BLUETOOTH AND WI-FI

Understanding these two technologies and how they can benefit you

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Introduction

The wireless revolution is underway, and devices based on radio technologies are expected to become a significant market in the next several years. Mobile phones, cordless phones, walkie-talkies, car door openers, and garage door openers are just a few examples of radio devices that have already achieved widespread adoption in the marketplace.

Out of the past several years, two innovations in wireless radio technology have captured our attention: Bluetooth™ and Wi-Fi™ (IEEE 802.11b). These wireless communication technologies show great promise in transforming how people work and communicate with each other.

The media and analyst communities continue to debate the virtues and pitfalls of Bluetooth and Wi-Fi (IEEE 802.11b), declaring one or the other "victor" in the fight for widespread integration into electronic devices and adoption by consumers and corporate technology buyers. The inundation of information is confusing to consumers wondering which technology to adopt, as well as to companies trying to choose a technology to deploy to mobile workforces.

Socket Communications has authored this paper to introduce the origins and characteristics of each technology, as well as to mitigate some of the confusion surrounding them. In the following pages, we will hold these technologies up side by side, in order to better compare and discuss them. We will show how they can complement one another and improve the lives of consumers, as well as benefit corporations by enabling a workforce to stay connected, informed, and thus more productive.

By explaining each technology and deconstructing the debate surrounding them, Socket hopes to illustrate how Bluetooth and Wi-Fi can be used to enhance your productivity and lifestyle.

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Wireless Technologies: How the Properties of Radio Waves Affect Networking Capabilities

To appreciate what Bluetooth and Wi-Fi are and how they work, it is essential to first comprehend some fundamental information about radio waves and how they behave. When used in wireless technologies, the ideal radio wave would have high speed, use little energy, and travel far distances. This type of radio wave would let us transfer information in a few milliseconds, require little battery power, and send signals at whatever range we needed.

In reality, however, it is impossible to achieve all three of these characteristics at the same time. It is an established fact that the further and faster that a radio wave travels, the more energy it needs.

Because it is impossible to simultaneously achieve high speed, low power consumption, and long range in a radio wave, product designers and developers have instead selected specific characteristics to optimize in certain conditions while creating wireless technologies. This approach has led to the concepts of wireless area networks of different magnitudes, (i.e., personal, local, metropolitan, global, etc.) Each type of wireless area network signifies a specific combination of radio characteristics that in turn translate into specific applications and usage scenarios.

For example, while developing applications for a wireless personal area network (WPAN), the wireless area network with the shortest range, product designers and developers need to consider what scenarios demand low power more than they do high speed or great range. Conversely, while developing uses for the wireless local area network (WLAN), product designers and developers must determine in which situations users would value moderate range and moderate speed more than they would low power consumption.

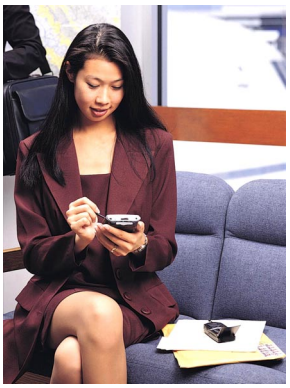
Figure 1. Characteristics of Different Wireless Area Networks

WirelessArea Network	Range	Power Drain	Transmit Speed*	Example	Primary Application/ Usage Scenario
Wireless Personal Area Network (WPAN)	10 m	Low	800 Kbps	Bluetooth	Cable replacement between nearby devices
Wireless Local Area Network (WLAN)	100 m (to an access point)	Medium	11 Mbps	Wi-Fi (IEEE 802.11b)	Accessing an existing Ethernet network run on cables
Wireless Wide Area Network (WWAN)	2-3 km (to a base station)	High	14.4-56 Kbps	GSM, CDMA, GPRS, CDPD, TDMA	Voice and data communications
Wireless Metropolitan Area Network (WMAN)	30 km	Very High	1.5 Mbps	Sprint fixed wireless	Replace ISDN DSL, cable modem
Wireless Global Area Network (WGAN)	500-1500 km (to a satellite)	High	64 Kbps	Iridium GlobalStar satellite phones	Military

**Note: With overhead and other variables, actual throughput will be less.*

What Is Bluetooth?

Bluetooth is a WPAN technology. Accordingly, its radio characteristics include low power, short range, and medium transmission speed. These characteristics influence what devices will incorporate Bluetooth, how users will experience it, and what it will be used for. First, its low power consumption makes Bluetooth ideal for small, battery-powered devices like mobile phones and Pocket PCs that have little energy to spare. As a result, Bluetooth is poised to capitalize on the emerging market of small mobile devices that is expected to grow in the next several years. Second, Bluetooth's short range (10 meters[1]) is ideal for the concept of "personal operating space"[2] and integrates the notion of using devices carried or worn on the body or otherwise located within immediate reach. And Bluetooth's transmission speed of 800 Kbps[3] works well for transferring small to medium-sized files.



With Bluetooth, you no longer need a cable to connect your Pocket PC and mobile phone for Internet access.

All of these properties make cable replacement Bluetooth's primary application. For example, while keeping your Bluetooth-enabled mobile phone turned on inside your coat pocket or purse, you could form a WPAN with your Bluetooth-enabled Pocket PC to dial into your ISP and access the Internet. After downloading a file, you could walk within 10 meters of a Bluetooth-enabled printer and send the file from your Pocket PC to the printer to have it printed. These examples show how Bluetooth can eliminate the need for a cable to the phone or printer.

A Bluetooth WPAN involves up to eight devices located within this 10-meter personal operating space that unite to exchange information or share services. Because it can be done spontaneously according to immediate need, it is known as "ad hoc networking." And because a WPAN involves directly networking between different points, without the use of network infrastructure, it is also referred to as a "point-to-point network."

Some experts even envision Bluetooth connections as "unconscious": with automatic settings, the connections could occur without any effort on your part (besides perhaps moving within 10 meters of a device).

Who will use Bluetooth?

Today, the Bluetooth market focuses on four categories of users: professional and field workers who need to travel off-site but still require access to corporate communications and information; technology-savvy electronics consumers; industrial and retail workers involved in automated processes where cables can get in the way; and office workers whose worksites are outfitted with Bluetooth devices.

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[1] There are different classes of Bluetooth devices, each with different characteristics. This paper focuses on Class 2 Bluetooth devices, which have a range of 10 m.

[2] IEEE defines WPAN as "specifically targeted to provide very low power consumption, low complexity, wireless connectivity among devices within or entering a Personal Operating Space (POS). This includes devices carried, worn, or located near a body." http://grouper.ieee.org/groups/802/15/pub/WPAN-FAQ.htm#03

[3] The transmission speed today is 800 Kbps. In the future, rates of 10-12 Mbps are expected.

How will Bluetooth be used?

Predominantly a WPAN technology, Bluetooth will primarily be used for cable replacement. Bluetooth eliminates the need to carry or handle bulky cables, frees up your ability to move around while using devices together, and lets you easily connect devices separated by physical impediments like walls.

The mobile device market is poised to explode in the next several years, and Bluetooth is an ideal solution for connecting the increasing number of devices designed to be held in the hand or worn on the body. These devices are being enthusiastically embraced by industries using mobile automation systems. For example, at a car rental facility, an employee could use a Bluetooth-enabled Pocket PC equipped with a bar code scanner to scan a Vehicle Identification Number (VIN), enter mileage and fuel data, then instantly transmit a receipt to a Bluetooth-enabled portable printer worn on the hip. Additionally, Bluetooth is an ideal solution for connecting mobile audio devices. Originally developed by Ericsson to eliminate the cable between a headset and mobile phone, Bluetooth features audio channel capability.

A car rental employee could use a Pocket PC to scan a VIN…

…Then use Bluetooth to send the information to a printer worn on the hip to make a receipt.

In Europe, Asia, and Africa, mobile phones based on GSM technology are popular. Each of these phones contains a smart card, known as the SIM, that holds unique customer information for billing purposes. Because of the SIM, industry experts foresee Bluetooth-enabled GSM phones to be used like credit cards. For example, you could use your Bluetooth-enabled mobile phone at a Bluetooth-enabled vending machine to charge your account and buy a drink.

The Bluetooth Specification, which defines Bluetooth and establishes its technical standards, impacts Bluetooth applications through its "profiles." Each Bluetooth profile provides device interoperability criteria for a specific functionality (e.g., serial port, dial-up networking, file transfer, LAN access, etc.). These profiles influence new applications, which in turn lead to new paradigms for using different devices together. Currently, there are thirteen Bluetooth profiles, and a Bluetooth device may have multiple profiles.

Using the Bluetooth Specification's LAN access profile, several manufacturers have created Bluetooth-enabled LAN access points. This means that in addition to WPAN, Bluetooth can also be used for WLAN. But due to its limited reach and relatively low data rates, Bluetooth is not an ideal technology for WLAN.

Where will Bluetooth be used?

One of Bluetooth's greatest advantages is that it can be used absolutely anywhere that at least two Bluetooth-devices share a 10-meter range. This is possible because Bluetooth is designed for direct point-to-point networking between devices and does not require proximity to infrastructure stations like signal towers or access points. So for someone who possesses at least two Bluetooth devices, that person can use Bluetooth wherever he/she chooses to bring those devices.

This freedom to roam will especially be important for traveling workers who need access to data communications and corporate data wherever they happen to be; locations will vary from a client's office or airport gate to a remote field site or restaurant. For example, a field technician

could carry a notebook computer, GPS receiver, and mobile phone, all Bluetooth-enabled, on service calls. All service calls recorded on the notebook computer could be time and location stamped via the GPS receiver, and completed forms could immediately be sent back to headquarters via email using the mobile phone.

Where electronics consumers use Bluetooth depends on what type of Bluetooth product they purchase; some gadgets, meant to be worn or carried, will be used wherever a person goes; other gadgets will find particular relevance in shopping malls, homes or cars. Industrial, retail, and office workers will also utilize Bluetooth at their worksites.

To a limited extent, Bluetooth will also be featured at public hot spots. These consist of popular commercial areas where Bluetooth users can tap into a wireless LAN to access customized information and services. When utilized at hot spots, Bluetooth participates in WLAN, not WPAN. Potential Bluetooth hot spots include shopping malls, airports, restaurants, cafes, and subway stations. They could offer everything from instant Internet access to targeted advertisements, facility information, and wireless ticketing. Socket and market analysts expect Bluetooth deployment at hot spots to be moderate due to Bluetooth's relatively slow data rates.

What types of devices will incorporate Bluetooth?

The largest Bluetooth market will be mobile phones, with over 70% of mobile phones expected to be Bluetooth-enabled by 2006.[4]

Backed by manufacturers like Ericsson, Intel, Microsoft, Motorola, Nokia, and Toshiba, Bluetooth will also appear in consumer gadgets like PDAs, notebook computers, computer games, headsets, alarms, smart home control units, TVs, VCRs, and auto PCs.

For retail, industrial, and office applications, Bluetooth will surface in mobile computers, bar code laser scanners, cash registers, vending machines, GPS receivers, slide projectors, printers, digital cameras, digital camcorders, test and measurement equipment, and LAN access points.

[4] Godell, Lars. "Bluetooth and W-LAN Will Coexist." Forrester Research, Inc. Oct 2001. p 13.

Who invented Bluetooth, and when was it invented?
Researchers at Ericsson, a popular mobile phone manufacturer, first began work on Bluetooth in 1998. Since then, the Bluetooth Special Interest Group (SIG), which currently includes more than 2,000 member companies, has been responsible for publishing the Bluetooth Specification. Socket Communications has been a member of the Bluetooth SIG since late 1998. Revision 1.0 of the Bluetooth Specification was published in July 1999, and Revision 2.0 is expected in the near future. For more information about the Bluetooth SIG, please visit www.bluetooth.com.

What does it mean to be Bluetooth-enabled?
A Bluetooth-enabled device has a radio that operates at Bluetooth frequency (2.4 GHz) and software that manages the connection data flow and security to adhere to the Bluetooth Specification. Bluetooth products need certification from the Bluetooth SIG, which ensures interoperability with other Bluetooth products.

What Is Wi-Fi?

As stated earlier, not all radio waves are the same, and the faster and further a radio wave travels, the more energy it requires. Herein lies the difference between Bluetooth and Wi-Fi, and from these technical differences, disparities in usage and target market also arise.

Unlike Bluetooth, which emphasizes low power and short range and in turn offers a transmission speed of approximately 800 Kbps, Wi-Fi depends on a higher energy intake to offer a 100-meter range and 11 Mbps maximum transmission rate. This speed makes Wi-Fi more than 10 times as fast as Bluetooth and similar to a high-speed modem. For large file transfers and quick Internet access, Wi-Fi outperforms Bluetooth.

The 100-meter range makes Wi-Fi conducive to wireless local area networking; its chief application will be to augment existing local area networks (LANs) that run on cables. Unlike Bluetooth, Wi-Fi does not involve new functionalities (e.g., Wi-Fi does not involve different profiles like Bluetooth). Rather, Wi-Fi simply provides a new wireless coverage area for an already existing cabled network. In this sense, Wi-Fi is not a completely cable-free solution — the wireless access points still must connect via a physical cable to the main network. Whereas Bluetooth is used for wireless cable replacement, Wi-Fi is utilized for wireless cable extension.

A LAN is a collection of devices linked together in a limited area (usually within a building or group of buildings) for exchanging information and services, and a wireless LAN accomplishes this via radio signals within a 100-meter range. For a notebook computer user, this translates into network access anywhere within the 100-meter range. For example, on a corporate campus outfitted with Wi-Fi, you could bring an Wi-Fi-enabled notebook computer from a colleague's office to a conference room or even the courtyard and use it to tap into the corporate network and check email or access files. By enabling wireless cable extension, Wi-Fi allows computer users to be more mobile and no longer tethered by cables.

A commonly known form of LAN is Ethernet, which includes a server to manage all the communal resources. Almost all Wi-Fi connections are Ethernet-style, linking each device to the server. Using Wi-Fi is also known as "infrastructure networking" because a server must be available for the WLAN to form (unlike Bluetooth devices, which can connect directly to each other without an intermediary). Occasionally, Wi-Fi can be used for WPAN, but because of its

high energy requirements, it is not ideal for ad hoc networking, especially for small peripheral devices or a group of disparate devices.

Similarly, the energy levels demanded by Wi-Fi render it impractical for small battery-powered devices like mobile phones, personal gadgets, and most PDAs. For example, typical Wi-Fi CompactFlash and PC Cards use 110-140 mA during idle mode and 200-300 mA during transmission, each at least twice the amount of power required by Bluetooth cards. As a result, most manufacturers today are implementing Wi-Fi into notebook and desktop computers and servers, whose power resources are better suited for the higher power requirements of Wi-Fi. The Socket Low Power WLAN Card is an exception. Because of its low power consumption (15-20 mA in idle mode), this CompactFlash card is ideal for use with Pocket PCs and other similar PDAs.

Who will use Wi-Fi?
Office and industrial workers and students will use Wi-Fi for network access. Socket and industry analysts believe that Wi-Fi will be easier to sell to workgroups or IT managers than the average consumer. Consumers who do purchase Wi-Fi will be technology savvy.

How will Wi-Fi be used?
Wi-Fi will primarily be used to replace or supplement existing LANs. It will give members of a workgroup more flexibility and convenience to work from different locations. Occasionally, Wi-Fi can be used for WPAN, but it is not ideal for ad hoc networking. Because Wi-Fi sends voice as compressed files, it is not ideal for audio applications.

Where will Wi-Fi be used?
Wi-Fi will appear anywhere that LANs are useful, such as corporate campuses and universities. Wi-Fi will also be used in home offices by technology-savvy consumers. Because Wi-Fi depends on proximity to infrastructure (i.e., access points) and because of its higher power requirements (which makes it practical to have an electric socket nearby), the technology is best used within a building environment.

Wi-Fi will also be a major force behind hot spots, to a much greater extent than Bluetooth will. More than four hundred airports and hotels in the U.S. are targeted as Wi-Fi hot spots.[5] Similar events are happening in Europe, with hundreds of hot spots already set up in Scandinavia alone.[6]

[5] Bassuener, Kristy. "Wi-Fi Taking Off in Hundreds of U.S. Airports," in *Wireless Week*. Sept 28, 2001.

When was Wi-Fi invented?
Work on WLAN began in 1990 by the Institute of Electrical and Electronics Engineers (IEEE), and Wi-Fi products first hit the market in 1999. Wi-Fi is based on the IEEE 802.11b specification, which was published in 1997. 802.11b belongs to a group of about a dozen 802.11 projects (ranging from 802.11a to 802.11i) organized by IEEE to define WLAN specifications. For more information on IEEE, visit www.ieee.org.

What does "Wi-Fi" mean?
Wi-Fi, short for Wireless Fidelity, refers to wireless LAN products based on the IEEE 802.11b specification. The Wireless Ethernet Compatibility Association (WECA) also has a "Wi-Fi" certification program for Wi-Fi products that meet interoperability standards. WECA is an international organization devoted to certifying interoperability of 802.11 products and to promoting 802.11 as the global wireless LAN standard across all market segments. For more information on WECA, please visit: www.wi-fi.org

What upgrades are expected for WLAN?
Each of IEEE's 802.11 committees is dedicated to designing a unique variation of WLAN using particular frequencies, power levels, transmission range, etc. Besides 802.11b, other prominent IEEE WLAN projects include 802.11a, which uses a 5.7-5.8 GHz bandwidth, 802.11d, which supports international roaming, and 802.11g, which aims for 22 Mbps maximum transmission speed.

How Are Bluetooth and Wi-Fi Complementary?

As Bluetooth and Wi-Fi began to capture the interest of the hi-tech industry, many understood the exciting potential of these technologies to revolutionize how people connect their devices. But negative publicity surfaced when analysts and members of the media speculated that the two technologies competed against each other. Most industry insiders and technology experts agree that the two wireless technologies do not compete but rather complement each other.

Speculations that the two technologies compete have come both from technical concerns and in reaction to a variety of events that occurred as the technologies were being pushed to market. Specifically, technical reservations have revolved around (1) Bluetooth and Wi-Fi signals interfering because they share the 2.4 GHz spectrum and (2) applications and devices overlapping because each technology is capable of both WPAN and WLAN. These technical doubts set the stage for the press to exaggerate certain events in the marketplace as evidence of one technology's victory over the other.

Will Bluetooth and Wi-Fi signals interfere, since they share the 2.4 GHz spectrum?
Interference can occur when radio signals occupy similar frequencies at the same time and place. Therefore, it seems logical to expect interference when Bluetooth and Wi-Fi are used together. However, such interference is not absolute and can be virtually eliminated with proper preventive measures. For example, in the unlicensed 900 MHz band, a wide variety of devices share similar frequencies without interference problems, including cordless phones, garage door openers, and baby monitors.

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[6] Frost & Sullivan. "Rapid Deployment Growth Moves Wireless LAN Hotspot Interest Centre Stage." Sept 13, 2001.

Likewise, research has demonstrated that interference between Bluetooth and 802.11 can be effectively minimized. Especially promising have been studies by both the Bluetooth SIG and IEEE on Adaptive Frequency Hopping (AFH). In AFH, a Bluetooth device tests the ISM band for interference and hops to a channel that is free. The Bluetooth SIG and IEEE are collaborating on AFH research and are working on an AFH specification as a recommended practice for Bluetooth and Wi-Fi coexistence. Besides AFH, other solutions to interference are underway. Engineers at Mobilian Corporation have successfully used a "systems-oriented approach" to simultaneously operate Bluetooth and Wi-Fi with minimal impact on performance.[7] Chipmaker Cambridge Silicon Radio is currently working on a single chip that will integrate both Bluetooth and 802.11 after intensive testing demonstrated effective concurrent performance.[8]

These examples are just the beginning. Only a few years old, Bluetooth is still a very young technology, and further developments in preventing interference with 802.11 are sure to come.

Do applications for the two technologies overlap? Will they appear in the same types of devices? Bluetooth and Wi-Fi can both potentially be used for WPAN and WLAN. Each technology, however, has specific strengths and weaknesses that make it far more suitable for either WPAN or WLAN, and more practical for use in certain devices.

Perhaps the most enduring difference between Bluetooth and Wi-Fi is power consumption; this determines which devices are capable of incorporating each technology. Because of its power requirements, Wi-Fi may never be incorporated into general usage mobile phones and other small, battery-powered devices, and minimal deployment is expected in mobile computers smaller in size than laptops. For example, a Wi-Fi PC Card can reduce a Pocket PC's battery life by 80%, while a Bluetooth PC Card on the same unit will reduce the battery life by only 15%. Notebook computers often hold twice or more the battery capacity of a typical Pocket PC, making them more suitable for Wi-Fi, with its higher power requirements.

Figure 3. Comparison Chart of Bluetooth and Wi-Fi

Characteristic	Bluetooth	Wi-Fi
Frequency	2.4 GHz	2.4 GHz
Range	10 meters	100 meters
Primary application	WPAN: cable replacement	WLAN: Ethernet
Data transfer rate	800 Kbps	11 Mbps
Power consumption	Low	Medium
Primary devices	Mobile phones, PDAs, consumer electronics, office and industrial automation devices	Notebook computers, desktop computers, servers
Primary users	Traveling employees; electronics consumers; office and industrial workers	Corporate campus users
Usage location	Anywhere at least two Bluetooth devices exist — ideal for roaming outside buildings	Within range of WLAN infrastructure, usually inside a building
Development start date	1998	1990
Specifications authority	Bluetooth SIG	IEEE, WECA

[7] Lansford, Jim, Nevo, Ron, and Monello, Brett. "Wi-Fi (802.11b) and Bluetooth Simultaneous Operation: Characterizing the Problem." Mobilian Corporation. 2000. p13.
[8] "CSR Shooting for $5 by 2003," in *Incisor*, issue 35, p14. Sept 2001.

Because Bluetooth has only a 10-meter range and 800 Kbps transmission rate, it is not ideal for WLAN. Because of Wi-Fi's power requirements, it is impractical for WPAN.

Additionally, the audio capabilities of the two technologies significantly differ. Originally developed at Ericsson to eliminate the cable between a headset and mobile phone, Bluetooth has audio channel capability. Conversely, Wi-Fi does not define how voice should be transmitted and does not define any special capabilities to do it. On Wi-Fi networks, voice would commonly be sent as Voice over IP (VoIP).

Recognizing that Bluetooth and Wi-Fi are used for different applications, some manufacturers have already started incorporating both technologies into a single notebook computer, including each component for separate usage purposes. For example, Toshiba debuted two models that support both technologies, marketing the Wi-Fi component for WLAN, and the Bluetooth portion for cable replacement.

Besides differences in performance and power drain, differences in chip price are also influencing manufacturers' implementation of Bluetooth and Wi-Fi into devices. In the future, Bluetooth chips are expected to cost less than Wi-Fi chips. Notebook computers, which cost more than PDAs, can more easily absorb the cost of incorporating a Wi-Fi chip. As a result, many notebook manufacturers are focusing on Wi-Fi, while many PDA manufacturers are interested in Bluetooth.

What events happened in the marketplace that led to speculations of the technologies competing?
Bluetooth and Wi-Fi are different wireless networking technologies at different stages of development. While Bluetooth is only a few years old, WLAN technology has been around for more than a decade. Members of the media who relentlessly compare Bluetooth and Wi-Fi fail to appreciate the technologies' differences in usage, maturity, and readiness for market.

The main events that fueled negative publicity primarily involved unrealistic expectations for Bluetooth to match Wi-Fi's performance in the market, even though Wi-Fi is eight years more mature and largely targets different users with different applications.

These events include:

1. March 2001 — The first attempt to demonstrate a Bluetooth trial at the CeBIT tradeshow in Germany failed. Organizers succeeded shortly afterwards, but Bluetooth's image was already tarnished, setting the stage for future comparisons in favor of Wi-Fi.
2. April 2001 — Microsoft announced that it would support Wi-Fi but not yet Bluetooth in its first version of Windows XP. To Microsoft's dismay, some members of the media construed Microsoft's decision as an absolute rejection of Bluetooth technology. As a result, Microsoft issued a statement reiterating its support for Bluetooth and explaining that it excluded Bluetooth from Windows XP only temporarily until more Bluetooth products reached market.
3. August 2001 — In a highly publicized article, an executive of Intel was quoted as saying that "802.11b has won" and Bluetooth was "in full retreat." This, perhaps, caused the most damage in terms of furthering the misperception that Bluetooth and Wi-Fi compete. Soon afterwards, the executive wrote an apology to the Bluetooth SIG, contextualizing his statement as concerning only WLAN, and declaring Intel a firm supporter of Bluetooth.

The media and some industry insiders were unrealistic in estimating how quickly Bluetooth products could appear. The market was expecting too much too soon from such a young

technology, and when Bluetooth products did not enter the market as quickly as expected, negative publicity spread like wildfire rejecting Bluetooth in favor of the more mature Wi-Fi. Contrary to some perceptions in the media that Bluetooth is behind schedule, Bluetooth product availability is actually occurring more rapidly than that of Wi-Fi. While it took nine years for WLAN products to appear in the marketplace using Wi-Fi, Bluetooth products already entered the market after less than three years of development.

It can be so easy to compare Bluetooth and Wi-Fi, and even pit one against the other, but in reality, they do not compete. They are different technologies with different timelines and can both succeed in the marketplace.

Have there been any successful implementations combining Bluetooth and Wi-Fi?
Perhaps the best way to demonstrate how Bluetooth and Wi-Fi are complementary technologies is through successful examples of their simultaneous operation. United Parcel Service is currently deploying a state-of-the-art package sorting system that involves Bluetooth and Wi-Fi integrated into a single device: the Motorola Emerald terminal. Package sorters wear two devices: a Bluetooth-enabled bar code scanning ring on a finger, and the Emerald terminal on the hip. After scanning a bar code using the ring, information travels via Bluetooth to the hip terminal, which then uses Wi-Fi to transfer the data via a WLAN access point to the UPS worldwide network. The hip terminals effectively avoid potential signal conflict problems through intelligent software that suspends Wi-Fi radios whenever Bluetooth signals are transmitting.[9]

Besides Motorola, other manufacturers are successfully integrating both Bluetooth and Wi-Fi into products. Cambridge Silicon Radio is developing a chip featuring both technologies, and Mobilian is doing the same in a two-chip set. Other companies are partnering to develop chips that combine Bluetooth and Wi-Fi: Bandspeed North America and Open Interface, and Silicon Wave and Intersil. Wireless hardware and software manufacturer Red-M has demonstrated Genos, wireless networking architecture that integrates both Bluetooth and Wi-Fi. Additionally, Compaq, Sony, and Toshiba are releasing notebook computers that support both technologies.

Conclusion

Bluetooth and Wi-Fi have the potential to dramatically alter how people use devices to connect and communicate in everyday life. Bluetooth is a low-power, short-range technology for ad hoc cable replacement; it enables people to wirelessly combine devices wherever they bring them. Conversely, Wi-Fi is a moderate-range, moderate-speed technology based on Ethernet; it allows people to wirelessly access an organizational network throughout a campus location. Although the technologies share the 2.4 GHz band, have some potentially overlapping applications, and have been pitted against each other in the press, they do not compete and have even been successfully combined for corporate use by United Parcel Service, Toshiba, Compaq, and others.

After recognizing important differences between the two technologies, consumers and corporate technology buyers alike can determine which one best fits their needs, or if it makes sense to use both. If you spend most of your time away from an office environment, but want to use mobile devices to stay in touch wherever you happen to be, then Bluetooth is the best choice for you. If your workplace has already set up Wi-Fi infrastructure, and you spend most of your time working from office buildings on your corporate campus, then Wi-Fi would serve you better. Lastly, if you

[9] Brewin, Bob. "UPS to Deploy Bluetooth, Wireless LAN Network," in *Computerworld*. July 23, 2001.

need to access mobile data communications both at your worksite and away from the office, then it makes sense to use both Bluetooth and Wi-Fi.

The potential uses for each technology are significant. By helping to revolutionize how and where we can communicate and access information, Bluetooth and Wi-Fi are improving our ability to stay connected, informed and productive in our daily lives.

GLOSSARY

ad hoc network
A spontaneous network of devices that connect together only for the duration of a communications session or, in the case of radio devices, while within transmission range with the rest of the network.

Adaptive Frequency Hopping (AFH)
A method for allowing coexistence of Bluetooth and Wi-Fi in which a Bluetooth device tests the ISM band for interference and then hops to a channel that is free.

bandwidth
The range of frequencies that a signal occupies.

Bluetooth SIG
Bluetooth Special Interest Group. International organization of more than 2,500 companies dedicated to developing, promoting, and publishing the Bluetooth Specifications and encouraging Bluetooth interoperability. www.bluetooth.com

Ethernet
A local area network composed of one or more servers that manage resources and services distributed through clients.

form factor
The size, configuration, or physical arrangement of a computer hardware object. For example, form factors of plug-in cards include CompactFlash, PC Card, Secure Digital, etc.

frequency
The channel that a radio wave or other type of electromagnetic radiation occupies.

GHz
Gigahertz. A measurement of radio frequencies equal to one billion hertz (Hz), or one thousand megahertz (MHz).

hot spot
A popular public commercial area where users can tap into a LAN for Internet access, facility information, online ticketing, etc. Common hot spots include airports, hotels, and shopping malls.

IEEE
Institute of Electrical and Electronics Engineers. U.S.-based organization responsible for publishing the 802.11b specifications. www.ieee.org

Kbps
Kilobyte(s) per second. Used to describe transfer rate for digital information.

LAN
Local Area Network. A network of devices within a local area, usually within a building or group of buildings.

Mbps
Megabyte(s) per second. Used to describe transfer rate for digital information. One Megabyte equals 1,000 Kilobytes.

PAN
Personal Area Network. A network of devices set up around the immediate bodily space of a person.

throughput
The amount of work that a device can do in a given time period.

WECA
Wireless Ethernet Compatibility Association. An international organization devoted to certifying interoperability of 802.11 products and to promoting 802.11 as the global wireless LAN standard across all market segments. For more information on WECA, please visit: www.wi-fi.org

Wi-Fi
Wireless Fidelity™. WLAN products based on the IEEE 802.11b specification. Also a certification program by the Wireless Ethernet Compatibility Association (WECA) for 802.11 products that meet interoperability standards.

WLAN
Wireless Local Area Network. A cable-less LAN, usually through Wi-Fi.

WPAN
Wireless Personal Area Network. A cable-less PAN, usually through Bluetooth.

