, some types of applications that would place a high value on extended range must also be able to accommodate a diversity of client WLAN equipment. WLAN deployments in large facilities with users coming and going constantly will not have the luxury of a homogenous, single-mode environment. The answer will be multimode.

Market Segments

Aside from the technical characteristics of the different versions of the 802.11 standard, the diverse requirements of the most prominent segments in the WLAN marketplace also will encourage a multimode environment in the future.

- **The Enterprise**

Most enterprise IT manages instinctively opt for ensuring the highest guaranteed speed possible, per user, as a primary requirement for any type of computer or communication equipment. With most of the communications occurring within the organization, the need-for-speed is understandable. But much of the enterprise market segment already has an installed base of 802.11b WLAN equipment, both clients and APs. During a reasonably long transitional period, the enterprise will continue to accommodate this base of legacy "b" equipment while it migrates to the higher speeds of the newer versions of the standard, 802.11g and 802.11a. Because the type of 802.11 clients used by laptop computers, smartphones and other new user devices is unpredictable, the enterprise will eventually evolve into a multimode AP environment accommodating both 802.11g and 802.11a.

As the enterprise's APs migrate toward a "g plus a" operating environment, client modules also will make a similar shift. With a full-blown multimode environment, enterprise IT executives will be able to take advantage of two frequency bands to maximize data throughput over the wireless network. For example, a heavy traffic load on the primary 2.4 GHz WLAN band may generate a high degree of communication collisions as users vie for access to the network, downgrading the data rate on the primary WLAN. In a dual-band environment, a portion of the traffic could be shifted to a secondary 5 GHz WLAN band where less traffic might assure higher data rates. This type of capacity-extending WLAN deployment would entail a certain amount of intelligence in the network because dynamic network traffic conditions and load factors would be monitored to determine which band would be used.

- **Hot Spots / Public Access**

Similar to the enterprise, the hot spot market segment already has an installed base of 802.11b equipment, but unlike the enterprise where speed is prized most highly, hot spot public places will place a priority on accommodating a diversity of mobile device types and WLAN modes. In fact, given the fact that a hot spot WLAN will almost certainly be used solely for Internet access, the speed of which is typically limited by the 1.5 Mbps available through a T1 or DSL connection, the need-for-speed on a hot spot WLAN is much less acute than it is in an enterprise environment. Unlike the enterprise where a substantial portion of the user equipment will be non-mobile desktop systems, most, if not all, of the client equipment in a hot spot environment will be mobile devices like laptop computers, smartphones, wireless PDAs and new types of web appliances.

User devices will enter and leave a hot spot WLAN frequently, often accessing the network only for a short period of time.

Because the operational mode of client devices cannot be anticipated in a hot spot WLAN, this market segment will migrate from its current base of 802.11b to a multimode environment with both 802.11g and 802.11a. Since 80.11g is backwards compatible with 802.11b, this type of multimode environment will be able to handle the most diverse set of clients. In addition, the hot spot market will feature frequent and often short network accesses. The APs in such an environment must be capable of quickly connecting clients to the network, efficiently handling their service requirements and rapidly disconnecting them at the completion of a session.

- **The Home Segment**

Cost, ease-of-use and ease-of-installation have been the primary concerns of the home WLAN market segment. Data-centric home applications will consist mostly of sharing Internet access. As a result, the speed of home WLAN applications will be limited by the speed of the Internet access connection, which is typically less than 1.5 Mbps for a DSL or cable connection. However, the ability to connect rich content devices at the highest possible speed is becoming a growing requirement of residential WLANs. For example, photographs and even high-quality video streaming will be downloaded over the WLAN from a camera to a PC.

To date, 802.11b has achieved the largest share of the home market. The user experience and installation process for 802.11b WLANs have been refined over the last few years. Coupled with the current cost advantage that 802.11b equipment enjoys, the home market will continue for a period of time as a single-mode 802.11b-only environment. Eventually though, as the price advantage of 802.11b narrows this segment will migrate to faster WLAN implementations using 802.11g and 802.11a. This was seen as users moved from 10 Mbps Ethernet to 10/100 Mbps Ethernet as the price differential narrowed.

In addition, an individual home network is something of a closed environment in and of itself. The residents of the home control the types of devices that access the network and, when compared to an enterprise or a hot spot application, the types and number of devices accessing a home WLAN is small and fairly constant. As a result, the capabilities of 802.11b should satisfy the needs of most residential WLANs for several years or until new entertainment technologies like digital TV take root in the home. Digital televisions connected to a broadband gateway via a WLAN will raise the data rate requirements on home networks. This or a similar leap forward in consumer electronics will usher in the migration from 802.11b to the newer versions of the standard, 802.11g and 802.11a.

- **The Embedded Segment**

Currently, the embedded market for WLAN clients includes laptop and desktop computers. Soon though, smartphones, high-end cellular handsets, web tablets, wireless PDAs and brand new types of mobile devices also will feature embedded WLAN capabilities. As nomadic systems, these devices place a premium on power consumption, size and cost. Presently, and for some time, these criteria are best met with 802.11b technology, because 802.11b has lower processing requirements and, hence, power requirements that are lower than those of the OFDM coding scheme used in 802.11g and 802.11a. This should remain the case for at least two years or until 802.11g products with comparable power consumption and size qualities reach the market.

As previously mentioned, 802.11b components like TI's TNETW1100B and TNET1130 WLAN processors hold a decided advantage in power consumption. The TNETW1100B's innovative handling of standby power modes has enabled a 10x reduction in power consumption over other WLAN processors. And because mobile devices will come in small, sleek enclosures, the size and board space requirements of the TNETW1100B have been reduced by 44 percent over its predecessor device, while dramatically increasing battery life for mobile devices.

Implications for WLAN Manufacturers

What will a decidedly multimode market mean for the manufacturers of WLAN systems, client modules and APs?

First and foremost, it will be critically important for manufacturers to team up with a broad-based silicon vendor that can provide components for all 802.11 modes, including those that will provide a transition to next-generation multimode WLAN technology. Soon after this transitional period, components supporting fully standards-compliant multimode 802.11g/802.11a operations will emerge. Partnering with such a broad-based silicon supplier now, while the transition to next-generation multimode is ongoing, will be critical later on as more WLAN functionality is integrated into fewer components. Gaining experience by working with a broad-based vendor's WLAN silicon now will facilitate a smooth transition once that vendor introduces full multimode components later.

Because of the considerable work being done on 802.11 WLAN standards, it would behoove system manufacturers to maintain as much flexibility in their products as possible. The IEEE 802.11 standards bodies are developing several new specifications that address issues such as the security requirements of wireless networks and the Quality of Service (QoS) capabilities of WLAN networks. As these improvements unfold and are incorporated into new standards, system manufacturers will want to upgrade their products as efficiently as possible.

A programmable media access controller (MAC) would future-proof a manufacturers' WLAN products by allowing easy upgrades to system software and enhancements to firmware. New features like dynamic frequency selection (DFS), which is being advanced by the 802.11h committee, could be accommodated through a simple download of a revised driver, once a new version of the standard has been approved.

In addition to programmability, next-generation WLAN deployments certainly will require a higher level of intelligence inherent in the network itself. Functionally efficient microprocessor-based WLANs will be needed to manage and shift traffic among the multiple modes on the network. And QoS issues, which are being defined by the 802.11e committee, will require greater intelligence at the MAC level. QoS will eventually provide for improved support of high-quality multimedia applications like video and voice over WLANs. In some market segments, QoS issues will be particularly critical. For example, voice over Internet protocol (VoIP) would be very beneficial in enterprise applications. And in the home, QoS would allow high-bandwidth multimedia entertainment centers to join the residential WLAN.

Conclusion

Just like its wired predecessor before it, several factors are driving the 802.11 WLAN market toward full multimode operations.

On one hand, the various modes of operation associated with the different versions of the 802.11 standard include differing capabilities, they operate in different frequency bands and they include divergent features. Only when the various operational modes are considered as a composite of WLAN technology does that technology offer a comprehensive set of benefits.

On the other hand is a market environment comprised of different segments, each with its own requirements, performance needs and operational processes. When one overlays the technical capabilities and features of 802.11's operational modes with the needs of the various market segments, what begins to emerge is the image of a marketplace that is best served by multimode wireless networks.

Therefore, it is incumbent upon WLAN manufacturers to seek out and team up with a broad-based silicon vendor capable of providing the appropriate technology for all of the 802.11 operational mode and, over time, able to integrate these modes with higher levels of intelligence for cost-effective 802.11 WLAN solutions.

Modulation Schemes

Modulation Scheme	Data Rates
Barker	1, 2 Mbps
CCK	5.5, 11 Mbps
PBCC	5.5, 11, 22 Mbps
CCK-OFDM	up to 54 Mbps
OFDM	up to 54 Mbps