Intel in Communications

Wireless Networking: Deployment Considerations for Today and Tomorrow

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Executive Summary

Wireless networking customers now have multiple standards to choose from—the widely deployed 802.11b, as well as the higher-speed 802.11a and the newly ratified 802.11g. The 802.11a and 802.11g standards provide data rates up to 54 Mbps and are poised for rapid expansion in businesses and homes. With all this activity, now is a good time to take a look at the venerable 11 Mbps 802.11b standard—by far today's most widely deployed wireless standard.

Should companies that already have 802.11b technology be considering an upgrade, or will 802.11b continue to provide the performance and features they need? Should companies that are planning to add wireless capabilities for the first time choose 802.11b, one of the newer standards, or a combination? Wireless local area network (WLAN) technology is reaching critical mass, and businesses need to know what technologies they can count on to meet their performance needs, while providing a dependable roadmap for the future. Today, 802.11b wireless networks are by far the most widely used and deployed.

With higher-speed wireless devices becoming more commonplace, many network administrators will be planning to accommodate 802.11a and/or 802.11g in the near future. Conversely, as 802.11a and 802.11g networks become more popular, they need to accommodate the large number of 802.11b devices already deployed. Either way, 802.11b is here to stay. And in fact, the best choice for many companies and individual users may be either 802.11b or a multiple-mode solution that includes 802.11b.

This white paper compares the major features of all three networking standards, examines the strengths of 802.11b for today and tomorrow, and describes typical scenarios where deployment of 802.11b makes the most sense. After reading it, you'll have a better understanding of 802.11b's role in wireless networking, and you'll be better prepared to make an informed decision—whether you're purchasing a single wireless device, deploying a new WLAN, or upgrading your existing wireless infrastructure.

What is Wireless LAN Networking

A wireless local area network (WLAN) is a flexible data communications system that can either replace or extend a wired LAN to provide added functionality. Using radio frequency (RF) technology, WLANs transmit and receive data over the air, through walls, ceilings and even cement structures, without wired cabling. WLANs provide the features and benefits of traditional LAN technologies like Ethernet, but without the limitations of being tethered to a cable.

The importance of WLAN technology, however, goes far beyond just the absence of wires. The advent of the WLAN redefines the traditional LAN infrastructure. No longer does the entire infrastructure need to be solid and fixed, difficult to move and expensive to change. Instead, the wireless infrastructure can move with the user and scale with the organization.

For example, employees can stay connected as they move throughout the corporate campus, easily tapping into the resources of the wired network. Students can access information from hotspots deployed in libraries, cafeterias, and other key locations across a wireless-enabled campus. Organizations leasing temporary office space can set up a WLAN and then easily take the wireless portion of the LAN infrastructure with them when they move.

The wireless networking specifications—802.11a, 802.11b and 802.11g—define how data is encoded in the radio frequency, and how end-user devices and access points communicate with each other. Let's take a closer look at the 802.11 standards, and particularly the continuing role of 802.11b.

The IEEE 802.11 Standard- An Overview

The IEEE 802.11 standard is the predominant WLAN standard. Any LAN application, network operating system or protocol, including TCP/IP, will run on 802.11-compliant WLANs as easily as they run over Ethernet.

Since ratifying the original 802.11 standard in 1997, the Institute of Electrical and Electronics Engineers (IEEE) has added three new specifications to the 802.11 WLAN family: 802.11a, 802.11b and 802.11g. Each has its advantages, and each appeals to a different segment of the market.

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802.11b: A Closer Look at the Market Leader

The original 802.11 standard was ratified in 1997, but wireless networking didn't really take off until the emergence of the much-faster 802.11b in 1999. It operates in the 2.4 GHz RF band, offering three non-overlapping channels and a maximum data rate of 11 Mbps at a typical indoor range of 100 ft.

As you increase the distance or the number of walls and other obstacles the signal must pass through, the maximum 802.11b data rate falls off to 5.5 Mbps, 2 Mbps or 1 Mbps at a range of about 300 ft or more from an access point. (See www.intel.com/ebusiness/strategies/wireless/wlan/tech.htm for more information.) Also, cordless phones, microwave ovens and Bluetooth* devices could interfere with the 2.4 GHz spectrum,.

However, in a well-designed 802.11b wireless environment, users can expect performance similar to wired 10 Mbps Ethernet. That, combined with the fact 802.11b products were the first and are still the most affordable WLAN devices on the market, have made this standard extraordinarily successful. Current estimates put the number of WLAN-enabled devices at 35 million or more around the world, the vast majority of them using the 802.11b standard.[i] Nearly all of the public wireless hotspots in use today are 802.11b. With widespread deployment, long operating ranges and all the performance needed for most applications and usage models, 802.11b is firmly established and will remain so for the foreseeable future.

802.11a: The First Step to High-Speed Wireless

802.11a was the first standard ratified after the initial 802.11 standard in 1997. Even though 802.11a was ratified prior to 802.11b, 802.11b has achieved higher market penetration with manufacturers and consumers alike, mostly due to the lower initial costs for 802.11b-capable hardware.

The 802.11a standard operates in the higher frequency spectrum of 5 GHz, where there is less RF "noise" from other devices compared to 2.4 GHz. It supports data rates up to 54 Mbps, using up to 24 non-overlapping channels (depending on the country). As such, 802.11a is often considered to be the Fast Ethernet counterpart to 802.11b's Ethernet-like speeds.

Using a more efficient modulation scheme and a broader, less crowded frequency range, 802.11a is able to support more users at higher data rates than 802.11b. However, the maximum operating range of 802.11b is slightly less than that of 802.11b. In addition, the relative cost of 802.11a devices remains slightly higher than 802.11b devices, due to the economies of scale driven by higher market penetration for 802.11b. Furthermore, the higher data rates achieved by 802.11a often remain underutilized due to bottlenecks on the wired portion of the network.

Because of longer operating ranges and relatively lower equipment costs, 802.11b devices have entered the marketplace in far greater numbers than 802.11a up to this point in time. As a result, a typical mobile user has a much greater chance of encountering 802.11b networks compared to 802.11a networks.

802.11g: The New Kid on the Block

Ratified by IEEE in June 2003, 802.11g is a third wireless standard that includes elements of the previous 802.11a and 802.11b standards. It uses use the same 2.4 GHz radio spectrum and three non-overlapping channels as current 802.11b equipment, but with the modulation technology and higher data rates of 802.11a.

Although some "802.11g" products were released before the final standard, these earlier products may not always perform as expected. True Wi-Fi CERTIFIED* 802.11g products are now coming to market. The Wi-Fi CERTIFIED* badge on any 802.11 product means that the product conforms to the IEEE specification, and has been validated by a third party to perform as specified thus providing interoperability.

Because they operate at the same frequency, Wi-Fi CERTIFIED* 802.11b devices and Wi-Fi CERTIFIED* 802.11g devices can communicate with each other on the same network. An 802.11b client can talk to an 802.11g access point, and vice versa, so new 802.11g devices can be introduced into an existing 802.11b network at any time. In such cases, the newer 802.11g devices emulate the data rates of the network, transmitting and receiving information at 11 Mpbs—similar to other devices on the 802.11b network.

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On the other hand, you can also use a Wi-Fi CERTIFIED* 802.11b client on a Wi-Fi CERTIFIED* 802.11g network. However, whenever an 802.11b device is present, the 802.11g network must automatically enable a "protection" mode to prevent higher-speed transmissions from disrupting 802.11b transmissions.

Comparing 802.11a, 802.11b, and 802.11g Wireless Standards

The following table summarizes the main operating characteristics of each of the three leading wireless standards. Keep in mind that actual throughput may be limited by data rates and traffic on the wired portion of the network. In other words, if a wireless access point is deployed on a 10 Mbps wired network, the highest throughput that can be achieved is 10 Mbps—even though the wireless device may be rated higher.

Specification	Maximum data rate/channel	Frequency band	Channels
802.11a	54 Mbps	5 GHz	24 non-overlapping (19 non-overlapping in some countries)
802.11b	11 Mbps	2.4 GHz	3 non-overlapping
802.11g	54 Mbps (11 Mbps when 802.11b devices are present on the network)	2.4 GHz	3 non-overlapping

802.11b: A Pervasive Standard

Many analysts believe the wireless market segment has now reached a "critical mass" of rapid and continuing growth. This critical mass has been achieved largely through 802.11b deployments—ensuring that the standard will continue to play a major role for many years to come. As users shop for new WLAN devices, they'll want to make sure they can communicate with the vast majority of access points already deployed in businesses and public places around the world. And as companies and service providers build out their wireless infrastructure, they'll want to accommodate the vast majority of users with 802.11b connectivity.

In other words, 802.11b is here to stay for the foreseeable future. And there are reasons to believe the standard will continue to grow even as 802.11g deployments come online. Simply stated, 802.11b is a very useful technology for a number of reasons that will be as compelling tomorrow as they are today.

- **Price.** 802.11b technology is the most affordable of the three standards, enabling manufacturers to include wireless capabilities in all kinds of products at little to no extra charge. By the end of 2003, prices for 802.11g chips should fall to within a few dollars of 802.11b.[ii] Because of their complexity and lower demand, 802.11a chips should continue to cost significantly more.
- **Power savings.** 802.11b technology typically consumes less power than 802.11a or 802.11g, since the faster standards require more intensive signal processing.[iii] For that reason, 802.11b will continue to be a perfect choice for notebooks, PDAs and other handheld devices that depend on long battery life.
- **Range.** 802.11b technology operates at the longest effective range of the three standards. This helps companies save on wireless infrastructure, and makes wireless computing possible in more places—such as outdoor courtyards and large convention halls.
- **Performance.** Although 802.11b has the slowest data rates of the three standards, it still compares well with the wired Ethernet connections that most people use every day. In fact, most wired LANs, cable modems and DSL lines deliver data at speeds that couple well with 802.11b's 11 Mbps data rate. For many networks, applications and users, 54 Mbps wireless connections would be significantly underutilized most of the time. Since the available

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bandwidth is shared, however, the higher-speed standards may provide an advantage in environments with a large number of users per access point.

- **Flexibility.** 802.11b offers manufacturers a simple, power-efficient, cost-effective and proven way to build wireless capabilities into a variety of new devices—including Internet access appliances, Voice over IP phones, scanners, printers, PDAs, wireless gateways, hybrid devices and more—providing all the performance needed for most specialized applications.
- **Compatibility and coexistence.** The 802.11g is designed for compatibility with 802.11b. So users can invest in Wi-Fi CERTIFIED* 802.11b, 802.11g or dual-mode 802.11b/g devices with confidence that they'll have trouble-free access to 802.11b networks around the world. And as higher-speed wireless networks become more commonplace, they'll be able to take advantage of the backwards-compatibility built into Wi-Fi CERTIFIED* 802.11g networks.

Making the Choice

Wi-Fi CERTIFIED* 802.11g offers the same high data rates as 802.11a, plus compatibility with 802.11b. In spite of the performance penalty when 802.11b devices are present, it may be a good choice for businesses that have a lot of 802.11b users today, and want the simplest upgrade path to high-speed wireless networking. However, Wi-Fi CERTIFIED* 802.11g products are only now reaching the marketplace, and it remains to be seen how quickly the new standard will take off in businesses. 802.11g is a good choice for businesses that have many users per access point or need to handle large media files. It's also a good solution for companies extending their wired network with wireless, or creating a new network in a hard-to-wire space. And it's an excellent choice for businesses that want to maintain backwards-compatibility with existing Wi-Fi CERTIFIED* 802.11b devices, or for mobile workers who want access to both high-speed corporate networks and the large installed base of Wi-Fi CERTIFIED* 802.11b public hotspots.

802.11b is often still the best choice for users who don't have extremely high throughput requirements (for example, viewing multiple, high-resolution video streams). In fact, it's ideal for companies that are concerned with start-up costs, want to implement wireless for their entire environment, need to support handhelds, have a relatively small number of users per access point, or want to install limited pockets of WLAN. And it offers great performance for the productivity and Internet applications that the overwhelming majority of users rely on.

For many businesses, deploying a multiple-standard solution may be the best way to meet the needs of all users. 802.11b will be the common denominator in any choice of multiple wireless standards for the foreseeable future. The question to ask is whether you'd rather give up some performance to achieve full compatibility (Wi-Fi CERTIFIED* 802.11b and 802.11g), or whether you'd like to allow standard and high-speed wireless users to coexist without interference in the same environment (802.11a and 802.11b). A third option is to deploy all three, giving all users access to the best available performance no matter what type of device they're using.

These options are perfect for users who occasionally access high-speed networks or who want to keep their options open for tomorrow. Businesses can use dual-band products to target the areas of the indoor/outdoor environment that each standard is best suited for, and can protect their existing investment in 802.11b infrastructure while providing a migration path to 802.11a. And for a modest additional charge, individual users can get the best that wireless networking has to offer—including all the advantages of 802.11b.

The table below outlines the major factors you should consider when choosing a wireless standard for deployment today.

How to decide which standard is the right one for you? Consider the following:	**Recommended Protocol**	**Comments**
Lowest deployment cost for new WLAN clients.	802.11b	802.11b represents the lowest initial investment when implementing a new enterprise network.
Ability to handle large number of	802.11a/b	802.11a/b offers greater capability to

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clients.		handle a larger number of clients for a given access point—thus making it a good solution for the enterprise environment.
Offers higher flexibility and minimal implementation changes.	802.11a/b	A dual band network provides higher flexibility and has the ability to leverage existing 802.11a and 802.11b clients.
Network should be able to handle e-mail, Internet and database accessing but not high-bandwidth multimedia.	802.11b	802.11 provides a maximum bandwidth of 11Mbps which is ideal for low bandwidth needs for those such as e-mail and accessing either the internet or the enterprise database.
No frequency overlap from commonly used devices.	802.11a	Operates in the 5 GHz versus the 2.4 GHz band, which is shared with other devices such as Bluetooth devices, cell phones, and microwave ovens.
Long distance in an office environment that causes reflections or signal attenuation (such as steel cubicles or other obstacles).	802.11b	Signals in the 2.4 GHz band, using the 802.11b modulation scheme, propagate better than 5 GHz signals when traveling through walls and other objects.
Backwards compatibility with large installed base.	802.11b	802.11b is by far the most widely deployed standard today.
Mature standards-based products.	802.11 a/b	Over two years of mature, stable products with IEEE approval and extensive interoperability testing.

In summary, the main purpose of 802.11g is to provide higher speeds with backwards-compatibility to 802.11b. Intel expects that widespread adoption of 802.11b/g solutions will begin to occur during 2004, and that multi-mode 802.11 a/b/g solutions will also become widely available during the same timeframe. Businesses that currently own systems incorporating 802.11b should continue using that standard for stability then begin migrating systems in the first half of 2004.

802.11b Deployment Scenarios

When does it make the most sense to deploy Wi-Fi CERTIFIED* 802.11b, either alone or in combination with the other standards? Only you can make the final decision, based on your physical environment, end users and applications. Here are a few scenarios where 802.11b deployment makes good sense.

- **Larger facilities with long range requirements.** When the physical environment is large—such as a warehouse or department store—the longer range of 802.11b may yield significant savings, since you can cover the entire facility with fewer access points.

- **Enterprises that have already invested significantly in 802.11b devices.** Migrating from an existing, large-scale 802.11b deployment to 802.11a may not be worth the cost—especially when 802.11b is already providing all the performance you need for your particular mix of users and applications. If some users need higher bandwidth, you

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might want to consider adding 802.11g or dual-band 802.11a/b in order to preserve your existing 802.11b investments.

- **Sparsely populated end-user environments.** If there are relatively few end users that need to roam throughout the entire facility, then 802.11b will likely meet performance requirements because there are fewer end users competing for each access point's total throughput.

- **Smaller businesses and branch offices.** For many environments—such as a small office with a single file server and a shared broadband line for e-mail and Internet access—802.11b provides more than enough throughput. In this scenario, there's no need to invest in a higher-performing WLAN. Contention for bandwidth is minimal, and the limiting factor tends to be the broadband modem rather than the WLAN itself.

Intel Is Committed to WLAN, and 802.11b Is the Flagship

Intel believes that 802.11b is here to stay, and we're committed to supporting it. Integrated 802.11b WLAN capability[†] was the highlight of the Intel® Centrino™ mobile technology launch in March, 2003. In the Second Half of 2003, Intel will announce the availability of a dual-band 802.11a/b module for Intel Centrino mobile technology. And Intel will continue to provide the latest security and other features via software upgrades to its existing 802.11b products.

More than just a processor, Intel Centrino mobile technology was developed and validated with mobility in mind --- with the Intel® Pentium® M processor, Intel® 855 chipset family, Intel® PRO/Wireless Network Connection.[†]. Now you can experience breakthrough performance, integrated wireless LAN, and enables extended battery life all in a lighter, thinner design. Intel Centrino mobile technology supports industry standard and leading third party security solutions enabling protected notebook connectivity.** Intel and leading WLAN service providers have worked together to verify interoperability across their Wi-Fi CERTIFIED* networks to enhance your Intel Centrino mobile technology wireless experience.[†]

No matter what the future brings, 802.11b will continue to be an important and widely used technology. You can invest in 802.11b devices confidently today, knowing that you'll have access to the widest range of wireless networks for many years to come.

For More Information

To learn more about WLAN solutions and Intel technology for wireless computing, please visit www.intel.com/network/connectivity/products/wireless.htm.

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[†] Wireless connectivity and some features may require you to purchase or download additional software, services or external hardware. Availability of public wireless LAN access points limited. System performance measured by MobileMark* 2002. System performance, battery life, wireless performance and functionality will vary depending on your specific hardware and software configurations. See www.intel.com/products/centrino/more_info for more information.

*Other names and brands may be claimed as the property of others.

** Some security solutions may not be supported by your PC manufacturer. Check with your PC manufacturer for details on availability.

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[i] In-Stat/MDR, "Popularity of Wi-Fi Drove WLAN Chip Market in 2002," April 7, 2003.

[ii] Simmtester.com, "802.11 wireless chip prices continue to slide," May 29, 2003.

[iii] Wi-Fi Alliance, "Q&A: Wi-Fi Alliance Certification of IEEE 802.11g," April 3, 1003.