Discovering Bluetooth

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About the Author

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Introduction

Everyone is always looking for the "next big thing"—especially in the world of technology. Emerging technologies attract interest because of their future application (how will it affect my life?), because of their potential investment value (it's good to get in on the ground floor of something big), and, quite frankly, because they're kind of cool.

Bluetooth is just such an emerging technology. Many—including me—think that it's going to be the "next big thing" in the computing and telecommunications worlds.

If you follow the technology news, you've probably heard about Bluetooth already. It's a new wireless technology that promises not just to eliminate the cables that connect our computing and electronics equipment, but also to spawn new and exciting applications for electronic information exchange, electronic payments, and who knows what else.

And, if it does half of what some people predict, it's going to be big.

It's that future potential that inspired me to write this book. The technology is interesting, yes, but Bluetooth also has the potential to dramatically affect the way we do many things in our everyday lives. It's quite possible, once the technology hits a critical mass, that we'll find Bluetooth driving literally dozens of our different activities each day. When we use our computers or PDAs, we'll be using Bluetooth technology. When we use our desktop or mobile phones, we'll be using Bluetooth. When we drive our cars, Bluetooth will be along for the ride. When we go shopping, or traveling, or out for a night on the town, Bluetooth will be there.

If you're at all like me (and millions of other technology enthusiasts), you want to be in on the Bluetooth revolution from the very beginning. Maybe you're the guy who has to be the first on his block with all the new toys and gadgets. Maybe you see how Bluetooth can provide a better way to do those tasks that are slow and cumbersome today. Maybe you see an investment opportunity, and want to know which companies will benefit from a Bluetooth boom. Maybe you work for a company that is considering adding Bluetooth functionality to its products. Maybe you just want to find out what all the fuss is about.

Whichever of these statements best describes your interest in Bluetooth, you've come to the right place. *Discovering Bluetooth* is the first book to examine Bluetooth from a consumer, rather than a technical, perspective. This book will tell you what Bluetooth is about, how it works (in general terms—not a lot of technobabble here), and how it's likely to impact your daily life. You'll learn the history of Bluetooth (it came from Sweden...), view some of the first Bluetooth products to hit the market, and discover all sorts of interesting potential applications of the technology.

In short, whatever your interest in Bluetooth, you'll find the information you seek within these pages.

To make it easier to find precisely what you're interested in, *Discovering Bluetooth* is divided into three major sections, as follows:

- **Part I, Discovering Bluetooth**, contains three chapters that provide the essential background and history of the Bluetooth technology and of the consortium of companies that are developing Bluetooth for consumer consumption.
- **Part II, What Bluetooth Does**, contains two chapters that describe a number of practical applications of the Bluetooth technology, as well as present a multitude of first-generation Bluetooth-enabled products that are either currently available or will be available soon.
- **Part III, How Bluetooth Works**, contains six chapters that present the technical background behind the technology, discuss potential competitors to Bluetooth and barriers to its success, and predict how Bluetooth will develop in the future.

If you get stumped anywhere in the text, you can turn to the useful reference information contained in this book's appendixes and glossary. Here you can find a list of Bluetooth-related acronyms (and this technology is very acronym heavy!), a glossary of Bluetooth-related terms, the basic technical specifications behind the technology, and a helpful list of other Bluetooth resources that you might want to check out.

I think Bluetooth is going to be a big thing; that's why I wrote this book. I hope that *Discovering Bluetooth* provides the information you need to make up your own mind about Bluetooth—and to whet your appetite for this exciting new technology!

Part I: Discovering Bluetooth

In This Part

Chapter 1: Introducing Bluetooth
Chapter 2: How Bluetooth Came to Be
Chapter 3: The Bluetooth Industry

Chapter 1: Introducing Bluetooth

There's a Bluetooth in your future. No, this isn't the kind of blue tooth that requires expensive dental whitening. This Bluetooth is a technology that promises to eliminate most of the cables that connect your various personal computing devices—and to create new types of smart wireless communications.

This book is your guide to Bluetooth, a consumer-level overview of the technology and its possible applications. Throughout the rest of this book you'll learn all sorts of details about Bluetooth—what it is, what it does, how it does it, and how you'll use it. Before we get to those details, however, this chapter provides you with a general overview of the Bluetooth technology. So even if you've never heard of Bluetooth before, you'll find out what all the fuss is about—and discover how and why you'll soon be using Bluetooth technology in your daily life.

Visions of a Wireless World

The computing, communications, and consumer electronics industries have introduced many benefits to today's consumers. Of course, they've also introduced many headaches, not the least of which is the necessity of connecting all these devices to each other, usually with a phalanx of cables and wires that are both annoyingly messy and mind-numbingly confusing. Wouldn't it be great if you could connect your printer to your PC—or your PC to your PDA or your PDA to your phone line—without fumbling with the necessary cabling and worrying about whether you're using the right type of connector?

If you'd like to nix all that messy cabling, Bluetooth is for you. Bluetooth technology enables wireless connections between any number of computing, communications, and consumer electronics devices—and promises much more than that, including "smart" device recognition and synchronization.

At its most basic, Bluetooth technology will usher in a world of wireless connections. Using short-range radio wave transmissions, Bluetooth technology will enable all your different electronic devices to connect to each other—*without wires*.

Cableless Computing

Consider the common chore of hooking up a printer to your personal computer. Today you have to buy a big, thick, ungainly cable with multi-pin connectors on either end, plug the cable into the proper ports on the back of both your PC and your printer, and go through a complex setup procedure to make sure your PC recognizes the printer. Even when everything goes right—and it often doesn't!—the process is a pain in the rear, especially if you want to put your printer in a place that is either awkward to get to or far enough away from your PC that the standard cables won't quite reach.

Now imagine that same task in a Bluetooth-enabled world. In this world, your printer sends and receives data to and from your PC via a wireless connection, so you don't have to mess with that bulky computer cable. That means that you can place your printer anywhere you want—even clear across the room!—because you're not limited by the constraints imposed by cable connections. Plus, since Bluetooth is a technology that automatically recognizes all active devices in the vicinity, the process of configuring your computer for your specific printer will become much easier—in many cases, totally automatic.

If the thought of hooking up your printer without a cable sounds appealing, think of all the other devices you currently have plugged into your PC. If you're like many computer users, you have at least a half-dozen different items wired to your system unit, including your keyboard, mouse, joystick, speakers (two or more, most likely), microphone, personal digital assistant, scanner, digital still camera, PC/Web camera, video camera, and, of course, your printer. In addition, you can't forget the connection between your PC's modem and the nearest phone jack, nor the network connection that is required of any PC connected to a local area network. Today, every one of these connections is made with a cable; with Bluetooth technology, almost all of these connections can be wireless.

Think of how cluttered the back of your computer (and the back of your desk!) looks today, and then try to envision the same setup, but without cables. *That* is how things will look when Bluetooth technology invades your desktop.

Automatic Synchronization

Bluetooth is more than just a cable-replacement technology, however. It's also a technology that enables any electronic device to communicate with any other electronic device, automatically. This means that, over short distances (30 feet or so), your cell phone or personal digital assistant (PDA) can connect to, synchronize with, and even control the other electronic devices in your home or office—such as your personal computer, printer, television set, home alarm system, or home/office telephone system. All of this communication can take place in an ad hoc fashion, without your being aware, totally automatically.

Consider this scenario. You have a PDA that contains your contact list and daily schedule. You need to synchronize the data on your PDA with similar data on your desktop computer. Today, you do this by connecting your PDA to your computer, typically via a serial cable. (Another cable!) Once the proper connections are made, you have to manually synchronize

the data between the two devices. And you have to go through this rigmarole every time you make a new appointment or add a new contact.

Now imagine the same scenario, but using Bluetooth technology. As soon as you walk into your office, your Bluetooth-enabled personal computer senses the presence of your Bluetooth-enabled PDA, and sends out a signal asking, in effect, what new data has been added to the PDA. Without your pressing a button—or even being aware that any exchange is going on—your two devices synch up with each other, ensuring that your database of information is current on both machines. No fuss, no muss—and, once again, no cables. Just automatic "smart" communication, enabled by Bluetooth technology.

An All-in-One Phone

Another application of Bluetooth technology is in the world of telecommunications. If you're like most high-tech consumers, you're currently juggling several different phones, and several different phone numbers. You probably have a cordless phone at home, and a more complex phone system in the office. You also have a mobile phone to use on the go, and you might even have a fourth phone in your car. Plus, depending on your situation, you could have a fifth telecommunications device in your possession—an alphanumeric pager. All of these phones are separate devices, and all have their own individual phone numbers.

How much more confusing can you get?

In a Bluetooth world, things will be much simpler. For one thing, you'll only have one telephone handset, and you'll carry it with you at all times. When you're at home, it will connect (via Bluetooth technology) to your normal telephone line. When you're at work, it will connect to your office phone system. When you're on the go, it will function as a cellular phone. And when you're in the car, it will connect (wirelessly, of course) to your car's built-in hands-free phone system. It will even, if you choose, function as an alphanumeric pager—as well as an e-mail retrieval device and a miniature Web browser. You'll choose which phone numbers to use, and where; if you want, a single phone number will travel with you, no matter where you go.

One phone, one number—how much simpler can you get?

And Much, Much More…

Knowing that Bluetooth enables smart, totally ad hoc wireless communications between different electronic devices, one doesn't have to think hard to imagine other uses of this technology. For example, imagine

- A PDA that controls a desktop computer used to display a PowerPoint-based presentation—and that you can also use to record meeting minutes and then "beam" those notes to other attendees at the end of the meeting.
- A single device that turns your home security system on and off, locks and unlocks your front door, operates your automatic garage door, and monitors and controls your home's heating and air conditioning systems.
- A portable device that can be used by factory supervisors to check the status of inventory or equipment—and then automatically send that data to a master computer.

- A PDA or mobile phone that also functions as a digital "wallet" for payment at stores and restaurants—and that downloads and stores movie tickets, car park tickets, and other important information.
- A portable device that stores your plane, hotel, and rental car reservations—and can be programmed on the fly to function as a digital key to your hotel room.
- An in-car device that communicates with other Bluetooth devices along your route to provide driving directions and sight-seeing information—in addition to functioning as a digital car key that contains your personal settings for your car radio, air conditioner, and seat adjustments.
- A mobile phone or PDA that stores all your personal contact information—and can send that data, automatically, to people with similar devices at trade shows, in meetings, or at your local bar.
- Bluetooth-compatible electronic components—CD players, DVD players, VCRs, audio/video receivers, speakers, and the like—that can combine to create a totally wireless home theater system.
- A Bluetooth-enabled controller in theaters and other public venues that can automatically turn off the ringers on all mobile phones in the audience when the movie or performance starts.

Would you be interested in any of these potential uses of the Bluetooth technology? Hundreds and hundreds of companies are betting so, and have invested billions of dollars in the technology that can enable these and other applications.

How Bluetooth Technology Works

Bluetooth is a global technology standard that attempts to bridge the computer and communications industries. It has been adopted by all the major players in the telecom and computer worlds, as well as an interesting cross-section of companies in other industries—including the home entertainment, automotive, health care, industrial automation, and toy industries. (Yes, that's right—Bluetooth technology can be used in children's toys!)

While there are lots of pie-in-the-sky ideas floating around that may or may not materialize, at the very minimum, the Bluetooth standard promises to do the following:

- Eliminate wires and cables between both stationary and mobile devices over short (30 foot) distances.
- Facilitate both data and voice communication.
- Enable ad hoc networks and provide automatic synchronization between multiple Bluetooth devices.

Put simply, Bluetooth technology enables short-range wireless communication—both data and voice—between all sorts of electronic devices. This communication takes place without the explicit manual intervention of the user; whenever one Bluetooth-enabled device detects another Bluetooth-enabled device, the two devices automatically synch up and a type of ad hoc wireless network is created.

Radios Waves and Piconets

Bluetooth does all this by embedding a small, low-powered radio-on-a-chip into a traditional electronic device. This radio—and the chip-based software associated with it—is capable of transmitting and receiving both data and voice communications from other such devices.

Bluetooth radios use a radio band (called the industrial, scientific, and medical band—or ISM, for short) between 2.4 and 2.48 gigahertz (GHz). Because the radios are incorporated into small computer chips, they have a very small form factor and can, eventually, be produced at relatively low cost. The combination of small size and low cost should help to make Bluetooth technology ubiquitous in a variety of electronic devices—especially in those with portable applications.

Note The ISM band is unlicensed, and thus available for use at no charge. (It is also shared with other types of non-Bluetooth communications.)

When one Bluetooth device senses another Bluetooth device (within about a 30-foot range), they automatically set up a connection between themselves. This connection is called *piconet*, and is a kind of mini-network—a *personal area network* (PAN), to be specific. In a piconet, one Bluetooth device is assigned the role of master, while the other device—and any subsequent devices, up to eight in total—is assigned the role of slave. The master device controls the communications, including any necessary transfer of data between the devices.

Since Bluetooth signals are sent via radio waves, walls and other physical barriers do not present the same problem that they do for infrared signals, which must operate within a narrow line-of-sight window. Bluetooth's radio frequency (RF) signals can travel through most solid objects, so Bluetooth devices can be used in a small office (walls and cubicles are invisible) or from inside a contained space (such as a briefcase or shirt pocket). As long as two Bluetooth-enabled devices are no more than 30 feet apart, they'll always be able to talk to each other.

A Bluetooth Example

Let's look at an example of how Bluetooth technology might be employed in a network of devices within your home. As you can see in Figure 1.1, in this home of the not-too-distant future, every electronic device is enabled with Bluetooth technology—a desktop PC, printer, scanner, PDA, cordless telephone, and all the components in the home theater system.

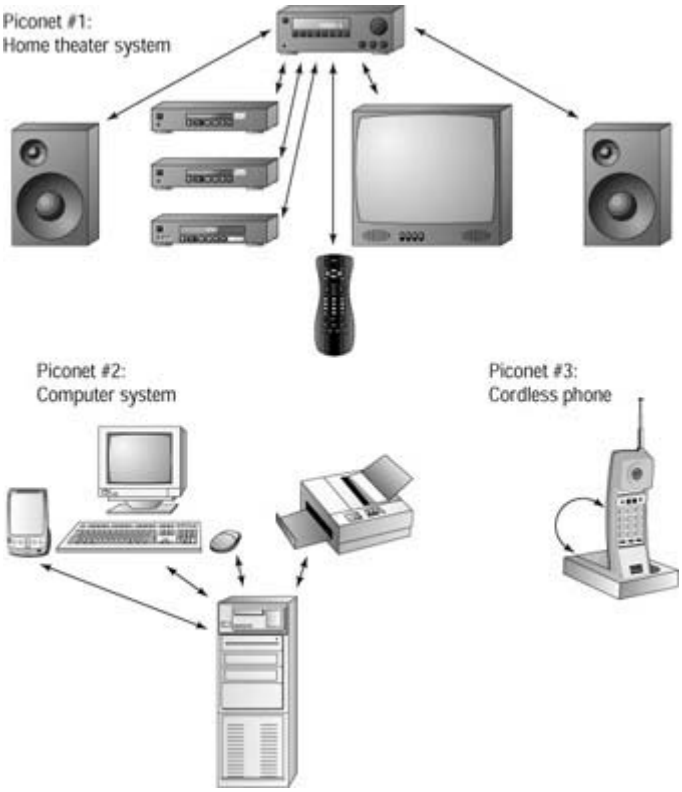

Figure 1.1: Bluetooth technology can connect all your household electronics.

Each of these devices is assigned a specific electronic address by its manufacturer. In addition, each device is programmed to automatically look for other devices within a predefined range, so that all similar devices automatically recognize each other—and automatically establish their own private piconet. This is done when each device, as it powers up, sends out a signal asking for responses from other devices within the predefined range; any responding devices are automatically added to the first device's piconet.

Note Each type of Bluetooth device is assigned a particular range of addresses—so that all cordless phones, for example, have addresses that fall within a predefined range.

As each device in our home of the future is powered on, three separate piconets are established. The home theater components establish one piconet, the personal computer and accessories (printer, scanner, etc.) establish a second piconet, and the cordless phone establishes a third piconet (between the handset and the base station—both of which include Bluetooth radios). Data (and voice, in the case of the cordless phone) are then routinely exchanged between all the devices within each individual piconet—the DVD player beams a movie to the A/V receiver, the computer sends formatted data to the printer, and so on. And all this happens without any data being inadvertently sent to the wrong device or network.

Of course, some devices can be instructed to work across different piconets. In our wireless home example, let's say that we've programmed the PDA to function not only with the computer piconet (automatically synchronizing key data) but also with the home theater piconet. Programmed in this fashion, the PDA can function not only as a personal digital assistant, but also as a wireless remote control unit for the home theater system, essentially bridging the two individual networks.

Note In Bluetooth terminology, when you connect two or more piconets together, you create a

scatternet.

One can also imagine the desktop PC operating across piconets. There is no reason why your PC, which might contain thousands of songs encoded in the MP3 format, can't use Bluetooth to beam the MP3 playback directly to your audio/video receiver—and also connect your home theater system directly to the huge database of audio files available on the Internet.

The neat thing about this type of Bluetooth-enabled home is that all this interaction—and more that we can't even imagine today—will take place relatively invisibly, and without messy cables strung around and across the room.

Note Of course, Bluetooth isn't the only technology available for short-range wireless communications. HomeRF and IEEE 802.11 (both discussed in Chapter 9, "Competitive and Complementary Technologies") are two competing standards for wireless networking that can be used either beside or in place of Bluetooth. While it's probably a good bet to assume that the combined industry might assembled behind Bluetooth bodes well for its ultimate acceptance as the de facto industry standard, there are no guarantees that a better or cheaper solution won't come along and steal Bluetooth's thunder—and market potential.

What Bluetooth Will Do for You

You now know that Bluetooth is a technology for wireless connections and communications. So what? It sounds neat and sufficiently high-tech, of course, but just how will this technology impact *your* life?

The Bluetooth SIG—the organization pushing the development and adoption of the Bluetooth technology—has developed several different "usage models." These models attempt to define the specific situations where consumers might utilize the Bluetooth technology.

While these usage models are discussed in more depth in Chapter 7, "Inside the Bluetooth Specification," here's a brief overview of how you might be using Bluetooth in the future.

The Cordless Desktop One of the most likely models, this scenario envisions cordless connections between your desktop PC and all manner of peripherals, from keyboards and printers to scanners and LANs.

The Internet Bridge In this scenario, Bluetooth technology is utilized to provide a wireless Internet connection, either to a mobile phone, portable PC, PDA, or some other portable device.

LAN Access This model is similar to the Internet Bridge model, except that the connection (via Bluetooth wireless technology) is between a computer (either portable or desktop) and a local area network.

File Transfer This scenario envisions the capability to transfer any type of data file from one device to another—from a PDA to a desktop computer, for example. This general model creates several other scenarios with more specific uses—including the Forbidden Message, Briefcase Trick, Interactive Conference, Automatic Synchronizer, and Instant Postcard models.

The Briefcase Trick This model describes how you can access e-mail while your portable PC is still in your briefcase—by transferring the messages, wirelessly, from your PC to your mobile phone.

The Forbidden Message Although this model has an ominous title (some companies prefer to call it the Flight Time With a Purpose model), it really has to do with composing e-mail messages while on the fly—literally inside an airplane, or anyplace where you don't have a live phone or network connection—and then having them sent automatically when you land (and walk by a Bluetooth transmitter/receiver in the airport).

The Interactive Conference This model contemplates using Bluetooth wireless technology to share electronic documents, business cards, contact and scheduling information, and meeting notes with other meeting participants via their portable computers—as well as using Bluetooth technology to facilitate control of a desktop PC or data projector via a Bluetooth-enabled PDA.

The Automatic Synchronizer In this scenario (also dubbed the Hidden Computing model), data located on separate Bluetooth-enabled devices are automatically synchronized when the different devices come into radio range of each other. Thus you could synchronize the calendar or address book on your mobile phone or PDA with your desktop PC, simply by walking into your office.

The Instant Postcard Under this model, still pictures taken with a Bluetooth-enabled digital camera are automatically sent over the Internet (via a Bluetooth-enabled mobile phone) to a Bluetooth-enabled personal computer.

The Three-in-One Phone This model envisions telephone handsets that can connect to three different types of telephone services—as a cordless phone connected to the public switched telephone service (your normal phone service), as a mobile phone connected to a cellular service provider, and as a type of "walkie-talkie" connected directly to similarly equipped Bluetooth phones.

The Ultimate Headset In this scenario, Bluetooth technology is behind a separate wireless headset that enables you to engage in telephone conversations without actually holding a phone in your hand. This product could be used in the home (the headset acts in the place of a traditional phone headset) or with your mobile phone—even when your phone is stuck in your pocket or briefcase.

The PC Speaker Phone This model envisions using Bluetooth technology to create a wireless connection between your cordless headset and your personal computer, to use the PC's built-in speaker as a speaker phone.

The Hands-Free Car Kit Under this model, there is no need to hook up your mobile phone to a hands-free kit when you get into your car; the Bluetooth mobile phone in your pocket (or briefcase) will automatically connect wirelessly to the hands-free kit built into your car, and all dialing and answering is voice controlled.

Why High-Tech Companies Are Excited about Bluetooth

The idea that eventually became Bluetooth was born in 1994, when engineers at Ericsson Mobile Communications investigated the feasibility of a low-power, low-cost radio interface between mobile phones and their accessories. This quickly developed into the concept of incorporating a small radio into both a cellular telephone and a portable PC, to connect the two devices without the traditional cable.

As work on the concept continued, however, the true potential of the technology eventually surfaced. If you could connect a cell phone to a PC, why not connect other devices as well? Why couldn't this radio-based technology become a universal bridge between devices—and to existing voice and data networks? And why limit the technology to "dumb" connections—why not provide the means for devices to automatically recognize each other, and perform key functions automatically upon connection?

As the concept of Bluetooth developed, Ericsson (in 1997) approached several manufacturers of portable electronic devices to discuss the development of this new short-range wireless technology, and in 1998 five key companies—Ericsson, IBM, Intel, Nokia, and Toshiba—formed the Bluetooth Special Interest Group (SIG), to coordinate the development of and promote the Bluetooth technology. Bluetooth was formally announced in May of 1998, and the Bluetooth SIG released version 1.0 of the Bluetooth specification in July of 1999.

Since then, membership in the Bluetooth SIG has grown to include more than 2000 different companies. Four other large companies—3Com, Lucent Technologies, Microsoft, and Motorola—have joined the five founding companies as so-called promoter members; these nine companies provide direction and promotion for the entire 2000-company Bluetooth effort. (The Bluetooth technology itself is available to all member companies via a royalty-free license—in other words, just about any company can use Bluetooth technology at no charge.)

Why are so many different companies interested in Bluetooth? Ask the companies themselves, and you'll get the standard "enabling the consumer with new technology" line. That may be true (and probably is true), but their motives are not entirely altruistic. The reality is that all of these companies are in bed with Bluetooth because they think there's money to be made—and lots of it.

Everybody expects Bluetooth to be a big deal—but how big is big? All the major market analysis firms are weighing in their forecasts, and the numbers are almost mind-boggling.

On the computer front, IDC predicts that 88.7% of all portable computers shipped in 2003 will incorporate integrated Bluetooth technology. On the mobile phone front, Cahners In-Stat Group predicts that 40% of all digital cellular phones shipped in 2003 will be Bluetooth enabled. Add it all up and you find that the folks who should know expect that the market will be flooded with hundreds of millions of Bluetooth-enabled devices, starting now and hitting a full stride no later than 2002. Merrill Lynch predicts that by 2005 there will be more than 2.1 billion Bluetooth-compatible devices on the market—creating a brand new $4 billion market.

With those kinds of numbers, you can imagine the dollar signs forming in the eyes of the world's major consumer electronics, telecommunications, and computer manufacturers. If the Internet was the last gold rush, Bluetooth could very well represent the next huge money-

making opportunity, with literally billions and billions of dollars to be made annually. The leaders in Bluetooth technology stand to reap a veritable bonanza when the market finally develops.

Of course, every company chasing the Bluetooth rainbow expects to be a leader. All the companies are betting that you'll become a huge user of the technology in general, and that you'll pick one of *their* devices as your primary Bluetooth controller—using it to handle your phone calls, control your electronic equipment, and store your electronic payment, ticketing, and personal information. The telecommunications companies (Ericsson, Nokia, Siemens, etc.) hope that some form of mobile phone becomes the dominant Bluetooth controller; the computer companies (Intel, Microsoft, 3Com, etc.) hope that some form of mobile computer (such as an enhanced PDA) becomes the dominant controller. It probably won't be a winner-take-all battle, but nobody wants to miss the revenues promised by this next big thing.

What to Expect in the Future

As with any new technology, it will take time for Bluetooth to become accepted and established. Despite all the hype over the past few years, the very first Bluetooth-enabled devices are just now hitting the market; it will take several years for Bluetooth-enabled products to become both common and affordable, and even more years for Bluetooth products to replace traditional wired products.

The first wave of Bluetooth-enabled products includes a variety of different high-tech devices, including:

- Adapters and PC cards to use with existing non-Bluetooth mobile phones and personal computers
- High-end (and high-priced!) mobile phones, cordless phones, portable PCs, and PDAs with built-in Bluetooth communication capability
- Wireless telephone headsets

That's just the first wave. As we move into 2002 and beyond, not only will you see lower prices on first-wave products, but you'll also see a new wave of totally different Bluetooth-enabled products, including:

- Desktop PCs with Bluetooth technology built into the motherboard
- Wireless printers, scanners, fax machines, digital still cameras, and the like
- Bluetooth-enabled home audio/video equipment
- Wireless products developed for use in specific industries, such as the industrial automation and medical industries
- Bluetooth technology integrated into various in-car functions and products—such as hands-free cell phone capability for your traditional mobile phone

Beyond this, the sky's the limit. Can you imagine Bluetooth-enabled kitchen appliances? (Some companies can, and have a vision of your toaster talking to your refrigerator and your refrigerator printing out a shopping list—based on how many slices of bread you've toasted.) How about Bluetooth-enabled sunglasses? (They would incorporate a heads-up map display for when you're driving, and an Internet-driven MP3 player for when you're not.) Or a Bluetooth-enabled key chain? (No physical keys, just encoded electronic impulses.) The possibilities, as they say, are endless.

The reality is that Bluetooth has the potential to be one of the defining technologies of the 21st century. By taking the wires out of the currently wired worlds of computing, communications, and consumer electronics, Bluetooth can make the real world a much more mobile, much more flexible, much more user-friendly place. If Bluetooth truly becomes *the* enabling technology for wireless connections and communications, expect many new and innovative applications to emerge—applications that could have the same impact on our future lives as the first computers and mobile phones had on our recent past.

Chapter 2: How Bluetooth Came to Be

There's a story behind any new technology, and the story behind Bluetooth is especially interesting. It involves a 10th-century Viking king, a group of Dutch and Swedish engineers, and an international consortium of high-tech companies—and it came about all because someone, somewhere, wanted to eliminate the thin little cable that connected his cell phone to an accessory headset.

Recognizing the Need

"It is not just a question of connecting to the other side of the globe. It is as much a question of connecting to the other side of the room."

Those words come from Ericsson Mobile Communications, the giant Swedish phone maker, and state in fairly plain language what the Bluetooth wireless technology is all about. While Bluetooth is a global standard (meaning that the technology is the same everywhere in the world), it's a relatively *local* technology—designed to connect devices no more than 30 feet (10 meters) apart.

So just how did this global standard for local communications develop?

The Mobile Phone Market Explodes

In the early 1990s, the market for mobile phones was exploding—particularly in Europe, which (unlike the U.S.) was unburdened by multiple, competing cellular standards. If you're an American who has never been to Europe, it's difficult to envision how pervasive mobile telephony is in that region. As an example, while just 26% of Americans had cellular phones in 1998 (according to Merrill Lynch), 48% of Swedes and 58% of Finns were talking via cellular—and many of them were completely replacing their traditional landline phones with cellular services.

When everybody and their neighbor has a cell phone, the market for mobile phone accessories also becomes quite significant. Of these accessories, particularly popular is the portable headset, a convenient accessory that makes it easier to carry on long conversations without having to hold a phone to your head for extended periods of time.

The problem with using a headset with a mobile phone, however, is the connection—in order to work, the headset has to be plugged into the handset. That means that a thin cable has to run from your head to your phone, which is awkward and annoying and a relatively serious impediment to increased headphone use. In addition, that darned wire rules out making your

conversation totally hands-free; you still have to hold the phone in your hand while you talk on the headset.

Cutting the Cable

One of the companies that recognized the need to break the cable connection was Ericsson Mobile Communications. In 1994 Ericsson commissioned a study to investigate an alternative to the cables traditionally used to connect cellular phones with headsets and other devices. Ericsson's research focused on developing a low-power, low-cost radio interface between mobile phones and their accessories.

Primary development of this new radio-link technology was initiated at Ericsson's research facility in Lund, Sweden. The lead engineers for the project were Swedish-born Dr. Sven Mattisson and his Dutch colleague, Dr. Jaap Haartsen, pictured in Figure 2.1.

Figure 2.1: Bluetooth's parents, Sven Mattisson (left) and Jaap Haartsen (right), of Ericsson. (Photos courtesy Ericsson.)

This study was part of a larger project within Ericsson that was investigating communications devices (such as PDAs) that could be connected to a cellular network via normal cellular telephones. As conceived by Ericsson's engineers, the last link in this chain was a short-range radio link between the communications device and the phone. Ericsson called this the *Multi-Communicator Link—MC Link*, for short.

The project gained momentum when the engineers discovered that they could tap into a low-frequency radio band that required no licensing, and was thus available to anyone in the world who wanted to use it, at no cost. This led to the development of a small radio embedded in a computer chip—small enough to be built into mobile phones and other portable devices.

A Greater Potential

As the MC Link project progressed, Mattisson and Haartsen became aware that there were other types of applications that could benefit from the technology they were developing. Ericsson's cheap, short-range MC Link radios could make wireless communication between all types of portable devices economically feasible. It wasn't just about phones, they realized.

Thus enlightened, Ericsson's engineers began to envision other applications of their new technology. What if a mobile phone could talk to a printer? What if a portable PC could connect to the Internet—using any office network? What if a PDA could communicate with a hotel reservation computer? And what if all these activities could take place without any manual configuration or initiation?

And thus the full potential of this new wireless technology was identified. What was initially conceived as a simple cable-replacement technology for cell phones and headsets was now something much broader, and much more important.

Haartsen confirmed that the broad application of the technology was almost an afterthought to the original research.

“The original intention,” Haartsen said, “was to make a wireless connection between something like an earphone or a cordless headset and the wireless phone.”

The fact that Haartsen and Mattisson were able to identify other, potentially more important, applications for the technology was a happy accident.

Creating a Standard

At the beginning of 1997, with its own engineers already working on what they were still calling the MC Link chip, Ericsson did something highly unusual—they decided to give the technology away.

The Necessity of a Global Standard

Ericsson realized that for the technology to succeed, there must be a critical mass of portable devices using their newly developed short-range radio. Unless the technology was embraced by a large number of other manufacturers, it would fail due to lack of support. In effect, Ericsson had to create a global de facto standard—before any other standards developed.

The importance of establishing an industry-wide (and cross-industry) standard cannot be overstated. In today’s consumer markets, products based on proprietary technologies rarely succeed. Consumers prefer to buy products that are based on common, if not ubiquitous, technologies. They don’t want to be stuck with an orphan that doesn’t work with similar products that their neighbors may own. Thus, if Ericsson was the only company creating products based on its own proprietary technology, they would inevitably lose in a marketplace where all their competitors embraced a different-but-common technology.

No-Charge Licensing

With this thinking in mind, Ericsson approached several manufacturers of portable electronic devices (both phones and computers) to discuss the development and the promotion of this new short-range radio technology. As the talks progressed, Ericsson discovered that they could best achieve their goals by abandoning a traditional licensing strategy and instead offering free licenses to any company that embraced the new technology.

This turned out to be a very smart move; by making the technology freely available to others, Ericsson encouraged faster development of the technology and persuaded a large number of companies to jump on the new technology’s bandwagon. This strategy also forestalled the development of any competing wireless standards, thus averting any potential “VHS vs. Beta” standards wars.

An Ideal Mix

Ericsson continued to talk with other companies, now determined to create a consortium to develop and push the technology across a variety of business disciplines. They were searching for the right industry mix—ideally, market leaders in mobile telephony, portable computing, and digital signal processing (DSP) chip technology.

That mix was achieved in early 1998, when Ericsson formed a close working relationship with Nokia (mobile telephony), IBM and Toshiba (portable computing), and Intel (DSP chips). All of these companies (along with Ericsson, of course) were instrumental in developing various aspects of what was to become the Bluetooth wireless technology.

Developing the Specifications

On May 20th, 1998, these five companies—Ericsson, IBM, Intel, Nokia, and Toshiba—held simultaneous press conferences in London, England; San Jose, California; and Tokyo, Japan. The purpose of this global press briefing was to announce that the five companies had joined together to develop a royalty-free, open specification for wireless connectivity between computing and telecommunications devices. As revealed that day, the specification was code-named "Bluetooth" and the organization behind the specification was called the Bluetooth Special Interest Group (SIG).

The Bluetooth SIG was initially charged with monitoring the development of short-range radio technologies and creating an open global standard. This standard—the Bluetooth Specification—was to become the primary focus of the SIG for the first year-and-a-half of its existence.

(For more information about the Bluetooth SIG and the Bluetooth Specification, see Chapter 3, "The Bluetooth Industry.")

The Need for Speed

Recognizing the importance of bringing this new technology to market on the fastest possible schedule, the Bluetooth SIG was organized into a number of topic-specific working groups. Each working group attacked a particular portion of the Specification—for example, there was a working group focused on technology profiles, and another on the radio and broadband layers of the technology.

Given the urgency of their task, most working groups met every few weeks, in locations all around the world. Most working group meetings were held at the locations of the SIG's founding companies—Lund, Sweden (Ericsson); Research Triangle Park, North Carolina and Hawthorne, New York (IBM); Chandler, Arizona (Intel); and Tampere, Finland (Nokia). When in-person meetings couldn't be arranged, conference calls were substituted.

Because the engineers working on the Specification were so geographically dispersed, communication outside these meetings became vitally important. Given the differences in time and in language between locations, e-mail became the primary messaging medium.

Creating a brand new technology out of whole cloth—and documenting that technology in infinite detail—was a huge undertaking. For many of those assigned to the various working groups, Bluetooth became their primary job, displacing their normal company-specific duties.

The coming months would be quite busy, indeed.

An Astonishing Achievement

Thanks to the combination of intelligent organization, frequent communications, and lots of long hours from all involved, the first release of the Bluetooth Specification was completed in about 18 months—an astonishing achievement, given the scope of the project and the number of companies involved.

Thus it was on July 26th, 1999, that the Bluetooth SIG announced the release of version 1.0 of the Bluetooth Specification. At almost 1500 pages in length, the Specification detailed all the profiles and processes necessary to utilize Bluetooth wireless technology in real-world applications.

Bluetooth was now ready for prime time.

Building Interest

The release of the Bluetooth Specification was only the beginning of the Bluetooth story. Now that there were technical specifications to guide the development of Bluetooth-enabled devices, other companies started to jump on the Bluetooth bandwagon. Ericsson and the other founding members of the Bluetooth SIG announced that the Bluetooth technology and brand would be made available to other companies on a royalty-free basis—all they had to do was join the Bluetooth SIG (also free of charge) and adhere to the SIG's guidelines and the Specification's technical details.

Growing the SIG

The first significant expansion of the Bluetooth SIG came in December of 1999, when 3Com, Lucent Technologies, Microsoft, and Motorola joined as promoter members. This put nine large and influential companies (the five founders and the four promoters) in charge of driving acceptance of the new technology.

Beyond these nine companies, other businesses could join the SIG on either the associate or adopter level. (See Chapter 3 for more information on the different membership levels.) Within a year, the SIG's membership rolls had climbed to more than 2000 companies, representing a broad cross-section of the global economy. Every one of these companies had a vested interest in producing Bluetooth-enabled products and services, and in seeing the technology succeed.

Fueling the Hype

The power behind the standard also attracted the attention of the world's press. By mid-2000 you could hardly open a newspaper or magazine without reading some story about the upcoming Bluetooth technology. (Co-inventor Jaap Haartsen was even named one of *Time* magazine's "Digital Dozen" upcoming movers and shakers in the world of technology for the

year 2001.) Whether you read *IEEE Personal Communications* or watch CNN, chances are you've heard something about Bluetooth, the technology that was set to change the world.

Of course, some of the hype was just that—hype. If you took some of these stories at face value, you'd think that Bluetooth would single-handedly eliminate all the wires everywhere in the world, and usher in an age of super-intelligent appliances and multi-function Dick Tracy–like wrist communicators.

Dick Tracy would have to wait, however—reality was about to make its presence known.

Dealing with Reality

Now that the Specification was written, the individual member companies of the Bluetooth SIG had an even more formidable challenge—to design and build real products that utilized the Bluetooth wireless technology. Dealing with the technology in theory is one thing; making that technology work in the real world is something much different.

Since it takes time to design, prototype, test, and then manufacture any complicated new high-tech product, there was a noticeable gap between the announcement of the Bluetooth Specification and the release of the first Bluetooth-enabled devices. In spite of all the attention from an increasingly restless press, it would be more than a year before the first Bluetooth products began to ship. Even then, very late in the year 2000, new products hit the market in mere dribs and drabs—ensuring that Bluetooth was born not with a bang, but with an expectant whisper.

It takes time for any new technology to reach a critical mass, of course, and that time is still several years in the future for Bluetooth. Still, as more and more Bluetooth-enabled products are announced, by hundreds and hundreds of companies large and small, it is apparent that the technology is eagerly awaited, and poised to truly become the "next big thing" for the telecommunications and computing industries. All indications are that consumers are prepared to embrace Bluetooth—as both a solution to existing problems and the catalyst for exciting new products and services. With time, Bluetooth is likely to become as ubiquitous as the computer chip, an accepted and necessary component of our high-tech society.

All of which is a fairly impressive accomplishment for what started out, back in 1994, as a simple project to eliminate one thin little cable. (Figure 2.2 shows the complete timeline of the Bluetooth project.)

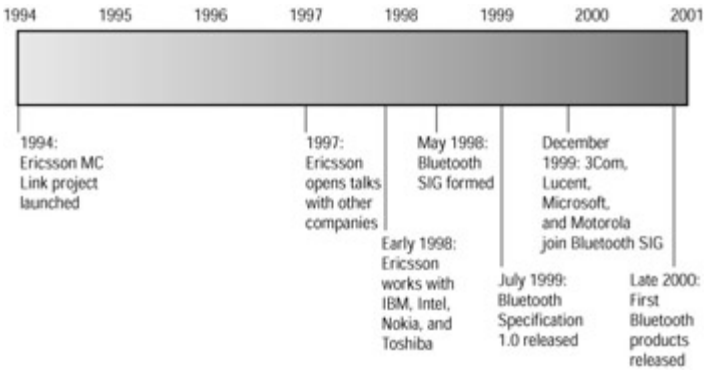

Figure 2.2: The Bluetooth timeline—from 1994 to today.

About That Name…

Before we finish this chapter, there's one nagging question that needs to be addressed: Where did they get the name "Bluetooth"? The answer to this question requires a brief knowledge of Danish history—and the awareness that the Bluetooth technology was developed by a Swedish company.

A Viking King

First, the history.

Harald (sometimes spelled Harold) Bluetooth, the future king of Denmark, was born in the year 911 A.D. He lived to the ripe old age of 74, dying in 985. Harald was born to royalty, the son of King Gorm the Old and his Queen Thyre (sometimes spelled Tyre). Thyre was herself the daughter of a nobleman, Schleswig, who is supposed to have been kindly disposed to Christianity. (Remember this last point—it's relevant.)

Gorm the Old was the King of what was then called Jutland, essentially the main peninsula of today's Denmark. In those times, and in that part of the world, Christianity was not yet the dominant religion. In fact, it was barely tolerated by King Gorm, who was a devout servant of the Norse god Odin. (Hey, we're talking Vikings here!) Gorm the Old had gone as far as to demolish the Christian churches in his country, which probably didn't sit well with his wife, who was raising their son with some smattering of Christian ideals.

Harald inherited the throne in 935, one year after his father was defeated in a war with the German King Henry I. The consequences of this defeat were such that King Gorm was forced to begin the restoration of the churches he'd destroyed and to grant some tolerance to his Christian subjects. On his death, King Gorm's throne was bequeathed to his son Harald, who was determined to further the acceptance of Christianity and to unite his kingdom against the continuing German threat.

King Harald enthusiastically continued the rebuilding of the churches that his father had reluctantly started. In 960, after years of spreading the Christian faith, King Harald was able to convert his country to Christianity. While some historians suspect Harold did this as a political ploy to protect his kingdom from further German invasion (his own personal conversion was conducted by the Archdiocese of Hamburg-Bremen), the act served to help unify Denmark and to solidify King Harald's place in history.

Of course, that's not all that King Harald did. He also conquered Norway (at the request of his sister, Queen Gunnhild of Norway) and exercised his hereditary right (through Queen Thyre's father) to parts of England. He strengthened the "Danawirk"—a series of ramparts and fortifications—to keep the Germans out of his kingdom. And, unfortunately, he was slain by his own son, Sven Fork-beard, after several years of plots and machinations within the royal family.

Note King Harald's expansionist tendencies were continued by his son and by his grandson, Canute—who became the only king to rule the Great North Sea Empire (comprising England, Denmark, Norway, and parts of Sweden).

King Harald's most significant accomplishment (aside from living so long in an age when most Viking kings died young and violently) was the unification of Denmark. Thanks to King Harald's efforts at rebuilding the churches and spreading the belief of Christianity, the provinces of Denmark were united under a single crown.

Note One of King Harald's lasting legacies was the creation of a monument to his late father and mother. Still preserved to this day in what has become a Christian shrine in North Jutland, the monument contains the following words, carved in stone as runic symbols: "Harald The King caused these monuments to be made to Gorm his father and Thyre his mother, the Harald who won all Denmark and Norway and made the Danes Christians." These engravings mark the first mention of "Denmark" in recorded history.

Why Bluetooth?

Now that we've had our history lesson, the question still remains: Why is this new wireless technology named after a 10th-century Danish king? It's all about King Harald's ability to unite. Like King Harald, the Bluetooth technology unites people and enables them to talk to each other. Thus King Harald Bluetooth, the uniter, gives name to Bluetooth, the uniting technology.

(Paying respect to King Harald, the official Bluetooth logo, shown in Figure 2.3, is composed of the runic characters H and B—for Harald Bluetooth.)

Figure 2.3: The Bluetooth logo. Those are the runic characters H and B, for Harald Bluetooth.

Oh, and about King Harald's second name. "Bluetooth" (or Blåtand, in Danish) doesn't have anything to do with the color of his teeth. Instead, it refers to his unusually dark complexion and his very dark hair. The word "Blåtand" is apparently derived from two old Danish words, "blå," meaning dark skinned, and "tan," meaning great man. In the land of fair-skinned Nordic blondes, Harold's distinct coloration apparently stood out like a… well, like a blue tooth.

Note You might think that the name Bluetooth was chosen because the company that developed the Bluetooth technology, Ericsson, is a close neighbor of King Bluetooth's Denmark; it would be hard to imagine an American company naming a technology for a somewhat obscure Viking king. However, the code-name "Bluetooth" (which eventually stuck as the technology's final name) was actually proposed by Jim Kardach of Intel, an American—and an avid history buff. Who would have thought it?

Chapter 3: The Bluetooth Industry

The entire Bluetooth industry—all the companies developing products and services based on the Bluetooth wireless technology—is centralized in an industry group called the Bluetooth Special Interest Group (SIG). The Bluetooth SIG not only creates and updates the technical specifications, it also makes sure products adhere to the technical standards and promotes the Bluetooth technology to consumers all around the world.

Any examination of the Bluetooth industry, then, must begin with a closer look at the Bluetooth SIG.

The Bluetooth SIG

The Bluetooth SIG is a consortium of companies that work together to define and promote the Bluetooth wireless technology. Members of the Bluetooth SIG create the specifications behind the technology—specifications that must be adhered to by any company adopting the Bluetooth wireless technology.

The Bluetooth SIG serves as a forum for developing and enhancing the Bluetooth Specification, provides a vehicle for interoperability testing, and functions as the primary instrument for generating market awareness and promoting the technology, worldwide. The common goal of all Bluetooth SIG members is to revolutionize connectivity for both personal and business mobile devices—by making ubiquitous the Bluetooth wireless technology.

The acceptance of the Bluetooth SIG has been immediate and universal. Today there are more than 2000 member companies, including the leading companies in a wide variety of industries.

Note The Bluetooth SIG is not a legally incorporated business entity, nor is it a formal standards body. Rather, it is an organization, governed by legal agreements between the member companies, chartered to define and promote the Bluetooth wireless technology. It is supported by the financial contributions of the member companies.

The Companies

For any company that wants a piece of the Bluetooth market, membership in the Bluetooth SIG is a necessity. For those smaller companies (and larger ones, too), it helps that basic SIG membership is free.

To join the Bluetooth SIG, a company must fill out the membership application form at the Bluetooth SIG Web site (www.bluetooth.com/sig/membership/membership.asp). All members of the SIG receive a royalty-free license covering all applicable intellectual property patent rights—in essence, a free license to develop products that incorporate the Bluetooth technology.

The companies in the Bluetooth SIG represent a number of different industries, including:

- Automotive
- Computing (hardware, software, and peripherals)

- Consumer electronics
- Industrial
- Networking
- Photography
- Semiconductor
- Telecommunications
- Test and measurement equipment

There are four primary levels of membership: founding, promoter, associate, and adopter. The founding and promoter levels are the province of the larger industry players; a new member can join at either the associate or the adopter level.

Table 3.1 details the key differences between the Bluetooth SIG's associate and adopter memberships:

Table 3.1: Associate and Adopter Member Privileges

Activity	**Associate Member**	**Adopter Member**
Marketing meetings and reflector	Yes	No
Architecture Review Board votes, meetings, and reflector	Yes	No
Regulatory meetings, reflector, and database	Yes	Yes
Test meetings and reflector	Yes	Yes
Working group chairs, meetings, and reflector	Yes	No
Working group drafts	Yes	Yes
Expert group chairs	Yes	No
Expert group meetings and reflector	Yes	Yes

Founding and promoter members have access to everything—all the groups, committees, task forces, meetings, and *reflectors* (communication forums for the various groups and committees)—and have first access to all developing standards and other available information.

Founding Members

The Bluetooth SIG was formed in May of 1998 by the following five companies:

- Ericsson Mobile Communications AB
- IBM Corporation
- Intel Corporation
- Nokia Corporation
- Toshiba Corporation

These founding members also serve as members of the promoter group, and are represented on the Program Management Board and most major groups and committees.

Promoter Members

In December 1999, four new companies joined the SIG's founding members as newly-christened promoter members. These new members, all major players in the world of high tech, included:

- 3Com Corporation
- Lucent Technologies, Inc.
- Microsoft Corporation
- Motorola, Inc.

The charter of the promoter group (which also includes the five founding members) is nothing less than to lead the efforts of the entire Bluetooth SIG. The nine promoter companies are the leaders in their respective industries, and combine their individual skills to help drive forward the development and acceptance of the Bluetooth technology.

Associate Members

Associate memberships are available to all companies that want a higher level of participation in the Bluetooth organization than what is granted to adopter members. While not nearly as powerful as the nine promoter members, associ-ate members can participate in many promoter-level activities that are off-limits to adopter-level members.

Associate companies receive early access to the Bluetooth Specification and other Bluetooth-related information. They also receive access to the SIG's reflectors and can become members of the Bluetooth working groups. (Working group membership is not open to adopter members.)

In order to be accepted as an associate member, a company must have signed the Bluetooth Adopters Agreement, must be sponsored by a promoter company, and must pay an annual fee—between $5000 and $40,000 per year, based on the company's annual revenues.

Adopter Members

Any incorporated company willing to sign the Bluetooth Adopters Agreement can join the Bluetooth SIG as an adopter member, at no cost. Adopter companies—along with all Bluetooth SIG members—qualify for a royalty-free license to develop and manufacture products based on Bluetooth wireless technology, and to use the Bluetooth brand and logo. They also gain access to the Bluetooth technical specification and related training and information—including training seminars and the annual Bluetooth Developer Conferences.

Note Some of the adopter companies in the Bluetooth SIG—those that signed the Early Adopter 1.0 contract—are known as *early adopter* companies.

Adopter members, however, have little say as to the continuing development of the Bluetooth Specification and promotion of the Bluetooth brand. These members—the bulk of the SIG's membership—belong to the SIG to have access to the technology, not to drive the technology.

The Structure

The initial objective of the Bluetooth SIG was to develop, as quickly as possible, an open specification for the Bluetooth wireless technology. To that end, the SIG was organized into a number of groups and committees, each focusing on a particular aspect of the Bluetooth Specification or the SIG's administration and promotion. Figure 3.1 details the structure of the Bluetooth SIG.

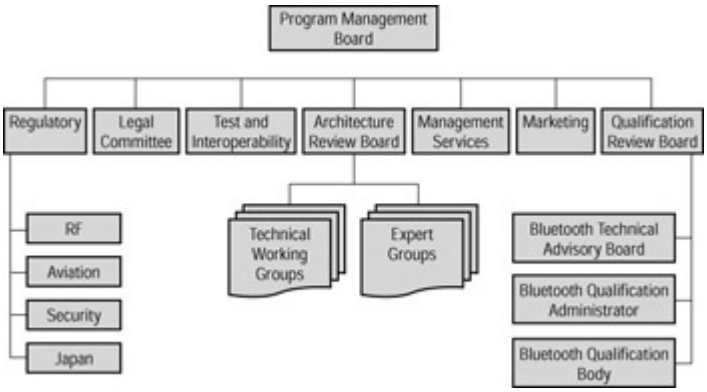

Figure 3.1: Bluetooth SIG organization

These groups and committees are coordinated by a Program Management (PM) Board, which is composed of representatives from each of the SIG's promoter companies. The PM Board is also charged with governing the overall SIG.

Management Services

The Management Services group is the administrative part of the Bluetooth SIG. In other words, this is the group that handles all the paperwork and the general day-to-day running of the organization.

Regulatory

The Regulatory group is responsible for ensuring that the Bluetooth wireless technology complies with the huge number of existing regulations present around the globe. The main Regulatory group comprises four subgroups, each focusing on a particular regulatory area:

- RF Regulations
- Aviation Regulations
- Security Regulations
- Japan Regulations

Legal Committee

The Legal Committee manages the legal affairs of the SIG, including the intellectual property agreements.

Marketing

The marketing group is responsible for promoting the Bluetooth technology, managing the use of the Bluetooth brand and logo, and helping to generate the Bluetooth usage models. When necessary, temporary marketing subgroups are formed to address specific marketing-related issues.

Qualification Review Board

The Bluetooth Qualification Review Board (BQRB) administers the Bluetooth Qualification Program, which is designed to guarantee global interoperability between Bluetooth-enabled devices—regardless of the manufacturer and the country where used.

The BQRB is composed of the Bluetooth Technical Advisory Board (BTAB), a Bluetooth Qualification Administrator (BQA), and multiple Bluetooth Qualification Bodies (BQBs).

Test and Interoperability

The Test and Interoperability group is responsible for developing product testing procedures and in ensuring interoperability between different Bluetooth-capable devices.

Architecture Review Board

The Bluetooth Architecture Review Board (BARB) oversees the various technical working groups and expert groups.

Technical Working Groups

Each working group is composed of representatives from both promoter and associate member companies, and is responsible for defining a specific Bluetooth usage model and then generating the technical specification to implement that model. The working groups report to the Architecture Review Board.

The exact number of technical working groups is always in flux; old groups are disbanded as specifications are completed, and new groups are formed as new opportunities are identified. You can find a list of the current working groups on the Bluetooth SIG Web site, at www.bluetooth.com/sig/sig/sig.asp.

That said, as of early 2001 there were eleven working groups focused on the 2.0 version of the Bluetooth Specification. These groups are described as follows.

Audio/Video (A/V) Working Group

The A/V Working Group is charged with developing usage models and profiles for consumer electronics equipment. Among the proposed usage models are CD-quality wireless headphones, speakers, and microphones; wireless video displays; dictation-quality wireless voice transmittal; wireless video cameras; wireless video conferencing; and wideband voice quality over wireless. This group is co-chaired by Philips and Sony.

Car Profile Working Group

The Car Profile Working Group is targeting applications for the Bluetooth wireless technology within the automobile environment. Potential usage models being investigated by this group include operating a mobile phone via an in-car device; exporting the interface of a portable device to an automobile; accessing the car via a remote device; determining the position of a car via a remote device; call handling between car-embedded and mobile phones; communication between the car and its environment; and automotive diagnostics and programming. The Car Profile Working Group is chaired by Nokia and co-chaired by Motorola.

Coexistence Working Group

The Coexistence Working Group focuses on making Bluetooth-enabled devices coexist with other devices that share the unlicensed 2.4GHz spectrum. The group works within the Bluetooth community as well as with cross-industry and other-industry groups (such as the IEEE and the HomeRF organization) to ensure that Bluetooth devices don't interfere with other devices, and vice versa. This group works closely with the Radio 2.0 Working Group, and is chaired by Lucent Technologies.

Extended Service Discovery Profiles (ESDP) Working Group

The ESDP Working Group is charged with developing Bluetooth profiles that are mapped to other industry service discovery protocols. Their initial focus is developing a profile based on the Universal Plug and Play (UPnP) technology. This group is co-chaired by Microsoft and 3Com.

Human Interface Devices (HID) Working Group

The HID Working Group is charged with developing a Bluetooth profile for the Cordless Desktop usage model. This profile will focus on connecting all manner of interface devices (mice, keyboards, joysticks, bar code readers, and so on) with desktop and portable computer systems. This group is chaired by Microsoft.

Imaging Working Group

The Imaging Working Group is investigating the display, storage, printing, and transmitting of digital still images using the Bluetooth wireless technology. This group is chaired by Nokia.

Local Positioning (LP) Working Group

The LP Working Group focuses on developing usage models and profiles that use Bluetooth technology to pinpoint the geographic location of people and devices—focusing specifically on local (indoor) positioning. This group is co-chaired by Nokia and Microsoft.

Personal Area Networking (PAN) Working Group

The PAN Working Group is charged with better defining the Bluetooth Specification in regard to ad hoc IP-based networking and security. This group is co-chaired by Microsoft and Intel.

Printing Working Group

The Printing Working Group focuses on developing usage models and profiles that address using Bluetooth technology to connect PDAs, portable computers, cameras, and other devices with color and black-and-white printers. This group is chaired by Hewlett-Packard and co-chaired by Ericsson.

Radio 2.0 Working Group

The Radio 2.0 Working Group is charged with further development of the Radio 2.0 specification within the overall Bluetooth Specification. In particular, this group investigates and proposes new extensions to the existing specification—including those that would increase the transmission speed of Bluetooth-enabled devices. This group is chaired by Ericsson and co-chaired by Nokia.

UDI Working Group

The UDI Working Group is developing a protocol and profile that extends the Bluetooth Specification to work with the Unrestricted Digital Information (UDI) transfer service used in Japanese-market 3G telephone handsets. This group is chaired by Intel.

Expert Groups

The expert groups, like the technical working groups, report to the Bluetooth Architecture Review Board. Where working groups are responsible for generating technical specifications, expert groups are more visionary in nature. Each expert group focuses on potential usage models and functions for a specific industry, and then acts in an advisory function to the appropriate working groups.

The Bluetooth Specification

Perhaps the most significant accomplishment of the Bluetooth SIG has been the development of the Bluetooth Specification. This document contains the technical information required to ensure that all Bluetooth-enabled devices can communicate with each other, worldwide.

Version 1.0 of the Bluetooth Specification was released in July of 1999. This document is more than 1500 pages long, and is divided into two parts: Volume 1 (Core) and Volume 2 (Profiles).

Note You can download the entire 1500-page document (in Adobe Acrobat PDF format) from the Bluetooth SIG Web site, at www.bluetooth.com/developer/specification/specification.asp.

Volume 1: Core

This part of the Bluetooth Specification specifies the various components and protocols of the Bluetooth wireless technology. Included is very detailed technical information about the following:

- The protocol stack—including core protocols, the Cable Replacement protocol, the Telephony Control protocol, and several adopted protocols
- The Bluetooth radio
- The link manager
- The transport layer
- Interoperability between different communication protocols
- Testing and compliance

Volume 1 is the most technical part of the Specification—which also makes it the largest of the two volumes, clocking in at nearly 1100 pages. (In contrast, Volume 2 is only about 400 pages long.)

For more information on Volume 1 of the Bluetooth Specification, see Chapter 7, "Inside the Bluetooth Specification."

Volume 2: Profiles

This part of the Bluetooth Specification deals with what the Bluetooth SIG calls "usage models" and "profiles." A usage model is a specific type of Bluetooth application, such as a three-in-one phone or an Internet bridge. A profile is the detailed technology and procedures required to implement a specific application.

Profiles specify precisely how to use the Bluetooth protocol stack, how to reduce options and set parameters in the base standard, and how to use procedures from several base standards. Profiles also define a common user experience for that particular type of use. All Bluetooth devices must be tested against one or more appropriate profiles in order to be certified.

For more information on Volume 2 of the Bluetooth Specification, see Chapter 8, "Usage Models and Profiles."

Licensing and Qualification

Products that meet the qualifications set by the Bluetooth SIG are licensed to use the Bluetooth technology and the Bluetooth brand and logo at no charge. This open standards strategy is designed to achieve broad market adoption and consumer acceptance, while ensuring adherence to a predefined set of specifications.

Any member of the Bluetooth SIG (and membership at the adopter level is free, remember) is partner to a licensing agreement that gives the member company the right to develop and manufacture products and software using the Bluetooth Specification, at no charge. This means that any member company can incorporate Bluetooth technology into their new or existing products or services, without paying one red cent to anyone. The only requirements are that they join the SIG and that their Bluetooth-enabled products comply with the Bluetooth Specification.

To carry the Bluetooth logo, all products must pass a rigorous test procedure, which verifies that they meet all requirements regarding the following:

- Radio link quality
- Lower layer protocols
- Profiles
- Information provided to end users

Bluetooth qualification is administered by the Bluetooth Qualification Review Board (BQRB). This Bluetooth Qualification Program comprises product testing by both the manufacturer and by the Bluetooth Qualification Test Facility (BQTF). The BQTF, after testing each product, issues a report to a Bluetooth Qualification Body (BQB)—a real human being!—who then approves (or disapproves) the product's qualification. Products passing qualification then go to the BQA (Bluetooth Qualification Administrator) for official listing and certification.

Note To ease the qualification process, products that incorporate a Bluetooth component that has already been qualified are themselves exempt from the qualification process.

Figure 3.2 details the steps involved in the Bluetooth Qualification Program.

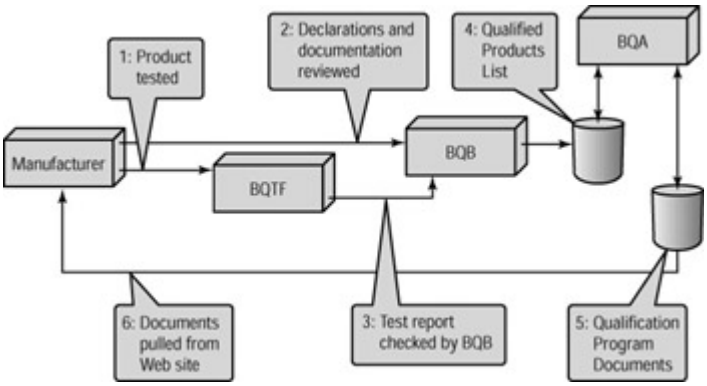

Figure 3.2: How to get a Bluetooth-enabled product qualified

The Products

After being thoroughly tested and subsequently qualified, a Bluetooth-enabled product can then officially be shipped to market—and officially carry the Bluetooth logo. Since Bluetooth technology is global, a single product could theoretically be shipped anywhere in the world.

The first Bluetooth-enabled products hit the market very late in the year 2000. Among the initial products were Bluetooth-enabled mobile phones, wireless headsets, PC cards for portable computers, and Bluetooth access points, from companies such as Siemens, Digianswer, Motorola, GN Netcom, Toshiba, Ericsson, and IBM.

Moving further into the year 2001, a veritable flood of products utilizing the Bluetooth wireless technology is set to inundate the market. By the time you read this book, you'll be able to shop at your local computer or electronics store and have no trouble finding products that bear the Bluetooth logo.

For an up-to-date list of products that have passed Bluetooth qualification, see qualweb.opengroup.org/Template.cfm?LinkQualified=QualifiedProducts. To learn more about these and other Bluetooth-enabled products, turn to Chapter 5, "Bluetooth Today."

Part II: What Bluetooth Does

In This Part

Chapter 4: Practical Uses of the Bluetooth Technology
Chapter 5: Bluetooth Today

Chapter 4: Practical Uses of the Bluetooth Technology

You know that Bluetooth is a wireless technology designed to replace cables and enable ad hoc connections between electronic devices. You know that some of the biggest names in the communications, computing, and consumer electronics industries are behind the development of Bluetooth. You even know that the Bluetooth SIG has written a 1500-page specification outlining all the technical details of the Bluetooth technology.

What you probably don't know—or what you're not sure of—is how Bluetooth will fit into your daily life. In other words, you have one basic question: What will Bluetooth do for you?

This chapter will answer that question.

Living with Bluetooth: Day One

The best way to examine the many practical applications of the Bluetooth wireless technology is to envision a typical day in a fully Bluetooth-enabled world. In fact, we'll examine two days—one at home and at work, and another away from home, on the road.

Bluetooth at Home

The buzzing of your alarm clock interrupts you from a shallow sleep. You turn over, wipe the sleep from your eyes, and glance across the room at the large digital numbers that are seemingly floating in air beside your bedroom door. It's six o'clock, time to rise and shine.

Sliding your feet to the floor, you reach out your arm, grab a credit card–sized remote control unit, and press a button; the buzzing of the alarm goes silent. You press another button on the remote and soft music fills the room, emanating from the compact stereo system sitting on your dresser, on the other side of the room. With another push of a button the lights start to rise, and you hear the sounds of your shower turning on. When you know the water is warm enough, you step under the showerhead for the kind of pulsing hot shower that really gets you going.

After your shower you dry off, pull on your robe, and shuffle to the kitchen. There, a fresh pot of coffee is brewing at just the right temperature, and two slices of toast pop up from the

gleaming chrome toaster as you walk by the counter, as if on command. You reach inside the refrigerator for some orange marmalade, and a slightly accented female voice speaks to you from the front of the refrigerator door, reminding you to stop and pick up groceries on the way home from work.

As you sit down at the kitchen table to eat your toast and marmalade, you pick up a thin pad about the size of the Etch-A-Sketch toy you had as a kid. This pad isn't a toy, however; you press a button on the side of the pad and the front page of today's newspaper appears on the pad's super-sharp electronic screen. You flip through the pages with the press of a button, finishing the newspaper—and your breakfast—in a matter of minutes.

You put your dirty dishes in the dishwasher and return to your bedroom to get dressed for work. On your way out the door, you pick up your palm-sized personal digital assistant, which is lying on the kitchen counter. A quick check of the PDA's screen confirms that your spouse has assembled a shopping list for your visit to the grocery store, and downloaded the list to your PDA. You smile to yourself at your spouse's efficiency, then you walk through the kitchen and out into the garage, ready for your morning commute.

Behind the Scenes

So far, this future morning routine isn't *too* different from your current routine. (Okay, the talking refrigerator and newspaper-on-a-pad are probably new—unless you happen to live in Bill Gates' house.) Just where does Bluetooth fit into all this?

Let's start with the alarm clock. This alarm clock doesn't sit on a nightstand beside your bed; it's built into the compact stereo system that sits across the room, and projects the time as a kind of hologram, so that the numbers seem to float in space. That's just high-tech magic, easily accomplished with current technology. What's really neat, however, is that you control the alarm via Bluetooth technology; the wafer-thin remote control unit includes a built-in Bluetooth transceiver.

This single remote unit controls several other devices in addition to your alarm clock. It also controls all the functions of your compact stereo system; it controls the water flow in your shower; and it communicates with several Bluetooth-equipped appliances in your kitchen. The system is smart enough to know that when you turn off the alarm and turn on the music it should start running your shower, start brewing your coffee, and (at just the right moment) start toasting your toast.

In your kitchen, all the appliances are connected together in a Bluetooth piconet. Your coffee machine talks to your toaster ("coffee's on—time to start the toast"), your toaster talks to your refrigerator ("just used two more slices of bread—better adjust your inventory"), and your refrigerator talks to you ("we're low on bread—need to stop by the store and buy a loaf"). More important, your refrigerator talks to your spouse's personal computer, using Bluetooth technology to transmit a current contents list; your spouse uses this list to create your weekly shopping list.Naturally, your PDA talks to your spouse's PC via a Bluetooth link. As soon as your spouse finishes the shopping list, it's stored on disk and queued up for transmittal to your PDA. The next time you walk by the computer, the shopping list is automatically transmitted to your PDA, where it stays in memory until you hit the grocery store later that day.

The electronic pad waiting for you on your kitchen table is called an e-book. Each morning the contents of the daily paper are automatically downloaded (from your home's Internet connection, via a Bluetooth link) into the e-book's memory; you don't have to worry about retrieving a paper newspaper from behind the bushes, or recycling the pages when you're done reading each day.

Bluetooth on the Road

As you head out into your garage, you have your PDA in one hand and your briefcase in the other. You touch a button on the PDA's screen, and the kitchen door locks behind you as the garage door begins to open. You smile because you know your house will be safe while you're gone; that touch of a button has also activated your whole-house security system, and readjusted the heating and air conditioning system to operate at a more efficient setting.

You open your vehicle's driver's side door, and note that your spouse must have driven the car to the neighborhood meeting last night; the seat is too far forward, and the radio is probably tuned to that radio station you really hate. You won't have to suffer, however, because the car senses your arrival, and automatically adjusts the seat position, turns up the air conditioning, and retunes the radio to your favorite oldies station.

As you slide behind the wheel, the video display on the car's dashboard comes to life. The screen is blank for now, but you hear a familiar tone as the in-car phone synchs up with the cellular phone in your briefcase. The cellular network now knows that you're online and available for incoming calls.

You pull out of the garage and the garage door automatically closes behind you. You drive out of your neighborhood and pull onto the freeway. There's a line of cars lined up behind the manual tollbooths, but you ease into the express lane and zoom through without even slowing down, knowing that your tolls will be registered automatically and electronically. Somewhere behind the scenes, fifty cents is transferred from your bank account to the state highway department.

After a few minutes you hear a soft chime and realize that you have an incoming e-mail message. Since you don't want to pull over to the side of the road to read the message—the car is smart enough to deactivate the on-screen messaging system while you're in motion—you push a button on the dashboard and speak two words: "Read message." The car's voice recognition system listens to your command, and then uses voice-synthesis technology to read the contents of your e-mail, in that familiar, slightly accented, female voice.

The e-mail is from a colleague in your West Coast office, confirming some details for your trip tomorrow. When the message is read, you say "Reply" and dictate a short response to the e-mail. When you say "Send" there's another short chime, and you know your reply has been sent on its way.

You turn onto the off ramp and hear your car's female voice alert you that you're low on gas, and that there's a gas station two blocks ahead. The voice also mentions that the gas station is having a sale on window washing fluid; it just so happens that you're low on that, too. So you pull into the gas station, fill up the tank, and pick up a gallon of the blue liquid that was on sale. While you're at the pump, you also download a new batch of MP3 files into your car's

audio system; the concept of "filling up" takes on new meaning when you can download all sorts of electronic information and entertainment via an ad hoc Bluetooth connection.

You don't bother pulling out your wallet to pay; that all happens automatically, just like it did at the toll booth. Somewhere behind the scenes, twenty dollars is transferred from your bank account to the big oil company that owns the gas station.

As you pull into the parking lot beside your office, a ringing sound comes from your car's dashboard; it's your mobile phone, running through a speaker and microphone built into your car's dash. You answer the phone by saying "Answer"; it's your assistant on the line, telling you that your boss wants to see you as soon as you get in. You tell her that you'll be upstairs in three minutes, then you shut off the engine, grab your briefcase, and head across the parking lot.

Behind you, you hear the sound of your car doors locking. It's time to start work.

Behind the Scenes

Bluetooth technology facilitated just about everything you did on the drive from home to work—everything except drive your car, of course. Let's start with what happened as you walked out into your garage.

When you pressed a button on your PDA, it sent a signal (via Bluetooth) to the electronic lock on your kitchen door. The door automatically locked, and another signal was sent to activate your house's central security system. A third signal was sent to your heating/cooling system, to adjust the settings to the "away" mode. Finally, a fourth signal was sent to your garage door opener, raising the door.

These signals were sent manually—at the push of a button—because you wouldn't want all that happening every time you walked out into the garage. (It would be extremely inefficient to activate your entire home security system each time you dumped an empty Coke bottle in the trash!) Your system is smart, but not that smart; when a range of different activities is possible, you have to manually tell the system which activity you're currently doing.

Getting into the car, however, is a different thing. Whenever you're near enough to open the car door, the car knows you're getting ready to go for a ride. All your personal settings for seat adjustment, temperature control, radio presets, and the like are stored in your PDA; your car and your PDA automatically establish a Bluetooth link and your personal information is downloaded and implemented, just like that.

Communication inside your car is also automatic. Your cell phone doesn't even have to leave your briefcase to link up with your hands-free car kit. With your cell phone as a focal point, your car can now send and receive phone calls (via a built-in speaker and microphone) as well as connect to the Internet, all through your cell phone—which remains in your briefcase, out of sight.

The voice-activation part of this system isn't reliant on Bluetooth technology, but it's still neat—and necessary, if moving vehicles are ever to integrate e-mail and Internet access. You can't read a screen or type while you're driving, but you can dictate commands and messages. Hence the necessity of voice activation and recognition.

Communication with the outside world is also facilitated by Bluetooth technology. When your car sensors indicate that you're low on gas, Bluetooth signals emanate outward, searching for the nearest refueling point. The nearest acceptable gas station (you can program the parameters—limiting the choices to specific brands, or instructing the system to scan for the lowest price within a certain range) is logged into your car's computer, and a real-time map to the station is displayed on your in-dash video screen—thanks to a combination of GPS, cellular, and Bluetooth positioning. You're even the beneficiary of Bluetooth-enabled marketing, as the station's daily specials are automatically beamed to you as you approach. Of course, if there had been a competing station across the street, you probably would have been beamed *those* specials, too; in-car advertising is one of the unfortunate side effects of all this Bluetooth messaging.

A more acceptable effect of Bluetooth in-car technology is the ability to initiate payment just by passing by a Bluetooth receiving device. One such "pass-by" payment system was installed in the freeway tollbooth; your car signaled your personal payment information (via Bluetooth signals) as you drove by, the signals were received by a Bluetooth access point in the toll plaza, the information was shot over the Internet to the state's e-payment system, and a payment request was then transmitted from the state to your bank. A similar system was in effect at the gas station, where payment was authorized as soon as you pulled up to the pump; a matching electronic receipt was simultaneously beamed to your PDA for record keeping.

Also in effect at the gas station was a Bluetooth-enabled server, designed to download MP3 files, games (for your kids to use in their backseat entertainment system), information, and other data directly to your in-car computer system. Some items (such as electronic maps and weather reports) are downloaded automatically whenever you fill up; other items (such as games and audio files) are downloaded only at your command. All the downloading, of course, takes place over a Bluetooth link.

Bluetooth at Work

Walking into your company's building, you stop by your office just long enough to drop off your briefcase and synchronize your PDA with your assistant's computer. You head to the top floor to meet with your boss, who asks you to do a brief inspection of the company's local factory this afternoon. You check your PDA to make sure your schedule is free; it is, so you block off a few hours to make your boss happy.

Back in your office, your PDA automatically synchronizes with your assistant's PC again, this time adding your afternoon factory trip to her version of your calendar. You have a few phone calls to make, and since you like to pace while you talk, you fasten a wireless headset over one ear and start calling—by using the phone's voice-activation feature to speak names into the headset, no buttons to push.

Your phone calls completed, you download your PowerPoint presentation from your desktop PC to your PDA and head off to a mid-morning meeting in the conference room. All the managers in your department are there, as is your assistant. She's brought a notebook PC, so she can take notes during the meeting. You press a button on your PDA, and the first slide of your PowerPoint presentation appears on the projection screen at the far end of the room. You pace around the table as you give your presentation, touching the screen of your PDA whenever you want to advance to the next slide. At the end of the presentation, your assistant

beams her notes from her notebook PC to all the attendees' notebooks and PDAs; you like the fact that everyone has an instant to-do list, based on the discussions held during the meeting.

After lunch you head out to the large building that houses your company's factory. The factory foreman greets you and begins his dog and pony show. Different items are assembled in different parts of the factory, and you use your PDA to tap into and monitor the testing procedures at each stop. Each test station is testing something different, and the screen of your PDA automatically changes to reflect the display and controls of each different test device.

You thank the foreman for the tour, and note that you have a bunch of test data stored in your PDA's memory. You head back to your office, send the data from your PDA, over your company's network, to the new kid in your department, for him to analyze. Then you make a call to your spouse, who answers via cell phone. You say you'll be a little late for dinner, as you need to hit the grocery store and also pick up that new DVD recorder you've been talking about. Your spouse sighs a kind of resigned sigh about the DVD recorder, and you promise you'll be home by seven.

Behind the Scenes

Bluetooth is everywhere in the office of the future, as this little scenario shows. The first application appeared when you walked into your office, when Bluetooth was used to automatically synchronize the data in your PDA with that in your assistant's desktop computer. One can assume that a duplicate schedule was stored on *your* desktop computer, and that the data was subsequently synchronized with that machine.

Next up is the Bluetooth headset you used to make your morning calls. A small base station is attached to your desktop phone; this base station contains a Bluetooth radio and antenna, and transmits and receives to the miniature wireless headset you wear when on the phone. The headset, small as it is, also contains a Bluetooth radio and antenna, as well as a toggle button you can use to pause and disconnect calls. You can place your calls via your desktop phone, or just speak the number into the headset, which is equipped with voice recognition software for hands-free dialing.

When you download your presentation from your desktop PC to your PDA, you use Bluetooth technology. When you use your PDA to control the presentation computer and display, you use Bluetooth technology. When your assistant beams her notes and to-do list to everyone around the table, she uses Bluetooth technology. If they were visible, you'd see 2.4GHz radio waves shooting all around the office.

Bluetooth is also an important technology to the industrial world, as evidenced in your trip to the factory. Wireless Bluetooth devices are used to monitor all the different processes in the plant—but no matter how many processes you have, you only need a single device. The control interface for the device automatically changes to reflect the process currently at hand, so a single PDA can monitor and control any number of processes.

Back in your office again, you use your PDA to access your company's local area network. There's no need to download the data to your PC and then send it from there; your PDA can access a Bluetooth LAN access point and transfer the data directly to the network, and then to the recipient.

Finally, when you call your spouse, the phone number you dial is a number that follows her around wherever she goes. You don't know whether she's at work, in the car, or out jogging. She carries a single handset—in the form of a mobile phone—with her wherever she goes, and connects (via Bluetooth) to the nearest phone system. If she's at home, the handset connects to your normal phone line. If she's at work, the handset connects to her office phone system. If she's somewhere in-between, the handset connects to the cellular phone network. The phone is smart enough to know where it is and what system to connect to—and to use Bluetooth wireless technology to make the connections, when necessary.

Bluetooth in the Store

The first place you stop on your way home from work is the giant consumer electronics store by the mall. You've had your eye on a particular model DVD recorder, and tonight's the night you take the plunge.

You head down aisle after aisle until you find the model you're looking for. Standing in front of the stack of boxes, you eye the price—for some reason, it doesn't feel like a good deal to you. You pull out your cell phone (which happens to be Bluetooth enabled) and point the phone at the tag on the front of the display model. The phone reads the information embedded on the tag (electronically, of course) and then connects to the Internet to compare prices. Seconds later, the extra-large display on the phone lights up, listing three other stores in your area that stock this particular model of recorder. The store at the top of the list has the item listed for twenty dollars less than the price this store is charging; you decide to bypass the current store in favor of the one with the lower price.

A half hour later a brand new DVD recorder is sitting in the trunk of your car, and you're heading to the grocery store to finish your shopping. You take your PDA inside the store with you, so you can cross off the items on your shopping list as you put them in your cart. When you can't locate a particular item (just where *do* they stock the Chai, anyway?), you punch a button on your PDA and a store map appears on the display, the item in question highlighted.

You decide to ignore the constant barrage of electronic coupons that are beamed to your PDA as you pass items on promotion, although the dollar-off coupon on pistachio nuts catches your eye. You grab the extra-large container of nuts and wheel your cart to the nearest checkout lane. As the clerk rings up your total, you beam the electronic coupon from your PDA to the electronic cash register. The clerk takes the dollar off, then tells you your total. You push a button on your PDA and payment is authorized; no cash changes hands.

Somewhere behind the scenes, a hundred and twenty dollars is transferred from your bank account to the grocery store's account.

Behind the Scenes

There are numerous applications of the Bluetooth technology in the retail store environment. In our little example, the first application is for in-store comparison shopping. In this world of the future, every display in the electronics store is equipped with a Bluetooth radio, which transmits information about the item for sale to all nearby Bluetooth devices. In this case, the DVD recorder's performance specs would be displayed on the screen of your Bluetooth phone; if you moved to the next item on display, specs about that model would show up on your phone.

Beamed along with the unit's performance specs, of course, is the unit's model number. It's a simple matter to use an Internet-based comparison shopping service to search for other local stores carrying that particular model, and then to display a list of prices. Thanks to Bluetooth, you can shop in Wal-Mart and decide to buy at Target, if the price is lower there.

Bluetooth technology can also be used to find things—particularly in a big store with lots and lots of items for sale. Can't find the Chai? Punch up Chai on your Bluetooth device, and it access the store's network (via Bluetooth signals) and returns a map showing the precise location of the item. If that isn't good enough, the store can beam precise directions to your device ("Walk three paces forward and turn left at the display of canned hams").

Moving through this example, we once again see the application of Bluetooth-enabled advertising. Radio waves are free, so it's likely that marketers will use them to bombard you with what they perceive to be targeted promotions. Fortunately, electronic coupons and advertisements should be as easy to ignore as the kind you receive through existing media.

Paying for your purchases is bound to be an important application of the Bluetooth technology. Your total bill is beamed to your Bluetooth device, and you press a button to authorize payment. Everything else happens behind the scenes, and totally automatically.

Bluetooth at Night

You make it home by seven, as promised, unpack the groceries, and have a nice dinner with your spouse and children. As the kids clear off the table (okay, so maybe this isn't a totally realistic view of the future!), you head to the living room and unbox your new DVD recorder. You eye all the different components of your audio/video system, and spy a space between your MP3 server and hard disk recorder where you can slide the new unit. The DVD recorder just fits in the space, and you're extremely thankful that you don't have to fuss with the mess of connecting cables that you had on your old, non-Bluetooth system. With your new system, all you have to do is plug your DVD recorder into the power strip; no other connections are necessary.

Now you sit back on your comfortable couch and pick up your A/V remote control unit—which looks suspiciously like your PDA. You press a button on the remote's touch screen display, and your entire system comes to life, including your new DVD recorder. On the main screen of your remote, you notice a new icon for your new component. Your remote was reconfigured when your system automatically sensed the new DVD recorder and beamed that information to your remote control. You press the DVD recorder icon, and your wide-screen HDTV monitor flashes on, your A/V receiver switches to the DVD recorder input, and the DVD of the latest Austin Powers movie you thoughtfully preloaded starts to play, in glorious surround sound. As the opening theme swirls around you, you glance back at your rear speakers and note how difficult it would have been to run wires from the receiver, through the attic, to the back of the room; wireless speakers are something else to be thankful for.

Your spouse puts the kids to bed and joins you on the couch to watch the movie. You tap the remote control to dim the lights, and settle back for a relaxing evening. Just then you hear the phone ring, and the movie sound is automatically muted. You pick up a nearby handset to answer the call. It's just your mother; you talk to her for the mandatory five minutes while your spouse pauses the movie. That chore done, you unpause the DVD and watch the rest of the flick without interruption.

When the movie is over, your spouse heads to the bedroom while you walk over to the PC in your home office. You check your e-mail and make sure you synchronize your PDA with your PC. You also download your electronic plane ticket for tomorrow's trip into your PDA and use your printer to print a hard copy, just in case. Your work done, you pack your PDA into your briefcase, next to your cellular phone and notebook PC, and head to bed.

Behind the Scenes

The first application of Bluetooth technology in this scenario occurred when you unpacked the groceries. As you put the groceries away, your master grocery inventory was automatically updated—by your PDA, which transferred the items on your electronic grocery store receipt to the computer built into your refrigerator. (In the home of the future, the refrigerator definitely runs things; it's a much more dominant "smart" appliance than your electronic waffle maker or egg poacher.)

Bluetooth technology is everywhere in the audio/video system of the future. Since Bluetooth serves as a cable replacement technology, new components can be added to your system merely by setting them in place; no cables have to be connected, no settings have to be adjusted. Everything happens automatically when the existing A/V system piconet recognizes the new Bluetooth device.

This extends to the remote control unit of the future—actually a mini-computer, in the form factor of a PDA. The touch screen on the remote adapts itself to the activity at hand—if you're watching a DVD, the DVD transport controls appear on the display; if you're watching satellite TV, the satellite receiver controls are active. In addition, new components added to the A/V piconet are automatically integrated into the remote control device's display and control structure. No programming is necessary.

Special mention should be made of the use of Bluetooth technology to create wireless speakers. Speaker placement—especially rear speakers in a surround-sound system—has also been problematic. If you're an A/V enthusiast, you're used to running speaker wire under carpets, behind baseboards, and through walls, ceilings, and crawl spaces. Using full-fidelity wireless speakers takes all the hassle out of speaker installation, and opens up surround sound to a whole new market that otherwise wouldn't bother with the messy and often expensive installation.

Naturally, Bluetooth technology will enable your home phone system to communicate and coordinate with the other systems in your home. In this example, when your phone receives an incoming call, a Bluetooth signal is sent to your A/V system, telling it to quiet down while you're talking. As soon as you hang up the phone (or walk out of the room with the phone handset), the system's settings return to normal. It goes without saying that the connection between your cordless phone handset and its base unit is enabled via Bluetooth.

In your home office, everything is connected without wires. Not only is downloading from your PC to your PDA done via Bluetooth, the printing of your tickets is enabled by a wireless Bluetooth connection between your PC and your printer.

As in your work environment, Bluetooth's 2.4GHz RF signals are everywhere in your home.

Living with Bluetooth: Day Two

Our first day in the future was a normal working day, more or less. For our second day, we'll look at how Bluetooth technology insinuates itself into all the facets of a typical business trip.

Bluetooth at the Airport

The next morning you wake up as usual, although a little earlier than normal; you have a plane to catch. You go through your morning ritual, quickly, then jump in the car and head to the airport.

As you turn off at the airport exit, the video screen in your dashboard alerts you that the short-term parking lot is already full. Knowing this, you decide to use the parking garage, which isn't full. You pull into the garage and zip past the machine that used to dispense parking receipts; now your entry is noted electronically instead.

After you find a parking space, you walk into the airport building, through the metal detectors, and head directly to your gate. Your wireless electronic ticket is stored in your PDA, so your arrival is automatically noted and your seat assigned.

You note that the flight is delayed by a half hour, so you head to the airline's frequent-flyer lounge to use the extra time productively. You pull out your notebook PC, turn it on, and use its Bluetooth wireless connection to check your e-mail. Nothing important is waiting, so you use your Bluetooth cellular phone to make a call or two. After you make your last call, your PDA starts beeping, alerting you that your flight is now ready for boarding, so you pack up your notebook and head back to the gate.

At the gate, you get in line and proceed down the jetway to the plane. There is no attendant at the door slowing things down; the ticket stored in your PDA is registered electronically as you walk past the door.

On the plane, you settle into your seat and wait for takeoff. You pass the time by putting on a pair of wireless noise-canceling headphones, and listening to some MP3s you'd stored on your notebook PC's hard drive. You get through two songs from the latest U2 album before the pilot automatically turns off all electronic devices on the plane via a master Bluetooth communication. After takeoff you pull out your notebook and compose a few e-mails; fortunately, it's a short flight, and you don't get interrupted by a boring in-flight movie.

Back on the ground, you exit the plane and walk past one of the ever-present Bluetooth access points that are distributed throughout the terminal. As you walk past, the e-mail you composed on the plane is automatically sent from your notebook PC through the access point out over the Internet. All of this happens without your even knowing it, of course; you're concentrating on getting down to the baggage carousel and retrieving your overnight bag.

At the baggage carousel, you watch dozens of different black overnight bags circle by. You pull out your PDA and stare at the screen for a few moments; it flashes an alert and beeps as your overnight bag approaches. You confirm that it's your bag by pressing a button on your PDA, which causes a red LED to flash on your baggage tag. Satisfied, you grab your bag—and head to the car rental bus.

Behind the Scenes

Okay, this little scenario introduced a host of new Bluetooth applications. Let's take these one at a time.

While you're in your car, your vehicle's built-in Bluetooth radio is set to receive information and emergency broadcasts along the route. In this case, your car is notified by a transmitter at the short-term parking lot that the lot is full. The notification is automatic, and accompanied with instructions on alternate parking.

When you enter the parking garage, your car's presence is noted electronically, thanks to a Bluetooth transmission from your vehicle to a receiver in the garage. This receiver notes the time of entry and enters that information into its database. When you get back from your trip and leave the garage, the precise duration of your stay will be recorded, and your bank account will be debited the appropriate parking fees.

By the way, something else Bluetooth-related will happen when you return from your trip. If you're like a lot of us, you sometimes forget where you parked your car. With Bluetooth, this isn't a big problem anymore; you can use your PDA to search for your car by exchanging Bluetooth signals. Your PDA will locate your car and provide an on-screen map and walking directions. It might even start beeping as you get close to the car, like a high-tech Geiger counter.

At the airport, the entire concourse is connected in a huge Bluetooth scatternet. Your PDA holds your ticketing information, which is transmitted via Bluetooth to the airline's check-in counter—and later to what used to be the gate agent, as you board the plane. The airline lounge is completely Bluetooth enabled, so you can connect your notebook PC to the Internet just by turning it on; there are no messy wires to plug into balky dial-up connections. Messages from the gate are also transmitted via Bluetooth directly to your Bluetooth phone or PDA; this way you can wander around to your heart's content while you're waiting for your flight to board.

On the plane, you choose to listen to MP3 files through a wireless headset. The headset, of course, is connected to your notebook PC via a Bluetooth link. This same link enables you to control your PC's MP3 player software from the headphones—so you don't even have to remove your PC from your briefcase to use this particular application.

One really neat application of the Bluetooth technology comes in the form of publicly broadcast commands. In this example, the pilot uses Bluetooth technology to broadcast a command to shut down all electronic devices during takeoff. Naturally, this command works only with Bluetooth-equipped devices, but it's still a pretty cool—and extremely useful—application of the technology.

(A similar application could be employed at movie theaters or other public venues; a public command could be sent that would turn off the ringers on all Bluetooth-equipped mobile phones.)

Composing e-mails during a flight isn't new; what is new is being able to send those e-mails, automatically, as soon as you land. In this instance, just walking within 30 feet of a Bluetooth access point activates the Bluetooth radio in your notebook PC, which automatically sends

any pending e-mail sitting in your outbox. Not only is this done totally without wires, it's done totally in the background; you're not even aware that it's happening.

Just as you can use your PDA to find your "lost" car in the parking lot, you can also use your PDA (or any other Bluetooth device, such as a cellular phone) to find and identify your luggage. A Bluetooth radio is embedded into a luggage tag, and your Bluetooth PDA or phone sends out "search" signals to locate your luggage—which beeps in recognition.

Of course, if the airline happened to put your bag on a different flight, your PDA won't be able to find it. In that case, the airline can use one of their own Bluetooth devices to read the flight information your PDA has previously transmitted to the luggage tag, and redirect your luggage to the correct airport.

Bluetooth may not signal the end of lost luggage—but it definitely makes it easier to find any bags that have been lost!

Bluetooth in the Rental Car

Your bag in hand, you exit the rental car bus and stand in front of what used to be the rental car checkout building. The only thing there now is a small Bluetooth access point, which is transmitting car rental information to all of the company's customers. You pull out your trusty Bluetooth cell phone and read the information that has been transmitted to the phone's display. This information tells you what kind of rental car is waiting and where you'll find it.

You follow the on-screen directions and find a dark green Camry waiting for you, all fueled up and ready to go. You throw your bag in the back and slide behind the steering wheel, happy that your Bluetooth PDA has transmitted your personal preferences to this new car. The seat adjusts automatically, the air conditioner dials in the proper temperature, and the car radio finds a local station that plays your favorite mix of oldies and soft love songs. You don't have to do a thing but get behind the wheel and turn the ignition key.

Comfortable in the car, you now proceed to the exit, which you zoom through without even slowing down. This is because all your information has been automatically transferred from the rental car's built-in Bluetooth radio to a Bluetooth receiver in the exit gate—and then transferred to the rental car company's main computer. All automatic, no people or paper required.

You're not entirely sure how to get from the airport to your hotel, as this is your first visit to this city. Fortunately, your itinerary has been automatically beamed from your PDA to the car's in-board computer, and a detailed map is now displayed on the car's in-dash video monitor. You press a button and your favorite slightly accented female voice proceeds to give detailed turn-by-turn directions. When you glance at the in-dash display, you see your position highlighted on the map, your location fixed by a combination of satellite GPS, cellular positioning, and Bluetooth technologies.

Before you get to the hotel, you decide to call your office back home. You press a button to use the car's built-in radio, which links to the cell phone in your briefcase to connect to the local cellular network. The call is automatically linked to your local cell phone number, even though you're in a different city, on a different network, with a different in-car phone.

Everything is okay back home, which you confirm just as you pull up to the front of your hotel. Now it's time to check in, and then you'll head down to the industry conference that starts just after lunch.

Behind the Scenes

Expect to find lots of Bluetooth applications in the rental car industry. The most natural application, of course, is electronic ticketing. Instead of waiting in line at a rental car counter, your arrival and check-in is done automatically and wirelessly as soon as you step off the rental car bus. The same system is used to transmit the location of your rental car to your Bluetooth device; now you'll know exactly where space Z24 is, without the agent having to draw you a map.

Exiting the rental car lot is also automatic and wireless, thanks to a Bluetooth transmitter embedded in the rental car. This same Bluetooth functionality will be used when you return the car. In this case, a real human being might still greet you when you pull up, but he or she will carry a handheld device (Bluetooth-enabled, of course) that will automatically read the mileage and fuel-level information from the rental car—and then beam that information back to the company computer to finalize your bill and debit your bank account.

Since you carry your personal preferences with you (in either your Bluetooth phone or Bluetooth PDA), your rental car is automatically personalized as soon as you walk up to it. Your Bluetooth device also transmits your destination information to the car's computer, which automatically generates a map and driving directions. While you drive, your position is triangulated as you pass each Bluetooth access point en route.

Using your cell phone on the road is also made easier by Bluetooth technology. Not only does your phone use Bluetooth technology to connect to the rental car's hands-free car kit, it also configures itself appropriately; you use the same phone number wherever you go.

Bluetooth at the Hotel

You have a few hours before the conference starts, so you hand the rental car over to valet parking and trundle your bag to what used to be the check-in desk. Instead of the long row of staff necessary in the old days, the only people there now are a bellboy and the concierge. That's because you essentially check yourself in, using your handy Bluetooth device.

In this case, you walk into the lobby and whip out your Bluetooth phone. When you flip it open, the screen displays confirmation of your check-in, and informs you that you'll be staying in room 304. You can even press a button to see a map of the hotel, in case you can't find your room.

Finding your room isn't a problem, so minutes later you're standing in front of room 304, bag in hand. You didn't get a key at the front desk (what front desk?), but you don't need one. All you have to do is point your Bluetooth phone at the door and enter your secret PIN; your phone then transmits a signal to your door, which then automatically unlocks.

Later on, when you're ready to check out, you go through a similar procedure. You walk down to the lobby and past the concierge, and your Bluetooth device signals the hotel that you're leaving. Your bill is transmitted to the hotel's central computer, which then contacts

your bank and debits your account for the appropriate amount. No waiting in line, no keys to fuss with—just walk by the front desk, and it all happens automatically.

Behind the Scenes

The hospitality industry is another industry that's betting big on Bluetooth. Bluetooth-enabled wireless check-in and room assignment is easily accomplished, with custom-built software systems and strategic placement of Bluetooth access points.

Also relatively easy to accomplish is Bluetooth-enabled room access. All it takes is the assignment of a PIN (transmitted directly to your Bluetooth device) and the installation of a small Bluetooth receiver in the door, connected to an electronic locking mechanism. As long as you carry your Bluetooth device with you, you'll never have to worry about losing your keys again.

Just as checking in can be made easy with Bluetooth, so can checking out. All you have to do is walk by a Bluetooth access point, and your personal Bluetooth device automatically transmits all the appropriate information to the hotel's computerized billing system. As with all other forms of Bluetooth-enabled e-payments, all debits to your bank account are done automatically, behind the scenes.

Bluetooth at the Conference

You freshen up, have a bite to eat at the hotel restaurant (billed to your room via your Bluetooth device, of course), and then head down to the hotel's main conference room. You find a seat in the middle of the room and wait for the presentation to begin.

The presentation is interesting (or as interesting as these things get), and you decide you'd like to share it with your staff back at the home office. The speaker announces that copies of the presentation are available for downloading, so you pull out your Bluetooth phone and push a few buttons. This causes a few things to happen: First, the presenter's PowerPoint file is transmitted to your phone, via Bluetooth. Second, your phone automatically establishes an Internet connection (via Bluetooth, of course) and e-mails a copy of the presentation file to your staff back home. You decide to send a voice message along with the file, so you speak a few words into the phone, press another button, and then put the handset back into your briefcase.

After the conference you meet the other attendees at a big cocktail party. You get a chance to chat with the guy who put on today's presentation, and you decide to exchange business cards—which you do by pulling out your respective PDAs and beaming your vCards to each other via Bluetooth.

The party over, you decide to surprise your family with a quick digital postcard of the hotel's impressive lobby. You connect a small digital camera attachment to your cell phone (it looks like a small ping pong ball) and snap a picture. With a press of a button, your phone automatically sends the digital picture via e-mail to your spouse's e-mail address, along with a short voice message you've attached.

You smile as you put your cell phone back in your pocket and head back to your room. The conference was a success, and you're ready for a good night's sleep before you head home tomorrow.

And tomorrow, as we all know, is another day.

Behind the Scenes

Beaming data files from one Bluetooth device to another is a simple application, as demonstrated here. What's slightly more interesting is the fact that the data file doesn't have to be beamed to a computer. In this example the file is beamed directly to a Bluetooth phone, which uses Bluetooth technology to establish an Internet connection and e-mail the file to another user. The file isn't stored in the phone, it's received and then sent back out again almost simultaneously. And, since Bluetooth can handle both data and voice transmissions, there's nothing stopping you from adding a voice annotation to any file you transmit from your Bluetooth phone.

Another simple application is the exchange of business card data between two Bluetooth-equipped devices. In our example the devices were PDAs, but you could also store your electronic business cards (in the industry standard vCard format) on a Bluetooth phone; watch, or other device.

Sending digital photographs via Bluetooth is an interesting application. Depending on the devices at your disposal, it could be a two-, three-, or four-step procedure.

If you use a stand-alone digital camera to take your photos, you'll need to use Bluetooth to transfer the digital pictures from your camera to your cell phone for transmittal. (Three steps: Take the picture, transmit from camera to phone, and then transmit from phone to Internet.) Alternately, you could beam the pictures to your notebook PC for a little digital touch-up and then link your PC to your cell phone to send the pictures. (Four steps: Take the picture, transmit from camera to PC, transmit from PC to phone, and then transmit from phone to Internet.)

A simpler two-step procedure can be had if you integrate a digital camera into a cell phone. This could be done via a single phone/camera device, or by plugging a modular camera unit into a standard cell phone. In either case, all you have to do now is snap the picture (step one) and then use the phone to send the picture (step two) to your designated recipients. No intermediary device is necessary.

Bluetooth in the Real World: The Industry Speaks

This vision of a Bluetooth world was compiled from ideas put forth from a variety of sources. The most visionary of sources are the members of the Bluetooth SIG, those companies that have a vested financial interest in the success of the Bluetooth wireless technology.

As I wrote this book, I thought it would be interesting to hear from some of the key people in the key companies, and let them share their vision with you directly.

The Telecom Industry's View—from Ericsson

Ericsson, as you learned back in Chapter 2, "How Bluetooth Came to Be," was the company that had the first vision for what later became the Bluetooth technology. I talked with Jeremiah Zinn, head of collaboration at Ericsson CyberLab in New York, and asked him about Ericsson's vision for Bluetooth. Here's some of what we talked about.

Michael Miller (MM): How important is Bluetooth to Ericsson?

Jeremiah Zinn (JZ): As you know, Bluetooth came out of a wireless technology that Ericsson was looking at called MC Link, and we actually initiated Bluetooth, with the SIG. We realized that this technology had a lot of opportunity, but really, the opportunity was in a lot of the industry players coming behind it and recognizing it as a standard.

We developed a lot of the original IP [intellectual property] within Bluetooth, and really saw an opportunity for business in that. There's obviously an opportunity in all the consumer products that we make, and those in the future will all have Bluetooth in them.

A bigger opportunity for us was the IP that came out of our development process. That's actually our major business today. We've just started a new company, actually called Ericsson Technology, for technology licensing. They're focused on just licensing the IP that we've created for Bluetooth. They have a bunch of different licensees, four of which are Lucent, Philips, ST Microelectronics, and Intel.

So that's really a big focus of our business with Bluetooth. Not as much a consumer angle, but more of a hardware/manufacturing angle.

MM: So these companies are buying chips from you?

JZ: They're actually not buying the chips, they're buying our IP. So they're buying our design for the radio, and then they're manufacturing chips based on our design. In many cases they're selling those chips to the big OEM integrators, like Sanyo and other large electronics manufacturers.

MM: How does Bluetooth fit in with the other wireless technologies—HomeRF and 802.11?

JZ: There are a lot of intersections of different networking technologies, and there's a little bit of overlap in some.

The primary goal of Bluetooth, and the focus of Bluetooth, was that it was low power, low cost, and could connect to anything—ad hoc networking. The user cases really flow out of that. So you imagine a small chip with a low power requirement—it's going to be used a lot more for peripherals that are connecting. We say, "Imagine anything with wires today; tomorrow won't have any wires."

HomeRF is really focused on creating broader networks in the home. Bluetooth has applications as a networking technology, but it's not the number-one goal.

In comparison, 802.11 can broadcast much farther and with much higher bandwidth, but it takes a lot more power and the components are much more expensive—they're never going to come down to the five-dollar price point that we're thinking of for Bluetooth.

802.11 is probably for more persistent connections, connections that take a little bit longer to set up but will be connected up for a long amount of time. Bluetooth is really for spontaneous connections. So if you imagine I'm in my office in Sweden, just flew in from New York, and need to print something from my PDA or a phone, I'm able to walk up to a Bluetooth-enabled printer and print it. Now, obviously, that printer will also have a LAN connection to do network printing. So Bluetooth is really another connection.

In the early days, things will be migrating to Bluetooth, but they'll probably have a lot of different ways to connect in. Just like you might have a parallel connector and a serial connector and an infrared connector on a printer right now, Bluetooth will really add on to many existing devices in the beginning, and as it becomes a standard will start replacing some of the current connectors.

MM: How are the infrared people responding to Bluetooth?

JZ: I haven't heard their specific response, but when we compare the two technologies, Bluetooth is a slightly higher cost technology, but it has a lot more benefits. Line-of-sight is always a huge problem with infrared, and then compatibility was also a huge problem, there was never a pervasive standard where you said "My Palm is going to be able to connect to my Psion because I have infrared." And that was unfortunate because there was a lot of opportunity. Irregardless of the technology, what we really focus on is that Bluetooth's big importance is being a standard that's adopted by all and implemented in the same way. That's why Bluetooth is not a technology that Ericsson owns, but instead is a technology that is managed by the Special Interest Group. We created an open specification that anyone can implement.

MM: As far as Ericsson is concerned, how broad is your focus? Are you focusing primarily on uses that come out of the mobile phone, or are you looking at things well beyond that?

JZ: In the early days it's obviously using the mobile phone as an anchor and then having peripherals that attach, based on that—and in many cases, adding peripherals to the mobile phone that Bluetooth-enable existing phones. Right now there are a lot of mobile phones out there that may not be replaced, and they need to have an add-on functionality. So Ericsson has a couple of different products that we're putting together, one of which is a dongle that attaches to existing phones, so they can have Bluetooth capability. Another is a Bluetooth headset. And then a "future phone," the 520, which has Bluetooth built in, as well as GPS. Obviously, there's a host of consumer devices that are planned, as well.

MM: Beyond the mobile phones and headsets, what other sorts of products can we look forward to in the next year or two?

JZ: You can definitely look forward to Bluetooth access points. That's going to be a product for Ericsson. This is the idea that you can connect an access point to a network, or to a printer, or to different peripherals, and then can print through that, or have network access through that.

You can imagine an access point being used for lots of different things. We have a prototype we're putting together in our office that, when we walk up to the door with our Bluetooth phones, opens the door, for example. Or when you walk up to your laptop, and you have a Bluetooth PCMCIA card in your laptop, you can log into your account, and then log out of your account when you walk away—which is a big problem in offices that have a lot of cubicles, and people don't want to stay logged in to their computers.

So in an office environment there are a lot of applications, especially for having access points spread all around, that are tied to the LAN, but maybe for a couple of different Bluetooth peripherals you could walk around and access the network.

You can imagine this new user case in airports, and it becomes more interesting. As you're pulling up to the airport you get pushed a message about whether or not your flight's on time. When you walk in and walk through, you register automatically, or it recognizes your e-ticket. Maybe when you're about to walk on the plane, it registers your Bluetooth device to turn off, because the radio can't be on on the plane—and when you walk out of the plane all of a sudden your Bluetooth device wakes up and sends e-mails, without you knowing it, that you have written on the plane.

There's a lot of opportunity for processes to go on without you having to initiate them. Like connecting to an access point, sending e-mail, and then disconnecting.

MM: Do you envision that there would be access points located just at specific points, or would you cover an area with one of these things every 10 meters?

JZ: It might be a situation where you're walking up to them, almost like kiosks. The one example people give a lot is walking up to the bus station. Instead of having to have the bus schedule, that could just appear on your phone. All this different location-specific information is definitely important. In more controlled environments, like in office environments, you may want to have a fixed network, you may want to have a wireless LAN, because it provides more pervasive access. Definitely for walk up, attach, and walk away, Bluetooth makes a lot of sense.

MM: The 10-meter range—do you see that increasing to 100 meters, or is it pretty much all going to stay at 10 meters?

JZ: I think the best uses of Bluetooth will be at the 10-meter range. There have been a lot of proposals for version two of Bluetooth that it will be higher bandwidth and have more range. I believe that you're going to see it used mostly at the 10-meter range, mostly on small peripherals, just because that was the original goal. There will be that opportunity for more technical capability of Bluetooth, but I think it will really shine at the 10-meter range.

There is in the 1.1 Specification for a Class 2 radio with 100 meters, but it's a much more high-power radio.

MM: So that really wouldn't be practical for the portable device itself—it might be more practical for base stations?

JZ: Exactly. It's practical for an access point, that would actually be near a power supply. But in terms of a headset it would drain the power too quickly—and we haven't invented wireless electricity yet. [laughs]

MM: What is this going to look like three or four years down the pike? How pervasive is Bluetooth going to be and what types of applications will we be living with?

JZ: There's been a lot of media hype about Bluetooth, so you've seen everything from wireless headsets to this idea that you're going to have virtual operators, where you'll have phone networks that run on Bluetooth. It'll probably be somewhere in-between those two extremes. [laughs]

What we're looking at is that over the course of this year [2001] we're going to build the critical mass of Bluetooth components that are out there, then next year [2002] will really be a time for a lot of devices to have built-in Bluetooth, and we'll be able to interconnect. Then in the following year [2003], once you have that critical mass of people who really understand Bluetooth, you're going to have very advanced cases of using Bluetooth.

This is the idea that when I walk over to a friend's house my phone no longer connects to the cellular network, but may connect to their line, and they can sell me access on their line, as an example, through their Bluetooth base station. Those sorts of cases are going to start to come, especially when you look at gas stations, as an example—driving up to the gas pump, getting some gas, and then maybe downloading some MP3s from the local Bluetooth connection.

There's a lot of opportunity because of ad hoc networking, where it would be difficult to set up an 802.11 LAN connection—but it might not be so hard to set up an ad hoc Bluetooth connection. So being able to access a network, and all that a network access can give you, would be possible.

The one that everybody's tried to crack, and there's a lot of focus on, is the point-of-sales terminal. We actually were involved with this Holiday Inn test, which is a good way of showing the types of user cases that people are going to have, in terms of opening the locks, and checking into their hotel, that sort of thing. There's a lot of opportunity, there, and also with point of sale. So, in many cases, you don't have to carry around 20 different credit cards, but your phone could be your credit card. And we look at Bluetooth as being a great bearer for that sort of thing, the transaction.

MM: You assume that for these sorts of transactions you have one device, your personal Bluetooth device. Obviously, the phone guys are saying the device is the mobile phone. On the other hand, you have IBM and 3Com and the PDA guys saying that maybe it's not your phone, maybe it's your PDA that does all of this. How's that going to shake out?

JZ: I think it'll be both, and I think there'll be opportunity for both. In many cases people say to us, just in the communications world, are people going to have mobile phones in the future? Are people going to have PDAs in the future? And our answer to that is, yes. [laughs] We think they're going to have all of those things, and maybe some of them and not others. For different user cases and different needs, different devices emerge. So the idea that I run around with a Blackberry e-mail pager that's a very focused device and it really suits my needs, that might not suit the needs of my wife, as an example, who doesn't use e-mail as much, who doesn't have as much access.

So if you start imagining that people are going to have different devices, and different kinds of devices for their use, Bluetooth is a great opportunity for that, where you don't have as many interoperability problems. I could have a PDA and then add on a radio or access to a network through Bluetooth, as a Bluetooth clip-on. The exciting part of this for me, as I look across our office right here, is how many different electronics components have small LCDs. The idea that how redundant it is that all these things have LCDs. Well, couldn't there be one LCD element that you use across many different devices? Why do I have a headset for my phone, and then a headset for my Walkman—why can't those be the same? So you're going to start to see some economies there, and some efficiency there. But it also allows users to customize much more for what they need in their day-to-day lives.

MM: We're talking about the screens—obviously, you can have a bigger screen on a PDA than you can on a mobile phone. If some people are going to be using their phone as a Bluetooth device, and others are going to be using their PDA, and other are going to be using…well, who knows what, maybe a little credit card thing, how does the back-end application, like the hotel application, know what kind of device is accessing it?

JZ: This is an interesting point you bring up, and a difficult one. All the Bluetooth Specification specifies is how to work with Bluetooth, and what the technology is. But in many cases, in implementation, things can be implemented in different ways. So there's a host of different software applications, as an example, that need to create standards for micropayments, as an example. How do I know that the software on my phone is the same software that's on my PDA, when I'm walking up to the counter at the Holiday Inn? Right now, in the telecom world that's being solved by standards like MET and others for micropayment transactions, and m-commerce transactions. Those are still issues that we all have to deal with for those transactions—and Bluetooth, unfortunately, won't address all those issues. Hopefully standards will emerge, like Visa and MasterCard emerged as standards in the credit card industry, for these sorts of transactions.

MM: This next question is for my editor, who is specifically interested in GPS applications. How will Bluetooth work with GPS?

JZ: That's really an interesting combination. We focus a lot, here at the CyberLab, on not only GPS but a technology called MPS that Ericsson has developed. MPS is a mobile positioning technology that, instead of using satellites like GPS, uses cell towers. If I'm standing with my cell phone in between two different cell towers, it can ascertain my position based on comparing the timing of signals that are sent to the phone. It's basically like triangulation.

When you look at being triangulated by satellites, being triangulated by cell towers, or even being triangulated by different Bluetooth access points, you have different levels of granularity, and different types of information that can be given to you. As an example, when I'm driving around in my car, I could use mobile position by cell towers to give a broad idea of where I am, and what the traffic is in front of me—because, in many cases, you don't need to know what the traffic is around you, you can see what's around you. But you may want to know what the traffic is way ahead of you, and maybe way behind you, if there's traffic ahead of you and you want to turn around and go back.

With Bluetooth, the positioning opportunities are much more granular—you can identify the position by floor, or even by cube in an office. So you can use GPS or MPS for positioning

outdoors, and then use Bluetooth for indoor positioning. The other technologies can add a little bit of accuracy when there isn't a satellite there.

MM: So the ultimate technology might incorporate all these things, the GPS, the MPS, the—what would you call it?—the BPS, the Bluetooth positioning system. So you could get positioning on a very large scale, on a block-by-block scale, or within a building, with the Bluetooth access points.

JZ: That's exactly the case. Ericsson, in this mobile positioning technology, this network-based technology, we're already doing half of that. So it does positioning by where you are in relation to cell towers, and then also it assists GPS by comparing the information from cell towers with the information from satellites, to create a more granular position. So feeding Bluetooth information into that is important, as well. There's a lot of fantastic applications for that—also a lot of thorny privacy issues.

MM: If you can identify somebody's position within a building by floor, or by cubicle even, what's to stop Big Brother from tracking you everyplace?

JZ: Or what's to stop my wife when I call and tell her I'm at the office late and I'm really at the bar? [laughs] There are issues like that, ones that aren't Big Brother issues, called social issues. That's why we've really focused on the technology space, on creating a lot of different types of server-based privacy software for that.

MM: From a convenience—or an annoyance—standpoint, by adding m-commerce and e-payments to a cell phone or PDA, is this just another PIN or ID number that I have to memorize?

JZ: We're hoping that your Bluetooth PIN will be the last PIN you have to memorize. [laughs] But I know this is a big issue for consumers. Is this going to lay another layer of intricacy on top of my life? It actually does create a lot of opportunity to have one thing, whether it be your phone or your PDA or maybe even a kind of Bluetooth "key," that you could then use to access all the different parts of your life. I hope it doesn't add another layer—because if it does, people might reject it. But that's really on the shoulders of everyone implementing Bluetooth, to create a standard for that.

MM: What would keep Bluetooth from being successful?

JZ: A lot of things. [laughs] Obviously, a consumer pushback is a big issue with the Bluetooth SIG right now, making sure that the consumer brand for Bluetooth is "easy access, anywhere, anytime." And that that's what that Bluetooth symbol means, and that's why there's a whole qualification process for Bluetooth devices. Definitely there are technology hurdles for that, in the beginning days, making sure that Bluetooth devices connect effortlessly.

We think Bluetooth has gotten off to a great start. Definitely Wall Street has looked favorably on Bluetooth, so we have to keep that momentum up.

The Computer Industry's View—from IBM

The same week I talked to Jeremiah I also talked to Ronald Sperano at IBM. Ronald is program director for mobile market development for IBM and, like Jeremiah at Ericsson, has done a lot of thinking about and working with the Bluetooth technology. Here is some of what Ronald and I discussed.

Michael Miller (MM): How important is Bluetooth technology to IBM?

Ronald Sperano (RS): Very important. What we're trying to do at IBM is to create a user experience—not just sell them a piece of hardware. Frankly, anyone can do that, and it's getting harder and harder to compete on the hardware, so we want to compete on the experience, especially as far as IBM ThinkPads are concerned.

So what we see Bluetooth doing is creating a more pleasant user experience. For example, what could be more pleasant or easier than, as soon as I walk into my office, I am automatically connected to all my peripherals? My mouse, my keyboard, my PDA, my cell phone, my camera. Not only am I automatically connected to them, but if I had my PDA on me at home, and had made some updates on it, as soon as I am in physical proximity to all my devices, and if I have multiple address books on these devices, which I might—I might have an address book on my phone, my PDA, and my ThinkPad—they get all synchronized, automatically. I, as the user, didn't have to do anything, except get all these devices together.

That's the promise of Bluetooth. We're not saying it's there yet; we are saying that we think it can get there. It's going to take stages. I'm fond of saying that IBM is bullish on Bluetooth, because it does improve the user experience.

But also, more in a parochial sense, if you look at the back of a ThinkPad—or any notebook, for that matter—there can be as many as eleven different ports back there. Each port adds weight, adds cost, and it is indeed a point of failure—whenever you try to physically connect something back there, you are potentially going to create a problem. So to the extent I can take one of those ports off, I reduce costs, I reduce weight, and I improve reliability.

I'm a computer manufacturer, a hardware manufacturer, and someone tells me, "I've got something that will allow you to make your ThinkPads smaller, thinner, lighter, and more reliable." What do you think? We're interested.

MM: So, theoretically, one Bluetooth radio could replace all the ports on the back of a laptop?

RS: Not all of them, no. We just don't have the bandwidth there. First of all, it's not going to replace power, you're always going to have power. It will not replace video, in the near term. So the ones that it can possibly replace quickly are any types of serial port—the serial port itself, the parallel port, the mouse port, the keyboard port. Those types of things we can see Bluetooth replacing, over time. Not all of them, but a good deal of them.

MM: How much of a cost savings is that to you guys?

RS: That's hard to quantify. It will be in the dollars, not in the tens of dollars. But, clearly, when you multiply those dollars over millions of notebooks, it's a huge savings to us. So we

are doing it to allow us to build better, cheaper, smaller, more reliable notebooks, and we're also doing it to provide our end users a better user experience with ThinkPads.

MM: It's probably easier for IBM to incorporate Bluetooth in a PC than it is to get all the printers and scanners and all that Bluetooth enabled. So, realistically, what kind of time frame are we looking at before this is a practical application?

RS: We have already announced Bluetooth PCMCIA cards for the ThinkPad, and Toshiba has announced cards, also. So we are already shipping product that will Bluetooth-enable a ThinkPad.

There are some two thousand companies that are Bluetooth adopters; they have raised their hands and joined the Bluetooth SIG, and they've said that they're going to build Bluetooth product. A number of those are, in fact, printer companies. So I do see, sometime this year, companies coming out with options that will plug onto the back of a printer's parallel port and, just like an IR dongle does today, they'll do that same thing for Bluetooth.

So the first generation will be Bluetooth options that will attach to things like printers. Then the next generation is for the printer manufacturers to build the Bluetooth radio right into the printer.

What's holding us all back now is the cost. Bluetooth is designed to be a low-cost RF device. But in order for it to get low cost, it has to be out there in quantity; for it to get out there in quantity, it's got to be low cost.

MM: Chicken and egg.

RS: That's right. The driving engine behind the adoption of Bluetooth will, in fact, be cellular phones. Cellular phones, and PDAs. Those are going to be the devices that are the driving engines—not the ThinkPads, not the Toshiba products, not the Dell notebooks. It's going to be the handheld terminal devices, the type of device that Bluetooth is designed for, because it's low power.

We are looking to companies like Ericsson, Nokia, and Motorola to start coming out with their Bluetooth-enabled cell phones, and then we're looking at companies like Palm—and, of course, IBM, with our WorkPad—to start to enable the PDA devices. Clearly, this year Ericsson will announce Bluetooth options for their G28 cell phone, Palm will announce Bluetooth options for their Palm device, and IBM will pick those Bluetooth options for IBM's WorkPad.

MM: Is it pretty much the same Bluetooth chips used in all devices?

RS: It's not, as a matter of fact. There are multiple Bluetooth radios used out there. Since there are multiple radios, Bluetooth has its own compatibility test suite. What you have to do is submit your product to the Special Interest Group, and we will test it, and allow you to put your Bluetooth logo on that card, so you know that it conforms to the Bluetooth spec. If your Bluetooth card has a Bluetooth logo, and the Toshiba Bluetooth card has a Bluetooth logo, they will, in fact, talk to each other.

MM: Is IBM manufacturing their own chips?

RS: No, we're not. We have a relationship with Digianswer for our Bluetooth technology.

MM: Could you compare Bluetooth with the other wireless technologies—which one is best for which kind of use?

RS: Let's look at the top view, where you have two different types of wireless technology—you have infrared, which is light, and RF, which is radio waves. Most top-tier notebook manufacturers have been incorporating IR—specifically FIR, which is Fast IR. It's on all top-tier notebooks.

I've used it, for the longest time, for wireless networking. I would have a wireless IR device in my office that I would have my ThinkPad pointed to—and that's the problem. The problem with IR is that it's line of sight. So I would have to have the IR dongle positioned on my desktop in such a way that it is in line of sight with the IR transceiver that's on my ThinkPad. A lot of times I would put my coffee mug down in the path and lose the connection to the LAN. That was one of the problems with it. They thought IR would be a good cable-replacement technology, but the line of sight was a problem.

The other problem with IR was that it was a one-to-one networking topology—only one device talking at a time. That's a problem.

Now we have Bluetooth. Bluetooth solves both of those problems. Bluetooth's networking topology is one-to-many, one master device talking to as many as seven slaves. So I've solved that problem, and I can have multiple devices connected to my ThinkPad—a PDA, a cell phone, a printer, a keyboard, a mouse, and so on.

The second problem it solves is line of sight. Bluetooth is omnidirectional, it is not line of sight. So now I can have those devices, quite literally, anywhere within my office, within a radius of about 10 meters.

So think of Bluetooth as a better IR. We think Bluetooth will, over time, supplant IR as the cable replacement technology of choice for notebooks.

MM: What about the difference in transmission speeds—is that an issue with Bluetooth?

RS: Bluetooth, nominally, is one megabit per second, but that will get faster. IR is about four megabits per second. So IR is, in fact, faster—but the two disadvantages of IR, the line of sight and the one-to-many, those two things detract from the benefit of being faster. The fact that it's faster doesn't make it any more attractive because of the other two usage problems.

MM: They're show-stoppers.

RS: Yes, they are.

Now let's address 802.11 and HomeRF. They're both radio frequency, they're both wireless LAN, they both work on the 2.4-gigahertz ISM band. And that's really where the similarities stop.

802.11b is eleven megabits, where HomeRF is only, I think, two megabits. 802.11b supports what's called roaming; HomeRF is really a one-user, two-, maybe three-user networking topology, it doesn't support roaming—it can't roam from place to place.

Note As noted in Chapter 9, "Competitive and Complementary Technologies," the latest version of the HomeRF technology increases speed to 10Mbps.

What's really going to impact HomeRF is the fact that if my corporation has a wireless network, it's going to be 802.11, no question about it. Then if I go home, why do I want another wireless network at home? Why wouldn't I want an 802.11 network at home, so I could quite easily use the client card in my PC in the office that I use at home? So for that corporate user, who uses wireless in the office and who wants wireless at home, 802.11 is the hands-down winner.

For those users who don't have a wireless network in the office, who could care less about enterprise wireless computing, all they want is to have a home wireless network, HomeRF is fine. It might be slow, but it's cheaper.

So 802.11 will supplant HomeRF in that market segment where the user is both a corporate and a home wireless user. 802.11 is going to bite heavily into HomeRF; if I were a betting man, I'd bet heavily on 802.11.

Now, let's look at 802.11 versus Bluetooth—also a lot of similarities. They both work in the 2.4-gigahertz range of the ISM band, they're both radio frequency technologies, they're both omnidirectional. And, once again, that's where the similarities stop.

802.11 is eleven megabits, Bluetooth is one megabit. 802.11 supports a many-to-many networking topology, Bluetooth supports a one-to-many networking topology—and has a limitation of eight devices. 802.11 supports roaming; I can go from one access point to another access point and not drop off the network. Bluetooth does not. With Bluetooth, once you're connected you're always connected. If I were to go to another access point, I would have to reconnect.

Bluetooth is a great in-office technology for connecting to a personal domain. 802.11 is a great technology for connecting to a wireless LAN infrastructure.

We are really positioning Bluetooth as your cable-replacement technology in your personal domain, in your office. We are positioning 802.11 as the wireless infrastructure for a wireless LAN.

MM: Can they coexist?

RS: Yes, they can coexist. There's been a lot in the press about 802.11 and Bluetooth not being able to coexist, because they're on the same frequency. That is not true. They do, in fact, coexist. We've been showing 802.11 and Bluetooth in demonstrations, showing their coexistence. To show this, what I have done, in an IBM ThinkPad, I've placed a Bluetooth card and an 802.11 card in the same PCMCIA slot.

The way that works is that Bluetooth uses frequency hopping, while 802.11 uses direct sequencing, which is not frequency hopping—it does something else to spread the spectrum

over the frequencies in that band. Since Bluetooth hops so many times—it's a very robust technology—any degradation you'll see is Bluetooth degrading an 802.11 network. So, to the extent that there's a lot of Bluetooth activity, it could in fact slow down any activity I have on 802.11.

For example, let's say I'm in my office, connected over the network and downloading Web pages over 802.11. I hit the hotlink button on my PDA, and maybe for a second or two, as I'm synchronizing over Bluetooth, I might be slowing down the downloading of those Web pages over the 802.11 LAN, until I finish the synchronization. I'm not stopping it, only slowing it down.

We've seen a degradation of maybe 10 to 15 percent, worst case, in the lab. What we have not seen is Bluetooth stopping 802.11 in its tracks.

MM: We've talked about the Bluetooth card—what other Bluetooth-type products can we see coming from IBM in the future?

RS: If you're familiar with the new ThinkPads that have what's called the Ultraport, that's on the top edge of the LCD panel, we will be coming out with a Bluetooth Ultraport device that snaps right in up there. Why would we do that, when we already have a PCMCIA Bluetooth card? The answer is that we need the PC card because not all ThinkPads or all notebooks have the Ultraport. The other reason that we do it is because we're talking about radio frequencies, and we're talking about antennas. The higher I can put that antenna above the desktop, and above the electronics of the ThinkPad itself, the better off I am. So, in theory, I can get better reception by having that antenna up high like that. We think the top of the LCD is just a damned good spot for an antenna.

As far as other products from IBM, look for our IBM WorkPad to become Bluetooth enabled, over time—first that will be through an option, then it will be through integration. So as far as our laptops and PDAs are concerned, there is no question that they will be Bluetooth enabled.

MM: I know that the telecom companies are looking for the cell phone to be the key Bluetooth device. Do you see that happening, or will it be a PDA—or some combination of the two?

RS: I have no doubt in my mind that you're going to see combination devices out there. When you talk about devices—PDAs, cell phones, and pagers—two things are going to happen. These devices are either going to become one, they're going to converge into one device, or they're going to cooperate. And the way to get these devices to cooperate is through Bluetooth. Bluetooth will be the technology that will allow all these devices to talk to one another.

Not everyone is going to want a device that does everything. The problem is, when you have a device that does everything, it doesn't do anything perfectly well. It isn't optimized.

For some people, that may be okay. But for others, some people might want the best cell phone capability, some people might want the best PDA capability. It really depends.

MM: From the standpoint of the back-end systems, does a back-end system care whether it's a cell phone or a PDA that it's talking to?

RS: To the extent that the back-end system pushes information down, it makes a big difference whether the receiving client is a ThinkPad, a PDA, or a cell phone. If it's a ThinkPad, I'm going to send it all the data I have, because the ThinkPad has a big screen, a lot of memory, a lot of processing power. I would not want to send that same amount of data to a cell phone.

What happens is, the IBM Pervasive Computing division has built something called WebSphere Everyplace Suite. What that does is provide a wireless infrastructure—it's the middleware that sits between your server and your client devices and it does the translation for you. The server doesn't care, then, whether it's a ThinkPad, a WorkPad, or a cell phone, the middleware knows what's out there and it will render the data to the proper device in the proper fashion.

That's how that's going to be taken care of.

MM: What specific Bluetooth applications are you personally looking forward to?

RS: One of my favorites comes from the fact that today you can buy an airline ticket with a cell phone—why not take that one next step? Not only do I buy an electronic airline ticket, why not have the boarding pass linked to it? So now I go to the airport, and the airport gates are Bluetooth-enabled. I have my Bluetooth enabled cell phone or PDA, I have my electronic boarding pass, I can quite literally walk right onto the plane, because the gate is going to interrogate my Bluetooth device to make sure I have a valid boarding pass.

Very, very doable.

Another application I think will happen, in some format, we'll see when I want to go shopping. I might download some product codes to my Bluetooth-enabled WorkPad. Now I'm walking through a mall, the mall could have Bluetooth access points throughout, and it's interrogating my Bluetooth device. It knows I'm in the market for a particular item, it sees a match, and it sends me a message that says, "Hey Ron, two stores on your right, there's a Foot Locker that carries that pair of running shoes you wanted, and it's on sale."

Very doable.

Things like that are where I think Bluetooth can shine, because it's both a push and pull technology.

MM: Do you see any impediments to Bluetooth becoming a success?

RS: Yeah, I do—it's gotta work! [laughs] It has to do what it's intended to do. It has to be easy to set up. It has to fulfill its promise. It has to be cheap.

So I'm not going to sit here and tell you that it's a foregone conclusion that it's a winner. But I am going to tell you that if you look at the promoter group on the SIG, you have IBM, Intel, Motorola, Lucent, 3Com, Microsoft, Ericsson, Nokia, Toshiba—these are big heavy hitters. Then on top of that you have some two thousand other companies who have raised their hands, saying they're going to jump on the Bluetooth bandwagon.

But I'm not going to be foolish enough to tell you that it's a foregone conclusion that it's going to be a success. We think it will be, we are on the right track—because we're learning from the failures of IR. I think we understand the pitfalls of IR, basically the compatibility side. We also have to make sure that the price is cheap—and that's going to happen as Bluetooth devices become more popular.

I have a good feeling that Bluetooth is going to be successful. I mean, IBM and Toshiba have already announced product, we see customers using the stuff in pilots. If I were a betting man, I'd bet that it's going to be successful. But I wouldn't be so arrogant as to think that it's a slam dunk.

Chapter 5: Bluetooth Today

In the last chapter you learned about the wonderful applications that may result from use of the Bluetooth wireless technology. But how much of this buzz is real—and how much is just wishful thinking?

This chapter lets you judge for yourself, by presenting a plethora of Bluetooth-related products that either have been officially announced or are actually available for purchase today. As you will see, there are a *lot* of Bluetooth products that are already ready for public consumption—no wishful thinking necessary.

Consumer Products

We'll start by presenting those Bluetooth products that are available for purchase by average consumers, just like you and me. (Products that have to be purchased and installed by businesses—such as Bluetooth access points and M-commerce systems—are discussed in the next major section, "Business Products and Services.")

Note The criterion for listing in this chapter is that, as of the first quarter of 2001, a product has been announced or demonstrated (at least in prototype form) by its manufacturer. This means, of course, that it's entirely possible that a manufacturer could announce a product and never ship it. That happens all the time in the real world; lots of products are announced but for various reasons never make it to market. That no doubt will happen with some of the products discussed in this chapter, and is not indicative of the success of Bluetooth in the marketplace.

Cards and Adapters

The initial Bluetooth products on the market were add-on products that added Bluetooth capability to existing products. This makes a world of sense; most people would rather spend $100 or so to make their existing PC or PDA or phone Bluetooth-capable, as opposed to spending hundreds or thousands of dollars more to buy a completely new device with Bluetooth capability built in.

There are several types of Bluetooth "enablers," and which type you choose depends a lot on the type of device you want to enable. Here's a quick guide if you're thinking of adding Bluetooth functionality to one of your existing devices:

- If you have a desktop PC, your best bet is a Bluetooth USB adapter, which will plug into a USB port on the back of your PC. Your alternatives are Bluetooth serial adapters (slower than USB adapters—and you probably don't have a free serial port, anyway) and Bluetooth dongles (which are actually very small USB adapters that hang off the back of your PC). The advantages of a USB adapter are that you probably have a free USB port on your PC (and if you don't, you can increase USB capacity by adding a USB hub), a USB connection is relatively plug-and-play in the Windows world, and the adapter itself is relatively flexible in terms of its placement.
- If you have a portable PC, your best bet is a Bluetooth PC card. Your alternatives are Bluetooth USB adapters (too big and bulky for a notebook), Bluetooth dongles (smaller than USB adapters, but not as portable as PC cards), and memory card/stick adapters (a viable choice, if your notebook has a CompactFlash or Sony Memory Stick slot). The advantages of a PC card are that it's small, it fits right into one of your notebook's PC card slots (and thus travels along with your notebook, almost unnoticeably), and it's relatively plug-and-play, installation-wise.
- If you have a PDA (such as a PalmPilot or a Handspring Visor), your best bet is a device-specific add-on card. If your PDA has a CompactFlash or Memory Stick slot, using a Bluetooth memory adapter is also a viable option. You may also be able to find a dongle that mates with your PDA, but the combination is extremely awkward.
- If you have a printer or scanner, your only choice is a USB dongle designed for printers.
- If you have a cellular phone, your only choice is a phone adapter. Check with the phone's manufacturer first, to see if a model-specific adapter is available; if not, Ericsson's Bluetooth Phone Adapter is relatively universal.
- If you have a digital camera, and if it has a Memory Stick slot (which pretty much limits you to Sony models), you can use a Sony "Info Stick" Bluetooth adapter. Otherwise, you're out of luck.

Now that that's out of the way, let's find out more about what kinds of Bluetooth adapter products you're likely to find in your local electronics store.

PC Cards

The first PC-related Bluetooth products on the market were PC cards for portable computers. These cards let you add Bluetooth capability to the host computer, just by inserting a small PCMCIA-compatible card into a slot on the side of the PC. (The card itself contains the Bluetooth radio and related electronics, including an antenna.)

IBM's Bluetooth wireless PC card was the first Bluetooth product offered from a major computer maker. IBM's card, shown in Figure 5.1, can be used in their ThinkPad portable computers (as well as notebooks from other manufacturers) and will enable similarly equipped ThinkPads to swap data and otherwise communicate with each other.

Figure 5.1: IBM's Bluetooth wireless card for their ThinkPad PCs (Photo courtesy IBM Corporation)

3Com, the company behind the PalmPilot, has also announced a series of Bluetooth PC cards. Their cards (like the one shown in Figure 5.2) feature a standard Class 3 Bluetooth radio with a 10-meter (30-foot) range. 3Com's Bluetooth cards also come with their easy-to-use Bluetooth Connection Manager software, which provides auto-discovery and point-and-click management for devices, resources, and services. If you look at the outside edge of each card, you'll find 3Com's award-winning XJACK antenna, which provides interference-free reception and transmission for all your Bluetooth connections.

Figure 5.2: 3Com's Bluetooth PC card, with a pop-up XJACK antenna on the end (Photo courtesy 3Com)

Nokia's Connectivity Card is like the other PC cards listed here, in that it adds Bluetooth capability to any notebook PC. Nokia's card is sold both as a stand-alone card and as part of

the Nokia Connectivity Pack, which also includes a Connectivity Battery, discussed later in this chapter. (The Connectivity Battery adds Bluetooth functionality to Nokia's 6210 cellular phone.)

TDK's Bluetooth PC card, shown in Figure 5.3, is one of the first on the market to be fully compatible with the latest 1.1b version of the Bluetooth Specification. The little lumpy thing on the outside edge is the antenna.

Figure 5.3: TDK's Bluetooth PC card is fully compatible with version 1.1b of the Bluetooth Specification. (Photo courtesy of TDK Systems Europe)

Acer NeWeb, in conjunction with Widcomm, is manufacturing a variety of Bluetooth PC Cards, for portable PCs and for PDAs. While Acer's Blue-Card is a standard PC card, usable in any brand notebook PC, the Blue-Connect card is more unique—it's a Bluetooth module designed specifically for the Handspring Visor PDA. As shown in Figure 5.4, the Blue-Connect gives the Visor full Bluetooth capability, just by plugging in the card. Acer plans to release a similar card, dubbed the Blue-Palm, for 3Com's PalmPilot.

Figure 5.4: Acer's Blue-Connect module adds Bluetooth functionality to the Handspring Visor. (Photo courtesy Acer NeWeb)

Several other manufacturers have announced Bluetooth PC cards for notebook computers, including 3Com, AmbiCom, Brain Boxes, DCM Technologies, Digianswer, Hewlett-Packard, Motorola, Primax, Sphinx Elektronik, Symbol Technologies, TDK, and Toshiba. In addition, Xircom has announced a card similar to Acer's Blue-Connect, dubbed the SpringPort, also for the Handspring Visor.

USB Adapters and Dongles

A Bluetooth USB adapter provides essentially the same functionality as a Bluetooth PC card, but in a more versatile form factor. Since most PCs—portable and desktop—have USB ports,

a Bluetooth USB adapter can work with more hardware configurations than can a Bluetooth PC card, which is designed for portable PCs only.

The world's first fully qualified Bluetooth USB adapter was shown by Siemens in February 2001. The Siemens Bluetooth USB-Adapter is a Plug and Play device that incorporates a Class 1 Bluetooth radio, for an extended 100-meter (300-foot) transmission range. Software accompanying the adapter allows wireless synchronization of contacts and appointments with other Bluetooth-equipped devices.

Digianswer's Bluetooth USB adapter incorporates the more common Class 3 Bluetooth radio, for standard 10-meter (30-foot) transmissions. As you can see in Figure 5.5, the Digianswer USB adapter is designed to be mounted on the side of a notebook PC.

Figure 5.5: Digianswer's Bluetooth USB adapter, mounted on a notebook PC (Photo courtesy Digianswer A/S)

3Com has announced a series of Bluetooth USB adapters that add Bluetooth capability to any computer or peripheral that has a USB port. The adapters can plug directly into a USB port or can use a USB cable to permit more flexible placement of the USB transceiver. The 3Com adapters are some of the smallest to date; as you can see in Figure 5.6, even with the XJACK antenna popped up, the adapter is no bigger than a typical pocketknife.

Figure 5.6: 3Com's ultra-small Bluetooth USB adapter (Photo courtesy 3Com)

Unlike some of the first adapters on the market, TDK's Bluetooth USB Adapter will be fully compatible with the Bluetooth 1.1b Specification. The TDK adapter is shown in Figure 5.7.

Figure 5.7: TDK's Bluetooth USB Adapter (Photo courtesy of TDK Systems Europe)

Acer NeWeb (in conjunction with Widcomm) is offering a Bluetooth adapter that works with either a USB or an RS-232 serial port. The dual-connection Blue-Share, shown in Figure 5.8, adds full Bluetooth functionality to any desktop or portable PC, no matter what kind of port is used.

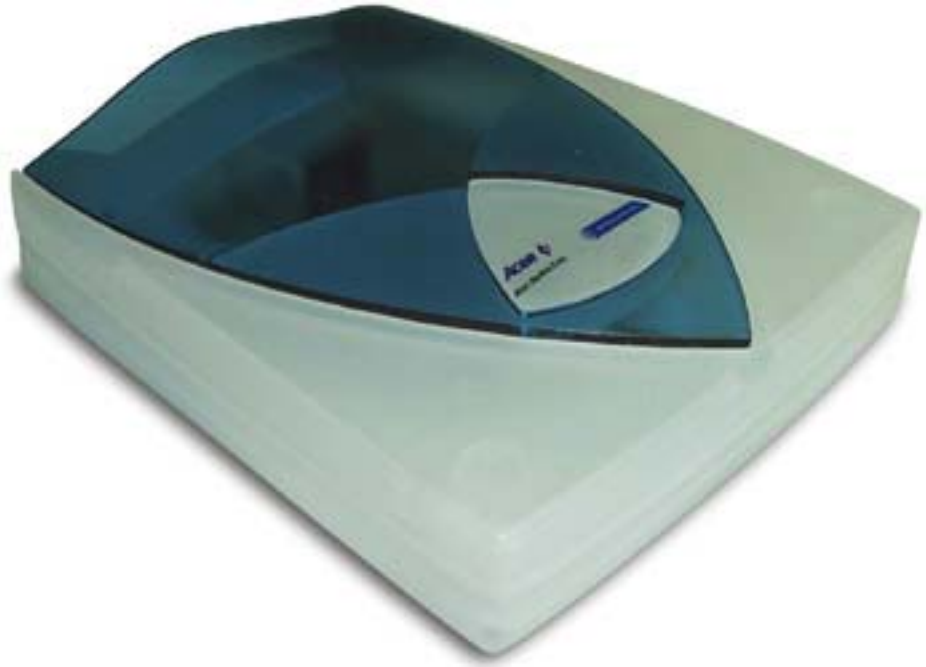

Figure 5.8: Acer's Blue-Share Bluetooth adapter connects to either a USB or a serial port. (Photo courtesy Acer NeWeb)

Some manufacturers call their USB adapters *dongles*—especially if they're small enough to "dongle" off the back or side of your PC, PDA, or other device. Other manufacturers that have announced Bluetooth USB adapters or dongles include 3Com, Ambicom, ELSA, Intel, Motorola, and Primax.

Not only will you be able to buy dongles to Bluetooth enable your existing devices, it's expected that some providers of Bluetooth-enabled services will distribute dongles to current and prospective customers. The strategy here is similar to the old razors/razor blades scenario; the providers give away the dongles to provide a much larger audience for their paid services.

As an example, an airline might provide Bluetooth dongles to frequent flyers. Customers can then attach the dongles to their various electronic devices, and thus be whisked through ticketing and check-in—as well as access the Internet and other Bluetooth-enabled services.

Several manufacturers either have released or plan to release various types of dongles for industry-specific applications. These manufacturers include Acer NeWeb, Adamya, Brain Boxes, Primax, Siemens, Sphinx Elektronik, Toshiba, and Widcomm.

Memory Adapters

If you own a Sony computer or consumer electronics product, chances are it has a slot for a Memory Stick, which is Sony's proprietary portable storage device. Sony recently announced that they will soon produce a device (dubbed an "Info Stick") that will plug into any Memory Stick slot and add Bluetooth capability to any Memory Stick-equipped device.

If you own a Sony digital camera, for example, you could plug the Bluetooth adapter into the camera's Memory Stick slot. Thus equipped, you could automatically transmit pictures from your digital camera to a Bluetooth-equipped notebook computer.

Along the same lines, Acer NeWeb plans to offer a Bluetooth adapter that fits into any device that has a slot for a CompactFlash memory card. The Blue-Flash Bluetooth enabler has the same form factor as a CompactFlash card, and includes full Bluetooth functionality. Similar CompactFlash adapters will be available from AmbiCom, Brain Boxes, Signia Technologies, Silicon Magic, Socket Communications, and other companies.

Phone Adapters

At this point in time, there haven't been a lot of Bluetooth adapters announced for cellular phones. This probably is a function of the complex and confusing multiple cellular standards enacted worldwide. If you want to add Bluetooth functionality to your current phone, your best course of action is to contact the phone's manufacturer to see what add-on devices are most compatible.

One relatively universal Bluetooth adapter is Ericsson's Bluetooth Phone Adapter. The Phone Adapter is a small module that plugs into the system connector found on the bottom of today's crop of mobile phones. This plug-in device (shown attached to the phone in Figure 5.9) adds Bluetooth functionality to most cellular phones being sold today.

Figure 5.9: Ericsson's Bluetooth Phone Adapter attaches to the bottom of any cellular phone. (Photo courtesy Ericsson)

If you have a Nokia model 6210 mobile phone, you're in luck. Nokia offers what they call a Connectivity Battery specifically for the 6210. The Connectivity Battery, shown in Figure 5.10, replaces the 6210's existing battery and adds 10-meter Bluetooth functionality to the phone. The Connectivity Battery is available separately, or in a Connectivity Pack with Nokia's Connectivity Card PC card (discussed earlier in this chapter). The idea behind the Connectivity Pack is to provide an all-in-one Bluetooth synchronization solution; with both Bluetooth add-ons installed, you can easily synchronize calendar and contact data between your Nokia 6210 phone and your notebook PC.

Figure 5.10: Nokia's Connectivity Battery adds Bluetooth functionality to their model 6210 cellular phone. (Photo courtesy Nokia Corporation)

Computer-Related Products

If you're in the market for a new PC, PDA, or other computing device, should you wait until Bluetooth-capable models are available? If that's what you want to do, you won't have to wait long; expect most of the computer-related Bluetooth devices listed here to be on store shelves by Christmas 2001.

Portable PCs

As this book is written (first quarter 2001), there are no Bluetooth-enabled PCs on the market—although several have been announced. Given that IBM and Toshiba are both

founding members of the Bluetooth SIG, it's a good bet that both of these companies will have Bluetooth notebooks available for sale in the near future.

It's possible that the first Bluetooth-enabled notebook PC could come from Toshiba. The company has shown a prototype model, code-named "Key West," that includes a built-in Bluetooth radio. Some industry experts expect a production model of this notebook to hit store shelves sometime in the second half of 2001.

Not far behind, IBM intends to add a multifunction port, code-named "Portofino," to the lids of selected ThinkPad computers, such as the one in Figure 5.11. This Plug-and-Play connection will support add-on Bluetooth transceivers, thus providing cable-free connection between the ThinkPad and Bluetooth-enabled peripherals such as printers, scanners, digital cameras, and mobile phones.

Figure 5.11: IBM will be adding Bluetooth ports to selected ThinkPad models. (Photo courtesy IBM Corporation)

Another company that has expressed interest in Bluetooth notebooks is Hewlett-Packard. The company has announced that future versions of its OmniBook notebook PC will incorporate built-in Bluetooth capability. They haven't, however, announced *which* future OmniBooks will be Bluetooth enabled, or *when* they'll ship.

Along the same lines, Dell has announced plans to embed Bluetooth capability in selected laptop PCs. Expect to see other companies follow suit.

PDAs

As discussed previously, the first PDA-related Bluetooth products you'll see will be add-on Bluetooth cards, for both the PalmPilot and the Handspring Visor. It's logical to expect Bluetooth versions of Microsoft Windows CE-based handheld and pocket PCs as well—especially since Hewlett-Packard has already announced that future versions of its Jornada line of PDAs will incorporate Bluetooth technology.

In addition to these potential products, IBM is said to be working on a Bluetooth modem that will work with all Palm devices, including its own Palm-compatible WorkPad. Palm itself is also planning to release a snap-on Bluetooth module for its PalmPilot models.

Back in Japan, Sony has announced plans for an "Info Stick" Bluetooth adapter for its CLIÉ PDA. This adapter will plug into the CLIÉ's Memory Stick slot, and include a fully functioning Bluetooth radio.

Over in Europe, Ericsson is entering the PDA market with a combination PDA/phone. Ericsson's Communicator, shown in Figure 5.12, offers traditional PDA features (based on Psion's Epoc operating system), as well as triband GSM cellular functions. It incorporates a color screen, GPS receiver, WAP browser, and Bluetooth functionality.

Figure 5.12: Ericsson's Communicator Bluetooth PDA/phone (Photo courtesy Ericsson)

Portable Storage

Who said you can't take it with you? IBM is working on a "wearable drive" gadget that would include a small IBM MicroDrive storage device; this unit could be used as a common storage device for any and all nearby Bluetooth-enabled computers. So instead of fussing with multiple diskettes, Zip disks, or removable hard drives, your data could be beamed directly from one or more PCs to the Bluetooth-equipped portable MicroDrive. Naturally, this "wearable drive" could also be used as a storage device for PDAs and other computing devices.

No ship date has been announced for this new technology.

Printers

At some point in time, all computer printers will come with built-in Bluetooth functionality. This may start out with a dual-technology product (a printer with both parallel and Bluetooth connections), but could end up with most printers being Bluetooth only—no other ports necessary.

One indication of Bluetooth's integration in the printer world is the fact that Hewlett-Packard, one of the world's largest printer manufacturers, has shown prototypes of Bluetooth-enabled LaserJet and InkJet printers. HP expects to ship their first printer with built-in Bluetooth functionality—the DeskJet 995c—in the third quarter of 2001. The company will also be shipping a Bluetooth add-on for its DeskJet 350c model at about the same time.

For its part, Toshiba has announced an add-on Bluetooth printer module (actually a dongle) that can be used with any brand printer, as has Troy XCD. The Troy XCD dongle, as shown to the press, is about the size of a computer mouse, attaches to the printer's serial port, and draws its power from the printer itself. Thus equipped, you can print directly from your Bluetooth-equipped notebook PC to your dongle-adapted printer, no cables necessary.

Toshiba and Troy XCD aren't alone in their quest to Bluetooth enable your existing printer. Several other companies—including Brain Boxes and NEC—plan to offer Bluetooth dongles for various types of printers.

Moving beyond the printer dongle is i-data, a company specializing in network servers. This company plans to offer their PlusCom Xpress PRO 10/100 BT PrintServer, which will enable one or more printers to be accessed from a variety of both Bluetooth and wired devices. As one might suspect, i-data will target their PrintServer at corporate markets.

Authentication

In an interesting application of the Bluetooth technology, Ensure Technologies has introduced XyLoc, a system that uses Bluetooth to authenticate individual PC users. The XyLoc system automatically unlocks a workstation when a person with a Bluetooth access card approaches. This enables PC users to wander away from their computers without having to log off or turn them off; they're logged on and off based on their proximity to the computer.

Note XyLoc isn't the only Bluetooth application in the works at Ensure; the company is working with several medical device manufacturers on Bluetooth-equipped handheld devices that doctors can use to write—and transmit—prescriptions.

Phone-Related Products

Since Bluetooth was initially developed by Ericsson (and since Nokia is one of the other five founding members of the Bluetooth SIG), you'd expect that a flood of Bluetooth cellular phones would already be available. For various reasons (including the extended wait for 3G cellular networks), this has not been the case. Still, a few Bluetooth phones have trickled to market, and the pump is already being primed for more models to become available later in 2001.

Mobile Phones

Ericsson's R520 was the world's first fully qualified Bluetooth-enabled mobile phone. The R520, shown in Figure 5.13, is a triple-band phone, featuring WAP, General Packet Radio Services (GPRS), and high-speed data capability. You can use the R520 to connect to any compatible Bluetooth device, including Ericsson's Bluetooth Headset. This phone will work on all GSM networks (including those operating at the 900MHz, 1800MHz, and 1900MHz frequencies) and also includes e-mail, calendaring, and voice recognition functionality.

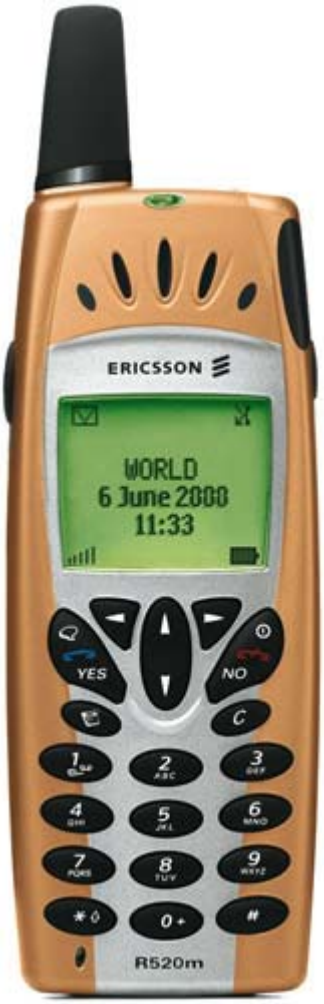

Figure 5.13: Ericsson's R520 Bluetooth-enabled mobile phone (Photo courtesy Ericsson)

Motorola's Timeport 270 is billed as a "Bluetooth-capable" phone. By itself, the 270 is a tri-mode CDMA phone with integrated speaker phone, built-in personal information manager (PIM) software, and four-way joystick for easy navigation. You Bluetooth enable the phone by adding Motorola's Bluetooth Smart Module, which is integrated into a replacement battery cover and contains a fully functional Bluetooth radio. With the Smart Module added, you can easily synchronize the data in the Timeport's PIM with the PIM on your PC or PDA.

As described earlier in this chapter, Nokia's model 6210 mobile phone (shown in Figure 5.14) can also be turned into a Bluetooth phone, by the addition of a unique Connectivity Battery. The Connectivity Battery replaces the phone's original battery, and includes all the necessary Bluetooth electronics. It's a neat way to add functionality without adding bulk.

Figure 5.14: Add a Connectivity Battery to Nokia's 6210 phone to make it Bluetooth-compatible. (Photo courtesy Nokia Corporation)

An interesting extension of today's mobile phone comes from an unlikely source—IBM. The computer manufacturer has demonstrated a prototype flip phone with a special mirror and magnification optics that provide a larger-than-normal virtual display. A phone with this extra-large display could also be used to display images from a notebook PC or PDA, via a Bluetooth wireless connection.

Headsets and Accessories

The market for headsets—both wired and wireless—is huge, and getting bigger every day. To feed this hungry market, several manufacturers have jumped on the Bluetooth bandwagon with Bluetooth-enabled wireless headsets.

The very first Bluetooth headset on the market was shipped by GN Netcom. As shown in Figure 5.15, the GN 9000 Digital Bluetooth headset is designed to be used with any cordless or corded desktop phone. The headset comes with a base station (which also doubles as a battery charger) that connects to your desktop phone. The headset then communicates with the base station, up to a distance of 30 feet, for placing and receiving calls. The headset itself is an over-the-head design that weighs in at 2.1 ounces.

Figure 5.15: The world's first Bluetooth headset—and matching base station—from GN Netcom (Photo courtesy GN Netcom)

Ericsson was second to market with their Bluetooth Headset, shown in Figure 5.16. The Bluetooth Headset connects to any mobile phone via the Bluetooth Phone Adapter, which plugs into the system connector on the base of the phone. As with the GN Netcom headset, the Ericsson Bluetooth Headset includes push-button controls that let you answer and disconnect calls from the headset itself. You can even (via voice recognition technology) place calls directly from the headset. The headset functions within the standard 10-meter (30-foot) Bluetooth Class 3 range, fits comfortably over one ear, and weighs less than one ounce.

Figure 5.16: Ericsson's Bluetooth Headset in action (Photo courtesy Ericsson)

Other Bluetooth headsets have been announced by Motorola, Samsung, and Plantronics. The Plantronics headset is powered by second-generation Bluetooth chipset technology, and is

said to provide superior sound quality, extended talk time, and lighter weight. This headset, like the Ericsson model, uses a convenient over-the-ear design that should appeal to the mobile user. Also like the Ericsson, all the controls for the Plantronics headset are incorporated into the headset itself; users can answer a call, hang up, adjust the volume, and mute the headset's volume with the touch of a button.

Car-Related Products

Given that the Hands-Free Car Kit profile has not been fully addressed by the Bluetooth 1.0 Specification (it's being worked on by the Car Profile Working Group for Bluetooth 2.0), it's no surprise that functioning Bluetooth products for the car are still a while away. That said, there have been some interesting announcements from a handful of companies that give some indication of what to expect later this year and into 2002.

Hands-Free Car Kits

The hands-free car kit is expected to be a major application of the Bluetooth wireless technology. To that end, Motorola has already announced plans to offer a Bluetooth Car Kit through professional installers. This will be a speaker/microphone/antenna combination that will use Bluetooth technology to link to any Bluetooth-equipped cellular phone.

A related product comes from Johnson Controls, which will market a Bluetooth version of their TravelNote in-car digital recorder. The TravelNote is integrated into a vehicle's visor or overhead console, and enables the driver or front-seat passenger to record, store, and play back reminder messages. The Bluetooth angle comes from the addition of the TravelNote Connect component, which enables the TravelNote device to link (wirelessly) with a mobile phone and provide hands-free speaker phone capabilities.

Information Exchange

Bluetooth in the car will be about more than just connecting a cell phone without cables. There are numerous uses for Bluetooth's ability to beam information on an ad hoc basis both inside the car and to Bluetooth access points along your route.

ELSA is one company that has embraced Bluetooth technology for in-car use; they've teamed with Ford's German operations to develop several different Bluetooth-based automotive applications. One potential product will connect a Bluetooth-equipped notebook PC or PDA to a personal computer built into a Jaguar automobile. Another application will exchange personal information between your PC/PDA and your car, including desired seating position, air conditioner/heater settings, and radio presets. This last application could even download MP3 files from your portable device to your car, for playback on your trip.

Along similar lines, other companies are working on applications that would embed a Bluetooth device in your car to automatically pay for road tolls, gasoline purchases, and other travel-related expenses. This way you could do all your car-related business without ever leaving the comfort of your front seat—thanks to Bluetooth!

Other Consumer Products

Computers, communications, and cars are the obvious Three Cs behind the first wave of Bluetooth applications targeted to the average consumer. There are, however, a variety of other consumer-related Bluetooth products slated for release—from MP3 players to a new type of "digital jewelry." Read on to learn more.

MP3 Players

MP3 is the audio format of choice for young America. The ability to download songs in MP3 format has transformed today's music industry—and spurred the introduction of a new class of Walkman-like portable MP3 players.

Presenting Bluetooth to the MP3 crowd is computer giant IBM, who is working on a prototype portable MP3 player with a built-in Bluetooth radio. MP3 files could be downloaded to the player via Bluetooth, and then stored in the machine's memory or on a nearby physical storage device, such as an IBM MicroDrive. Files could be downloaded manually from a Bluetooth-equipped computer, or on an ad hoc basis from a public Bluetooth network. Just imagine jogging along with your headphones on, while your Bluetooth MP3 player downloads the next song from the nearest Bluetooth access point. It's possible—and likely to happen, within the next year or so.

Digital Still Cameras

There haven't been a whole lot of Bluetooth applications announced for the digital camera world as yet—probably because still imaging won't be added to the Bluetooth Specification until version 2.0. (See Chapter 11, "Bluetooth in the Future," for more information on the Imaging Working Group.) That said, several companies have discussed the types of products they may be releasing sometime in the near future.

First out of the gate is Sony, which has announced Bluetooth adapters that will work with any device that includes a Memory Stick slot—including Sony's popular line of digital cameras. Slide the "Info Stick" into the Memory Stick slot, and your camera can now transmit pictures directly to any other Bluetooth-equipped device.

Using a Bluetooth adapter is a stopgap measure, of course. You should expect digital cameras with built-in Bluetooth capability to hit the market sometime in 2002. To that end, Hewlett-Packard has announced that future models in its PhotoSmart digital camera line will be Bluetooth enabled; other manufacturers are bound to follow suit.

More interesting is that fact that Nokia has been working with Fuji Photo to develop Bluetooth technology that can transmit digital still images between digital cameras and 3G mobile phones. This would enable future phone users to send data messages that include color or black and white still images, or to use their phones to send digital images from the camera to a Bluetooth-enabled PC or printer.

More futuristic still is a combination digital camera/cell phone that Sanyo has been demonstrating. The camera part of this Bluetooth-enabled device can transmit pictures directly to a printer, no cables (or PCs) necessary. Just point, click—and dial.

Watches and Digital Jewelry

Remember Dick Tracy and his two-way wrist radio? This futuristic technology might finally be ready for prime time—at least in prototype form.

At recent trade shows, Ericsson, Au-Systems, and Seiko have shown a prototype combination cell phone/watch. This extremely compact phone/watch (shown in Figure 5.17, and dubbed the Wrist Companion) is WAP-enabled for Web access, and includes a Bluetooth radio for communication with other similarly equipped devices.

Figure 5.17: Ericsson's Wrist Companion Bluetooth watch (Photo courtesy Ericsson)

Seiko has also shown a pulse-sensing watch that uses Bluetooth technology to transfer its data to PCs for more efficient pulse rate monitoring. Another future product is a GPS-enabled watch that measures distance traveled and calculates average travel velocity. As with the other Seiko/Ericsson prototypes, this GPS watch would transfer data back to a base PC via Bluetooth signals.

Along a similar vein, IBM intends to produce its own type of super-watch, dubbed the WatchPad. The WatchPad will be a wristwatch that incorporates a high-resolution (720 dots per inch) touch screen, capable of displaying about the same amount of type as one of today's PDAs, but on the smaller watch-sized screen. Consumers will be able to use the WatchPad as a miniature PDA, complete with organizer and messaging functions.

If all works according to plan, the WatchPad will communicate with your PC (and with other devices) via Bluetooth. In one demonstration of the WatchPad technology, IBM's John Kardis used the touch screen controls on a prototype WatchPad to control his PowerPoint presentation, which was running on a nearby ThinkPad equipped with a Bluetooth PC card. Expect to see WatchPad products on the market by 2003.

Also on the drawing board at IBM is something they're calling "digital jewelry." This would be a stylish device, worn as a ring or a necklace, that would provide information to the wearer by turning a specific color or emitting a particular signal. As shown in Figure 5.18, the digital jewelry might signal incoming e-mail by turning yellow, or alert a change in a specific stock

price by turning red. Naturally, each piece of digital jewelry would include a small Bluetooth radio, and operate when in contact with another Bluetooth device or LAN access point.

Figure 5.18: IBM's digital jewelry prototype (Photo courtesy IBM Corporation)

Another application of the digital jewelry concept, shown in Figure 5.19, would be to utilize a small (and stylish) wrist band as an electronic medic alert bracelet. This device would send Bluetooth signals to the closest emergency medical personnel in case of an emergency—and perhaps even function as a high-tech wristwatch at all other times.

Figure 5.19: A prototype Bluetooth medic alert bracelet and watch, from IBM (Photo courtesy IBM Corporation)

Wireless Pens

You're probably thinking that all pens are wireless. This is true, unless you want to connect a pen to your personal computer and "write" directly into an onscreen document. For this application, your pen would need to be connected to your PC—probably by a serial or USB cable.

Anoto, in conjunction with Ericsson, has developed a platform that enables wireless writing (via Bluetooth) in a new and unique fashion. Whereas past pen input devices included both a pen and a writing tablet, Anoto uses only a pen (shown in Figure 5.20)—you can write on any surface, from a pad of paper to a tabletop. The Anoto pen follows and records the patterns of

your writing and drawing, transmits that information to your PC (via Bluetooth), digitizes your input, and either stores your input or makes it available to other applications.

Figure 5.20: Anoto's wireless pen connects via Bluetooth to your PC. (Photo courtesy Ericsson)

Think of it as a digital tablet without the tablet.

Tracking

Ever lose a piece of luggage? Ever lose a pet? Ever lose one of your kids?

If so, you'll see the benefits of BlueTag, a new product from a Danish company of the same name. A BlueTag uses Bluetooth wireless technology to identify and track any tagged object via Bluetooth-equipped mobile phone or PDA. You can place BlueTags on just about anything—suitcases, bicycles, dogs, cats, even your kids.

The initial product from BlueTag is BlueTag Travel, a so-called intelligent tag optimized for travel purposes. Not only can you use your phone or PDA to locate your baggage at the airport, you can also download your travel itinerary into the BlueTag device—which would make it possible for your luggage to find *you* (with the help of a cooperative airline, of course) should you and your bags get separated.

Business Products and Services

All of the products discussed so far will be available (if and when they're available, of course) at traditional retail stores, ideally at consumer-friendly prices. Many more potential Bluetooth products (and related services) will be available to consumers, thanks to implementation by specific businesses or government entities. This next section looks at these business-oriented Bluetooth products and services.

Access Points and Servers

A Bluetooth access point is a piece of hardware that includes a Bluetooth radio and a connection to a wired network of some kind. In essence, access points connect mobile Bluetooth devices to central LANs, and will be necessary for any public implementation of Bluetooth-enabled services. Because of the potentially huge demand for these base stations, an unusually large number of manufacturers have entered this part of the market.

In terms of pure access point products, Siemens is fast out of the gate with their blu21 access point base station. As shown in Figure 5.21, the blu21 product resembles nothing more than the black monolith in *2001: A Space Odyssey*. Still, it doesn't matter what an access point looks like, as it will typically be positioned out of public view, but within the typical 30-foot Bluetooth transmission range.

Figure 5.21: Siemens' monolithic blu21 Bluetooth base station—just plug it in and hang it on a wall! (Photo courtesy Siemens)

Another access point product is 3Com's Bluetooth Access Point 1000, which is designed to provide Ethernet LAN access for up to seven Bluetooth client devices. The access point itself serves as the master device on a piconet, enabling seven slaves to join the piconet and access the LAN through the access point. The Access Point 1000 uses a Class 1 Bluetooth radio, with high-power (100mW) output and a 300-foot (100-meter) range. (That's 100 meters in an open space; 3Com says the Access Point 1000 has a 30-meter range in typical indoor environments.)

Perhaps the most ambitious access point product announced to date is Ericsson's new BLIP base station. (Ericsson says that BLIP stands for *Bluetooth Local Infotainment Point*.) The

BLIP device, shown in Figure 5.22, is designed to resemble the runic stone that marks King Harald Bluetooth's shrine to his mother and father, right down to the runic-style lettering on the face of the base station.

Figure 5.22 : Ericsson's BLIP access point base station/server (Photo courtesy Ericsson)

BLIP is unusual in that it has its own stand-alone server built right into the base station, which also provides processing and data storage functionality. (Most access points function as gateways to a separate LAN.) Transmitting range is the standard 10 meters (30 feet), and the device includes 2MB RAM and 2MB FLASH memory. Both serial and Ethernet connections are standard.

Ericsson sells BLIP either as a stand-alone device or as part of several different application packages. Also provided is a BLIP software developer's kit (SDK) which enables businesses to develop their own custom Bluetooth applications.

Because BLIP can be used as a stand-alone server (as well as a gateway to a larger network), Ericsson envisions a large number of unique uses for the hardware. Peter Lunden, BLIP's chief developer, believes that BLIP will be used for what he calls "active blipping" and "killing time blipping." Active blipping involves using Bluetooth devices to access productive information; killing time blipping is typified by downloading games or music while waiting for a bus or standing in line. Another possible use, Ericsson freely admits, is to beam local advertising to nearby Bluetooth devices.

Several other companies have announced Bluetooth access point units, including AmbiCom, Axis Communications, Brain Boxes, BrightCom, Motah, Red-M, Tadlys, TDK, and Widcomm. Widcomm's BlueGate network access point will be one of the few to offer the extended 100-meter Class 1 range.

Public Access and Control

Naturally, any of the Bluetooth access points just discussed can be used in a public setting, to provide Internet or proprietary network access to travelers or commuters equipped with Bluetooth devices. That said, a variety of usage-specific implementations of the Bluetooth technology, all currently in the planning stage and dependent on access point hardware, deserve closer examination.

As this book is written, a six-month trial of public Bluetooth access is underway in England. BT Syncordia, in partnership with Midland Mainline (a U.K. rail company), has equipped 100 frequent rail travelers with Bluetooth-enabled telephones and portable PCs, and installed Bluetooth access points and servers in designated train carriages. The travelers will have access to proprietary information on the train's intranet and cached information (such as news feeds and travel information) from the Internet. Users will also be able to send and receive e-mail (when trains are at stations) via Midland Mainlane's e-mail hub. Purchasing of electronic tickets is also planned.

Public access is one thing; public control is another. In an interesting international partnership, BlueLinx, Inc. (based in North Carolina) and the Centre for Telecommunications Information Networking (based in Australia) are co-developing what they call a "politeness" feature for mobile telephones, utilizing the Bluetooth wireless technology. Their product—named Q-Zone, for *quiet zone*—is a location-based service that will enable public venues to end forever those annoying public interruptions by mobile phones and other wireless devices.

The operator of a Q-Zone will have the option of automatically lowering or silencing the ringers of all mobile phones within the zone. When a user leaves the zone, his or her phone ringer will return to its previous setting.

If you're constantly annoyed by ringing phones in movie theaters, churches, restaurants, and other public venues, then you might find Q-Zone to be one application of Bluetooth technology worth waiting for!

M-Commerce and E-Payments

E-commerce is a term you're no doubt familiar with; it's shorthand for *electronic commerce*, or shopping conducted over the Internet. *M-commerce* is probably a new term for you; it's shorthand for *mobile commerce*, or shopping enabled by mobile communications devices—cell phones, PDAs, and so on. To facilitate m-commerce, in-store checkout systems are being developed that will utilize real-time electronic payments made from portable electronic devices, such as a Bluetooth-equipped PDA or mobile phone. These so-called *e-payments* very well could revolutionize how you pay for items at retail stores everywhere.

One of the first trials of e-payment via Bluetooth was conducted in November 2000 at an ICA store in Täby, Sweden, just outside Stockholm. Ericsson equipped the store with multiple Bluetooth access points and a Bluetooth-enabled network server, which was connected to a cash register server and payment processing system. Customers could use Ericsson R320 mobile phones, equipped with the Bluetooth Phone Adapter, to pay for goods, check their accounts, and find out about current offerings.

By all accounts, the trial was a success. Said Jan-Olof Jarnesjö, Manager of IT Infrastructure at ICA, "The trial clearly demonstrated the opportunities in using mobile devices as payment instruments, with substantial convenience for people when shopping in our stores." ICA and Ericsson discovered that paying for items via Bluetooth was both faster and easier than the old-fashioned methods of paying by either cash or credit card.

Voice Flash Networks, a division of Registry Magic, Inc., is behind an m-commerce/e-payment system called the Consumer Payment Network. This system enables any Bluetooth-equipped mobile phone to serve as a type of virtual wallet. In essence, the phone is

transformed into a one-stop device that can perform everyday consumer interactions—including paying for purchases, validating the consumer's personal ID, and conducting inter-person messaging. Equipped with such a phone—and dealing with merchants who've adopted the Consumer Payment Network system—consumers need never again carry credit cards in their wallets.

Similar systems from other manufacturers—including Classwave and ZebraPass—are also in the works. Some of these systems would automatically alert you to store specials as you stroll through the mall or drive past participating merchants. Merchants, especially, are eagerly anticipating what may be a completely new medium for advertising. Consumers are expected to be less enthusiastic.

Hotel Guest Services

Voice Flash Networks, the company behind the Consumer Payment Network, has—in conjunction with Ericsson—demonstrated a unique application of Bluetooth wireless technology for the hospitality industry. Voice Flash Networks' system enables guests to check in and out of a hotel, make payments at hotel restaurants, secure access to their rooms, and connect to the Internet—all with a single Bluetooth-enabled device.

This system was first demonstrated at New York's Holiday Inn Wall Street in February 2001, as part of the Internet World Wireless show. As Bluetooth devices hadn't yet hit the street (so to speak), Ericsson provided all show guests staying at the Holiday Inn with free loaner versions of their R520 phone. By all accounts, the technology actually worked—which doesn't always happen in this sort of test!

A guest equipped with Ericsson's R520 Bluetooth-enabled mobile phone could simply walk by the hotel's registration desk to initiate the check-in procedure. Reservation information was stored in the Bluetooth phone, and automatically transmitted to the hotel's computers. The hotel guest received, in turn, a room number and the access code to that room, all beamed to and stored in the Bluetooth phone. When the guest walked up to the door to his or her room, the Bluetooth phone communicated with the Bluetooth-enabled security system, and the door was automatically unlocked.

Voice Flash Networks is said to be working with Ericsson and several large hotel chains to implement this system on a larger scale. Expect several other large companies to introduce similar systems in the near future.

Industry-Specific Products

As you can already see, numerous manufacturers are working to provide complete solutions custom-designed for specific industries. In these solution packages, the manufacturer typically supplies the Bluetooth hardware (access points, servers, dongles, and so on), the generic Bluetooth and server software, and the custom software specific to the application.

To whet your appetite, take a brief look at a few more potential Bluetooth products and services, all either demonstrated or announced at recent industry conferences:

- A rental car check-in/out system, incorporating in-car Bluetooth devices and matching handheld devices for agency personnel, developed for Avis by Symbol Technologies

- Soft drink machines that pop out your pop with the push of a button on your Bluetooth device
- Movie previews beamed to your Bluetooth-enabled PDAs as you wait in line outside your local movie theater
- Home automation systems (from ELSA and others) that enable you to turn on and off your lights, security systems, and home electronics from your Bluetooth-enabled PDA or mobile phone
- Set-top boxes, announced by Eagle Wireless and others, that allow control of your TV and cable programming via Bluetooth remote control

Finally, consider one last industry-specific Bluetooth device—one with truly life-changing potential. MicroMedical Industries has developed a miniature Bluetooth-enabled heart monitor that can be implanted under the skin to monitor the heartbeat patterns of cardiac disease sufferers. The output from this device is automatically sent—via Bluetooth signals—to the patient's cell phone, and then on to a central monitor located in their doctor's office or hospital. It's hard to imagine a better use for the technology.

Industrial and Technical Products and Services

Beyond the products and services already discussed in this chapter, there is a whole other market for Bluetooth technology. This behind-the-scenes market provides Bluetooth hardware and technology to the companies that develop and manufacture the products sold to businesses and consumers—the chipsets and circuit boards necessary to build each and every Bluetooth product.

Chips and Circuits

Eventually, there will be thousands of companies selling Bluetooth-enabled products. Few of these companies will manufacture the Bluetooth circuitry they build into their products; most companies buy either custom or pre-built chips and circuit boards from other companies that specialize in making chips and other small electronics.

The circuitry necessary to build a Bluetooth radio today includes numerous individual components. As an example, Philips Semiconductor's first-generation Bluetooth chipset consists of a baseband controller chip, a transceiver chip, a radio module, a baseband/transceiver interface chip, and the necessary power amplifiers. Second-generation chipsets will cram all this circuitry into just two chips, a controller chip and a radio/transceiver chip. (Separate power amplifiers may still be necessary in some second-generation designs.) Third-generation technology—still several years away—will inevitably squeeze all of this onto a single chip.

Some manufacturers sell the chips and other components separately, so that hardware manufacturers can integrate them directly on their products' motherboards. Other manufacturers preassemble the chips into freestanding Bluetooth modules, which can then be plugged into existing motherboards. Either approach is equally valid.

There are a number of companies currently producing or intending to produce Bluetooth chipsets. These "silicon makers" include ALPS Electric Co., Broadcom Corporation, Digianswer, Ericsson, HCV Enterprises, IDmicro, Infineon, Philips Semiconductors, Siemens, Silicon Wave, Stonestreet One, Taiyo Yuden International, Widcomm, and Zeevo.

Testing Devices and Software

Any company incorporating Bluetooth capability in a product must develop the applications that use the technology, and then make sure that the applications (and the technology) actually work. To that end, a secondary behind-the-scenes market has developed for hardware and software that can be used to test newly developed Bluetooth devices. Many of the same companies also sell predeveloped Bluetooth protocol stacks, which save the product manufacturers the task of writing their own protocol software.

One of the leading companies in this part of the market is Digianswer, which provides chipsets and testing products to a number of hardware manufacturers. One of Digianswer's hot products is their Bluetooth Protocol Analyzer, shown in Figure 5.23. This device is used to test the protocols used in Bluetooth devices. Digianswer bundles their Protocol Analyzer with their proprietary Bluetooth Software Suite, which helps engineers design and test their own Bluetooth-enabled products.

Figure 5.23: Digianswer's Bluetooth Protocol Analyzer hardware (Photo courtesy Digianswer A/S)

As shown in Figure 5.24, Digianswer's Bluetooth Software Suite contains a fully qualified Bluetooth protocol stack, and runs on Windows 95, Windows 98, Windows NT, and Windows 2000. Access to the stack is via Digianswer's Bluetooth Neighborhood application, also part of the Software Suite.

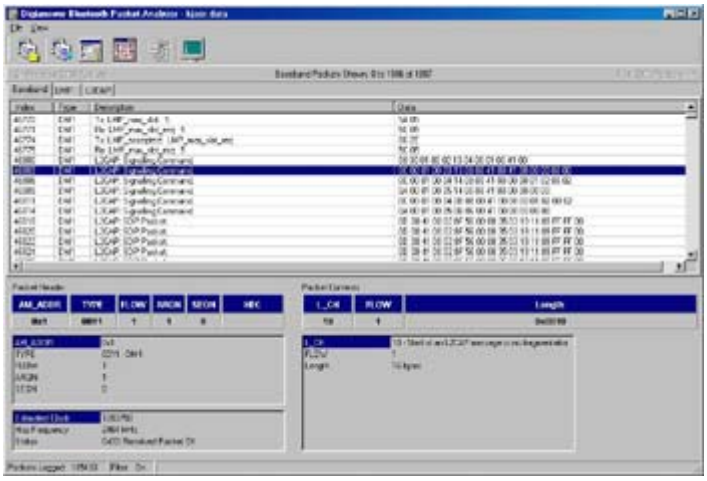

Figure 5.24: Digianswer's Bluetooth Software Suite (Photo courtesy Digianswer A/S)

Digianswer also offers their own Bluetooth Software Developer's Kit (SDK). The Bluetooth SDK enables application programmers to create their own programs that take advantage of all the features defined in the Bluetooth Specification. Programmers can write complete programs or plug-ins to existing programs. Digianswer's Bluetooth SDK is available for download from Digianswer's Web site, at btsws.digianswer.com.

Similar SDKs are available from other companies, including Ericsson. As one of the primary Bluetooth developers, Ericsson offers a full range of testing equipment and software, including:

Bluetooth Development Kit, for professional hardware and software development, as well as the evaluation of existing products

Bluetooth Application Tool Kit, for software development—includes Ericsson's Bluetooth Module, shown in Figure 5.25, which connects to a PC for development and testing purposes

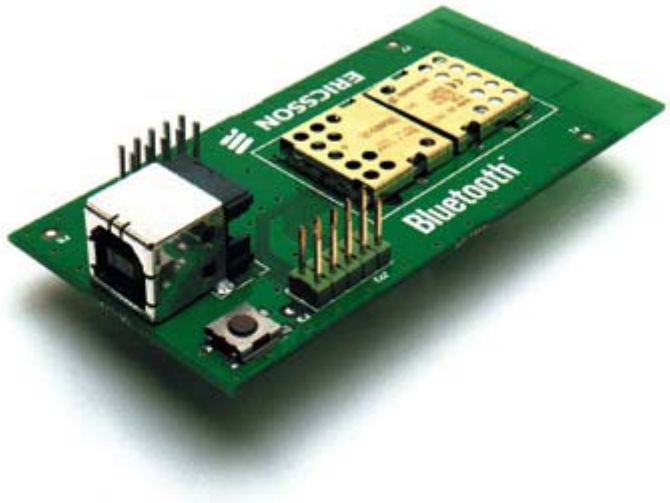

Figure 5.25: Ericsson's Bluetooth Module, used to develop and test new Bluetooth applications (Photo courtesy Ericsson)

Bluetooth Application and Training Tool Kit, designed specifically for schools conducting hands-on Bluetooth training

Bluetooth HCI Toolbox, a software tool for testing of the HCI module

Bluetooth Script Engine, a software tool that verifies application porting

Bluetooth Log Analyzer, a software tool that enables developers to view the internal signaling of a Bluetooth application

There are many other companies offering their own proprietary Bluetooth protocol stacks, as well as testing hardware and software. This list of behind-the-scenes companies includes Adamya, Arca Technologies, BrightCom, Cambridge Silicon Radio, Canon Information Technologies Philippines, CATC, Ericsson, Extended Systems, Impulse Software, Siemens, Silicon Wave, Stonestreet One, Texas Instruments, Troy XCD, Widcomm, and others.

More on the Way…

As you can see, there are already dozens of Bluetooth-related products either currently available or soon to hit the market. The shocker is that this list of products is just a start—these first-generation products will be quickly followed by more (and more robust) second- and third-generation products. Indeed, it will soon be impossible to keep up with the flood of Bluetooth products from all the major computer, communications, and consumer electronics manufacturers.

How can you keep up with the latest Bluetooth product announcements? One good place is at the Bluetooth SIG Web site, which keeps up-to-date lists of products that have been approved for released by the Bluetooth Qualification Board. Go directly to qualweb.opengroup.org/Template.cfm?LinkQualified=QualifiedProducts to see all the latest products—often *before* they're publicly announced!

Part III: How Bluetooth Works

In This Part

Chapter 6: A Quick Guide to the Bluetooth Technology
Chapter 7: Inside the Bluetooth Specification
Chapter 8: Usage Models and Profiles
Chapter 9: Competitive and Complementary Technologies
Chapter 10: Challenges to Success
Chapter 11: Bluetooth in the Future

Chapter 6: A Quick Guide to the Bluetooth Technology

Now that you have a good sense of the different applications for Bluetooth—and the variety of Bluetooth-enabled products soon to be available—it's time to gain a better understanding of how the Bluetooth wireless technology works. This chapter presents a layman's overview of the Bluetooth technology; you can find more technically detailed explanations in Chapter 7, "Inside the Bluetooth Specification," and Chapter 8, "Usage Models and Profiles." In

addition, Appendix C, “Technical Specifications,” presents the key tech specs from the Bluetooth Specification.

Bluetooth Basics

If you read Chapter 1, “Introducing Bluetooth,” you know that Bluetooth is a technology that facilitates short-range wireless connections and communications between various electronic devices. In slightly more technical terms, Bluetooth utilizes radio frequency (RF) signals to establish point-to-point and point-to-multipoint voice and data transfer within a 30-foot (10-meter) radius. The technology behind Bluetooth is defined in a 1500-page Bluetooth Specification; all devices that incorporate Bluetooth technology must adhere to the details in this Specification.

For two devices to communicate with each other, both devices must contain a Bluetooth radio. This radio is extremely small (it’s built into a computer chip, which also contains the Link Controller that establishes and manages the individual connections) and consumes very little power. Every Bluetooth radio conforms to the exact same specifications for both transmitting and receiving signals, so that they can be used anywhere in the world without modification. Figure 6.1 shows a typical connection between two Bluetooth-enabled devices.

Figure 6.1: Two Bluetooth-enabled devices, connected via RF signals

When two or more Bluetooth devices are connected together (wirelessly, of course, and in an ad hoc fashion), they form what is called a piconet. Each piconet can contain up to eight different devices, and multiple piconets can be connected in larger scatternets. It is this capability to link from piconet to piconet that enables Bluetooth devices to connect (through a series of piconets) to larger local area networks, and to the global Internet.

Difficulties in Connecting

Whether you’re connecting with or without wires, the simple act of connecting any two devices—a printer and a PC, for example, or a DVD player and an A/V receiver—is actually a quite complicated procedure. The connection has to both be physically correct and use the proper electronic protocols so that both devices are “talking” the same language.

Physical Connections and Protocols

In the wired world, creating the proper physical connection is sometimes quite challenging. The plugs on the connecting cable must match the jacks on the devices you’re connecting, pin

for pin. Given the variety of different types of connectors available—serial, parallel, RCA, DIN, optical, coaxial, and so on—just determining the correct connector is a major accomplishment. Then you have the occasional issue of combining different types of connectors on a single cable (is there any way of connecting a serial device to a parallel port?) and bridging male/female jack and plug incompatibilities, and you see how problematic connecting with cables can be.

Even if you get the cables connected properly, the job is only half done. The electrons that flow through the cable, between the two devices, have to travel in a manner that both devices understand. The electrons can travel one bit at a time (called *serial communication*) or in groups of 8 or 16 bits (called *parallel communication*). The bits of data also need to be accompanied by a series of commands, in order for the devices to properly translate and handle the data; these commands create a specific *protocol* for handling the data, and different devices sometimes use different protocols.

In other words, it's sometimes difficult to communicate.

Connecting the Bluetooth Way

The Bluetooth wireless technology is designed to ease the complexity of connecting two or more devices. It does this by creating a standard for communicating that is adhered to by all Bluetooth devices; by minimizing the number of options, connecting becomes more simple and, in theory, less expensive.

The first part of the Bluetooth standard dictates that all devices connect via a specific set of radio frequencies. You don't have to worry about which type of plug connects to which type of jack; Bluetooth completely replaces the vagaries of the physical connection with a predefined type of wireless RF connection.

The balance of the Bluetooth standard dictates the precise protocols used to transmit and receive data over the wireless connection. All Bluetooth devices must use the same protocols, so they all talk the same electronic language. Unlike the problems you often encounter in the wired world, you won't run into any "translation" problems with Bluetooth.

Communicating via Radio Waves

There are many different ways to connect without wires. For greatest flexibility, the designers of the Bluetooth standard chose to use radio frequency (RF) communications—the same manner of broadcasting used by television and radio stations.

How RF Works

Radio waves are used to transmit all sorts of information and programming—from Rush Limbaugh's AM talk radio program to the commands used to open your garage door to voice communications on a cordless phone. That the engineers behind Bluetooth chose radio waves to make their wireless connections isn't surprising; it's a relatively simple, reliable, and versatile technology.

A radio wave is nothing more than a pulse of electromagnetic energy. As you can see in Figure 6.2, radio waves are generated when a transmitter oscillates at a specific frequency.

The faster the oscillation, the higher the frequency. An antenna is used to amplify and broadcast the radio signal over long distances.

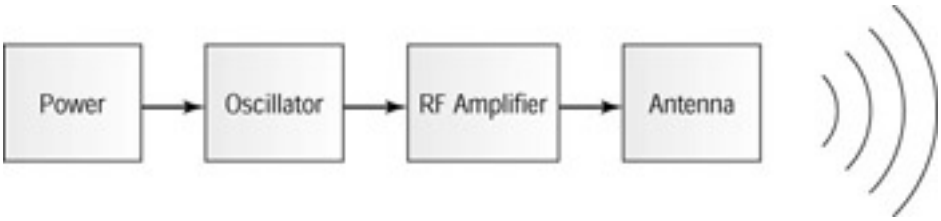

Figure 6.2: How a radio transmitter works.

To receive a radio signal, you need a radio receiver. The receiver is tuned to a specific frequency to receive signals oscillating at that rate. If the receiver is not tuned to that frequency, the radio waves pass by without being received.

RF transmissions are spread over a broad range of frequencies, which are measured in cycles per second. For example, 93.5MHz is a frequency of 93,500,000 cycles per second. (MHz is shorthand for megahertz, or millions of cycles per second; GHz is shorthand for gigahertz, or billions of cycles per second.)

Different frequency ranges are used for different types of communications. The range of frequencies between 88MHz and 108MHz, for example, is known as the FM range, and is where you find all your favorite FM radio stations. Table 6.1 details some of the more popular RF bands.

Table 6.1: Popular Radio Frequency Bands

Frequency Range	**Use**
535KHz to 1.7MHz	AM radio
5.9MHz to 26.1MHz	Shortwave radio
40MHz	Garage door openers (older)
43.72MHz to 49.97MHz	Cordless phones (older)
49.83MHz to 49.89MHz	Baby monitors (older)
54MHz to 88MHz	VHF television low (channels 2–6)
88MHz to 108MHz	FM radio
162MHz to 168MHz	FBI communications (private)
174MHz to 220MHz	VHF television high (channels 7–13)
462.550MHz to 467.725MHz	Family Radio Service (“talkabout” two-way radios)
470MHz to 890MHz	UHF television
824MHz to 849MHz	Cellular phones
902MHz to 928MHz	Cordless phones (newer—so-called 900MHz phones)
960MHz to 1.215GHz	Air Traffic Control radar
2.29GHz to 2.3GHz	Deep space radio
2.40GHz to 2.48GHz	ISM band (Bluetooth, HomeRF, 2.4GHz cordless phones, etc.)

Unlike infrared transmissions, which use light waves and require connecting devices to be in sight of each other, radio waves have no line-of-sight requirements and can, in fact, pass through most solid objects. This means that a Bluetooth radio can transmit its RF signals from inside a briefcase, or through office walls.

Neighbors in the 2.4GHz Band

Bluetooth communications—for both voice and data—utilize an unlicensed RF band in the 2.4-to-2.48GHz range, as shown in Figure 6.3.

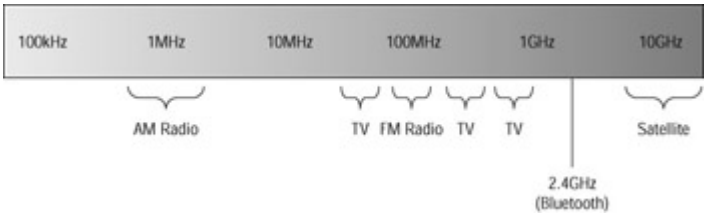

Figure 6.3: The 2.4GHz band and its closest neighbors

This frequency band, alternately called the 2.4GHz or ISM (for industrial, scientific, and medical) band, is free for anyone to use, for any purpose. That's both good and bad—good because it can be used at no cost (without potentially expensive licensing fees); bad because space within the band is finite, and there are several other types of devices that also use this band.

Currently, the 2.4GHz band is used by:

- 2.4GHz cordless telephones
- 802.11 wireless networks
- HomeRF wireless networks
- Baby monitors (newer models)
- Garage-door openers (newer models)
- Urban and suburban wireless communications systems, including many emergency radios
- Some local government communications in Spain, France, and Japan
- Microwave ovens

Note In regard to microwave ovens, 2.4GHz is the resonating frequency of water molecules; since microwave ovens work by exciting the water molecules in organic materials (such as food), they transmit their microwaves at this 2.4GHz frequency. While microwave ovens are theoretically shielded against microwave leakage, in practice they all leak to some degree—older models more so than newer ones. If you're using a Bluetooth device near a microwave oven, the oven can effectively "jam" your device's transmissions; this can cut your device's throughput by up to 75 percent.

Hopping around Interference

With all these different devices utilizing the same frequency range, at some point the 2.4GHz band is going to get so crowded that the various devices could start interfering with one another. This could lead to devices effectively "waiting in line" to transmit, which could be perceived as a slowdown in the data transfer rate.

To minimize interference issues, Bluetooth radios utilize a technique called *spread spectrum frequency hopping*. Spread spectrum refers to a number of different techniques that divide the available radio band by frequency, time, or some other method. Frequency hopping is a common spread spectrum technique, where a signal hops from one frequency to another during the course of a single transmission.

In the Bluetooth world, this means that a Bluetooth radio is constantly and randomly changing frequencies among a broad spectrum of frequencies, hopping to a new frequency after transmitting or receiving each packet of data. The result is that a Bluetooth transmission doesn't stay on a single frequency long enough to be impacted by interference with that frequency.

Note For easier transmittal, data is typically broken up into very small parts, called *packets*. See the "Circuit and Packet Switching" section later in this chapter for more information.

Frequency hopping isn't a new technology, but compared to other devices utilizing the 2.4GHz band, Bluetooth devices typically hop faster and use shorter packets. According to the Bluetooth Specification, Bluetooth radios can execute up to 1600 hops per second. The signal hops among 79 frequencies between 2.402GHz and 2.480GHz, at 1MHz intervals.

With all this hopping going on, how do two connected devices know how to hop together? This is accomplished by assigning a frequency-hop channel, determined by the frequency-hop sequence (the order in which each frequency is used) and by the phase in this sequence. The sequence is determined by the system clock in a piconet's master unit. In essence, the slave units synchronize their internal clocks with the master unit's clock, which puts them all in the same frequency-hopping sequence.

This frequency hopping, designed to reduce interference with other 2.4GHz devices, also serves to increase the security of Bluetooth communications. See the "Secure Communications" section, later in this chapter, for more information on Bluetooth security issues.

Transmitting Voice and Data

All Bluetooth-enabled devices must be capable of transmitting both voice and data signals. This means that Bluetooth can be used to connect both computing devices (which transmit raw data) and communications devices (which carry voice signals).

Circuit and Packet Switching

In all electronic components, data signals (which consist of a series of bits and bytes) travel in a different fashion than do voice signals. The Bluetooth Specification is designed to handle both types of signals, seamlessly.

Data signals typically utilize a technology called *packet switching.* With packet switching, data is divided into small groups, or *packets*, before it is transmitted. A single message, sliced into multiple packets, can actually be transmitted over different routes, at different frequencies, or in a different order than the original. Once all the packets for a message are received, they're recompiled into their original order.

Voice signals, on the other hand, utilize a technology called *circuit switching.* With circuit switching, messages are *not* sliced into packets; instead, a dedicated channel (or *circuit*) is established for the duration of the transmission.

Packet switching is an efficient way to transmit binary (or computer) data; circuit switching is preferred when communications (such as voice calls) have to take place in real time. Bluetooth devices can work in both packet-switched and circuit-switched modes—simultaneously, if necessary.

Speed—Both Ways

The Bluetooth 1.0 Specification allows for a gross data transfer rate of 1Mbps (megabyte per second). To put this speed in perspective, a Bluetooth connection is much faster than a standard computer modem (operating at 56Kbps, or 0.056Mbps) but slower than an Ethernet network connection (which typically operates at 10Mbps).

Note, however, that Bluetooth's 1Mbps gross transfer rate is the theoretical maximum—the width of the "pipe," if you want to think of it in that way. Actual transfer rates are slightly lower, and differ by type of communication.

For example, full duplex data transmission (where signals are traveling both directions, simultaneously) is accomplished at 432.6Kbps. Asymmetric data transmission (where signals in one direction are faster than signals returning from the other direction) take place at 721Kbps out and just 56Kbps back.

These speeds are just for data transmission. If you're transmitting voice signals (via mobile phone, for example), the Bluetooth Specification calls for three synchronous voice channels of 64Kbps each.

Add the voice and data specs together, and a Bluetooth radio can support three simultaneous synchronous voice channels and one asynchronous data channel—or a single channel that simultaneously supports asynchronous data and synchronous voice.

Duplexing

When we were talking about speed, we touched upon the concepts of duplexing and synchronous/asynchronous communications. Both of these concepts have to do with data flowing two ways—out and back (or sending and receiving).

Full duplex refers to the transmission of data in two directions, simultaneously. *Half duplex* means that data can flow in only one direction at a time. A telephone is an example of a full-duplex device (both parties can talk at the same time); in contrast, a walkie-talkie is a half-duplex device (one party has to stop talking before the other one starts).

Full-duplex communications are also called *synchronous*, and half-duplex communications are also called *asynchronous*. Or, in Bluetooth terminology, full-duplex/synchronous communications are called *SCO* (for S*ynchronous Connection-Oriented*) links, and half-duplex/asynchronous communications are called *ACL* (A*synchronous Connection-less*) links.

In the Bluetooth Specification, full duplex transmission utilizes a Time Division Duplex (TDD) scheme. In this scheme, each frequency is divided into time slots, each 625ms (milliseconds) long. As shown in Figure 6.4, TDD assigns subsequent time slots for transmitting and receiving; master units transmit in even-numbered slots, while slaves reply in odd-numbered slots. By alternating back and forth like this on a single frequency, two different transmissions can share the same frequency—and enable full-duplex communications.

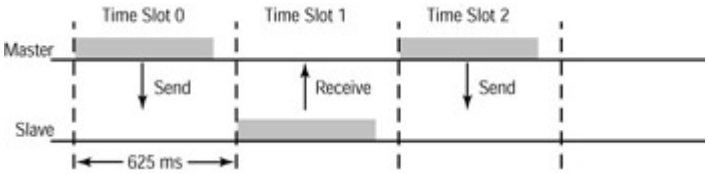

Figure 6.4: With Time Division Duplexing, Bluetooth masters and slaves take turns sharing a single frequency.

Establishing the Connection

Any two Bluetooth devices that come within 30 feet of each other can set up an ad hoc point-to-point and/or point-to-multipoint connection—in effect, an "on the fly" personal area network.

Connection States

A Bluetooth device can operate in either of two major states—*Connection* and *Standby*. The device is in the Connection state if it is connected to another device and involved in current activities. If the device is not connected—or if it's connected but not actively involved with other devices—then it automatically operates in the Standby state.

The creation of a Standby state was conceived as a way to conserve power in Bluetooth devices. If a device doesn't have to be actively participating at any given moment, there's no reason why it should be consuming power at peak levels.

When a device is in Standby state, it "listens," every 1.28 seconds, for messages from other devices. Each listening session takes place across the set of 32 hop frequencies defined for that type of unit. (Each type of Bluetooth device is assigned a different group of hop frequencies; cordless phones hop among a different group of frequencies than do PDAs, for example.)

Once a device comes off Standby and enters the Connection state, it can be placed in one of four possible Connection modes:

Active A Bluetooth device is said to be in Active mode when it is participating actively in the piconet, either transmitting or receiving. Active slave units are automatically kept synchronized with the piconet's master.

Sniff When a device is put into Sniff mode, it listens to the piconet at a reduced rate, thus lowering its power consumption. The sniff rate is programmable, and varies from one application to another.

Hold Within a piconet, master units can put slave units into Hold mode. This power-saving mode is used when no data needs to be transmitted. When a device is put on Hold, only its internal timer remains active. This is a popular mode for low-power devices with relatively simple data transfer needs, such as temperature sensors.

Park When a device needs to stay connected to a piconet but doesn't need to participate in the ongoing data traffic, that device can be put into Park mode. In Park mode, the device remains synchronized to the piconet, but gives up its MAC address. By parking inactive devices, a piconet can actually include more than seven slaves. (The theoretical number of parked slaves that can be connected to a single master is 255.)

Inquiring and Paging

All unconnected Bluetooth devices start out in the low-power Standby state. When one unit senses another Bluetooth device in the area, a connection procedure is initiated. At this time, the first device (the one that found the second unit) assumes the role of *master* unit in what will soon become a mini-network.

Note Since the radios in all Bluetooth devices are essentially identical in function, any device can be a master, and any can be a slave. It's really a function of which device broadcasts first—first come, first served, as the saying goes.

A Bluetooth device can issue two different types of commands to initiate the connection procedure. The first command is called an *inquiry* command. An inquiry command is issued when the identification number, or *address*, of the other device isn't yet known. Once the device's address is known, a *page* command is issued. The page command serves to "wake up" the other unit and establish a full connection between the two devices.

Figure 6.5 shows the typical sequence of commands necessary to establish a Bluetooth wireless connection.

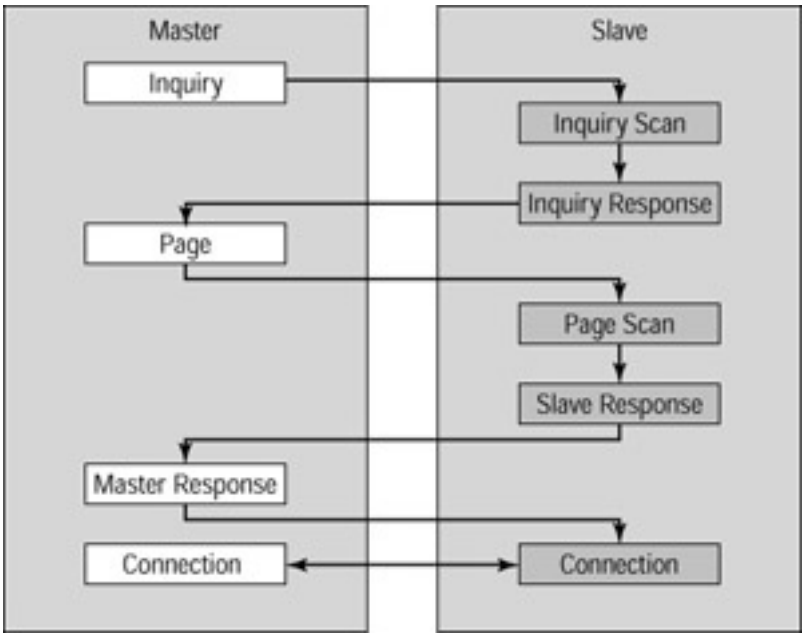

Figure 6.5: The sequence of recognition commands

Piconets

When two Bluetooth devices establish a connection, they have created a type of personal area network called a *piconet*. Each piconet can contain up to eight different Bluetooth devices.

Within each piconet, one device serves as the *master*, while the other seven devices function as *slaves*. Any individual device can belong, simultaneously, to multiple piconets.

Figure 6.6 shows a typical piconet in action.

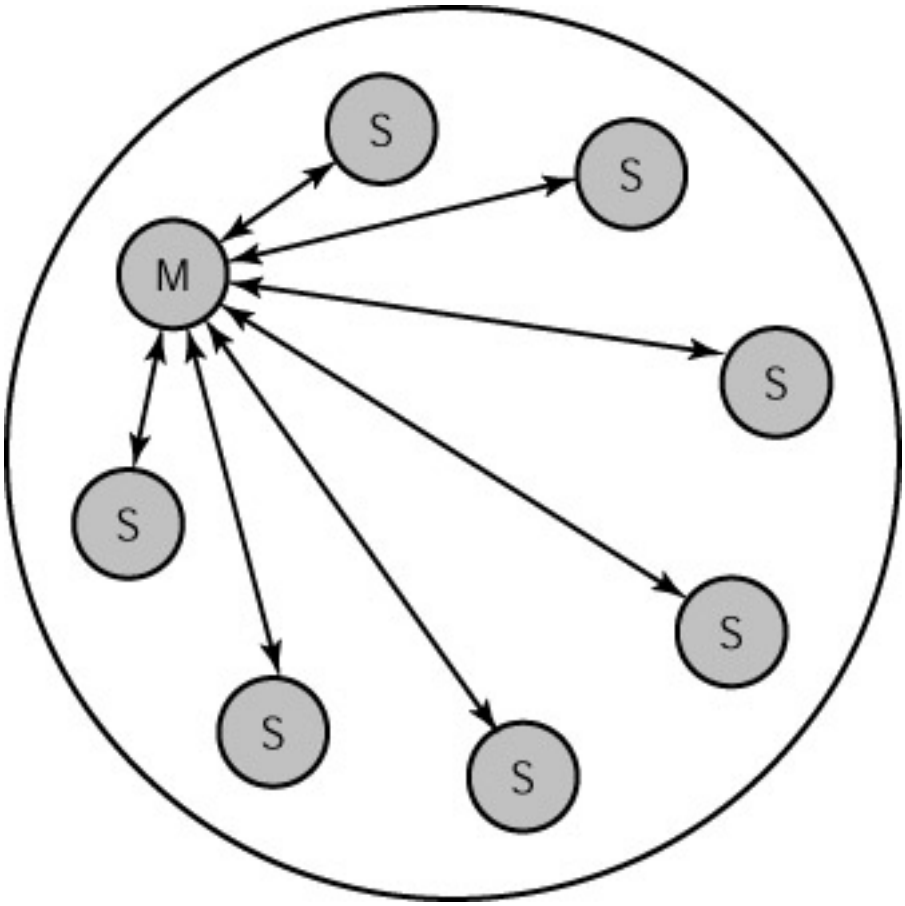

Figure 6.6: A piconet consists of one master device and up to seven slaves.
Note While each piconet can contain up to eight different devices, only three of them (at a time) can carry full-duplex voice transmissions.

All the devices in a piconet share the same frequency-hop channel, which is established by the slaves synchronizing their internal clocks to the master unit's clock. This enables all the units in a piconet to hop from frequency to frequency in the same sequence—and establishes a unique identity for that piconet. Because different piconets have different identities based on different frequency-hop channels, multiple piconets can share the same physical space without interfering with each other.

Scatternets

To connect more than eight devices together, you have to form multiple piconets, and then connect the master devices from each piconet together. This larger combined structure is called a *scatternet*, and is illustrated in Figure 6.7.

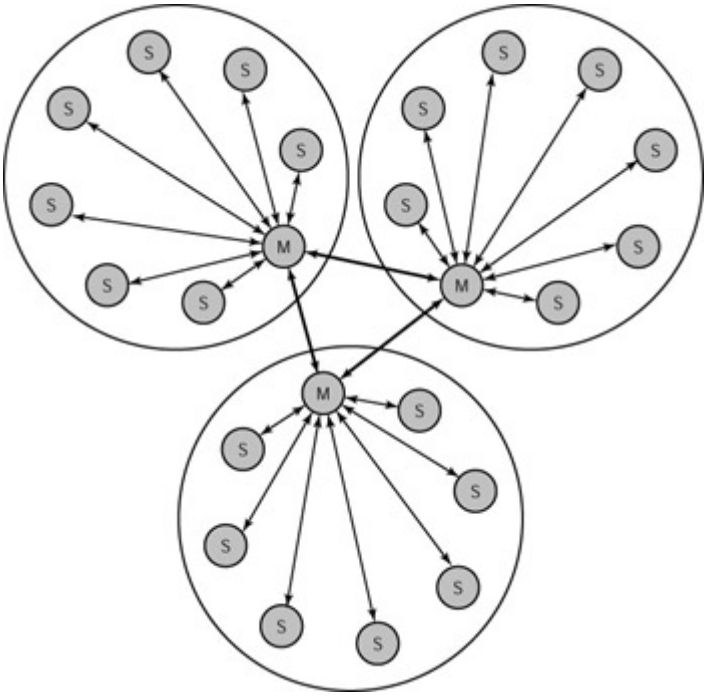

Figure 6.7: A scatternet composed of multiple piconets—the master devices serve as the bridges between networks

In a scatternet, all communications between different piconets are filtered through the individual piconet master devices. Up to 10 piconets—containing 80 different Bluetooth devices—can be included in any single scatternet. Beyond this number, the network saturates, since Bluetooth only uses 79 frequencies in total. (See the "Hopping around Interference" section for more background on this.)

Note, however, that multiple piconets sharing the same physical space do not have to be connected—they can continue to operate independently, without interfering with each other. This is because each piconet operates on a different frequency-hop channel; the result is that the devices in piconet number one never share the same frequency as the devices in piconet number two.

Cellular vs. Ad Hoc Networks

Both piconets and scatternets are types of networks, established in an ad hoc fashion. In an ad hoc network, all devices in the network are treated as peers. Even though one device in a piconet will assume the role of master, that role could be assumed by any device, and can be swapped between devices as necessary. (The master is simply the device that got there first—it's kind of a reward for promptness!)

It's interesting to compare an ad hoc network with the more structured type of relationships found in a cellular telephone network. In a typical cellular network, base stations (or transmitters) are placed at strategic positions to provide local cell coverage, while cellular phones (or radios) are used to connect via radio link to the base stations. With a cellular network, there is a strict and permanent separation between the base stations and the terminals. A cellular phone can never function as a base station, and vice versa; only the base station can provide channel access, allocate channels, control network traffic, and otherwise manage the flow of signals through its particular cell.

The advantages of an ad hoc network are many. First, there is no need to establish a costly infrastructure to service a particular geographic region; ad hoc networks are formed on the fly, where the devices are, without the need for base stations to control network communications. Second, unlike cellular networks, multiple ad hoc networks can occupy the same physical space without fear of interference. Third, any Bluetooth unit can "control" an ad hoc piconet as a master device; no special control devices (or operators) are necessary.

Secure Communications

With all these wireless signals bouncing back and forth within and between piconets, what's to keep someone else's Bluetooth device from picking up your personal signals? That's certainly a concern—especially if Bluetooth becomes as big as everyone thinks it will. Just imagine a crowded airport terminal, with every businessperson there carrying Bluetooth-enabled phones, PDAs, and portable computers. You could have hundreds of Bluetooth devices operating within a single 30-foot radius!

The Bluetooth Specification addresses security issues by specifying 128-bit public/private key authentication. Combined with a streaming cipher (up to 64-bit) based on A5 security, this makes a Bluetooth transmission just about as secure as a wire-based connection. (See Chapter 7 for more details on Bluetooth's security provisions.)

This robust encryption ensures that every Bluetooth connection is a secure link—and may be so robust as to cause problems when exporting Bluetooth products from the U.S. (The U.S. government has some very strict export restrictions on encryption technology—if the encryption's too good, it gets classified as a secret weapon!) Because of this issue, different hardware with smaller encryption key lengths may be required to meet U.S. legal requirements.

In addition to this encryption—and equally important—Bluetooth radios also incorporate frequency hopping, discussed earlier in this chapter. Because Bluetooth signals are constantly hopping between 79 different frequencies between 2.4GHz and 2.48GHz, it is difficult for an outside device to lock onto a signal for purposes of monitoring or theft.

Building the Bluetooth Radio

All of this technology is incorporated into every Bluetooth radio—and every Bluetooth-enabled product must include a Bluetooth radio. Unlike the AM/FM radios with which you're no doubt familiar, a Bluetooth radio doesn't have any knobs or buttons; in fact, it's a radio you'll never see or touch, because it's built into a computer chip that is directly connected to the circuit board of the host device.

Small and Cheap

The key to widespread acceptance of the Bluetooth standard is to make the Bluetooth radios inexpensive enough to be included in even the lowest-priced electronic devices—and small enough to fit in even the smallest conceivable portable units.

As to price, it was originally thought that the initial Bluetooth radios might cost in the neighborhood of $20–$25 apiece. That estimate was a little high (the initial cost was closer to $15 per chipset), but still wasn't cheap enough for mass consumption. However, after

production ramps up and manufacturing efficiencies come into play, the cost for a Bluetooth radio should eventually drop to the $2 range, no later than 2005. (See Figure 6.8 for Merrill Lynch's estimate of chipset prices over time.) When this lower cost is achieved, it becomes a no-brainer to add Bluetooth capability to just about any portable electronic device.

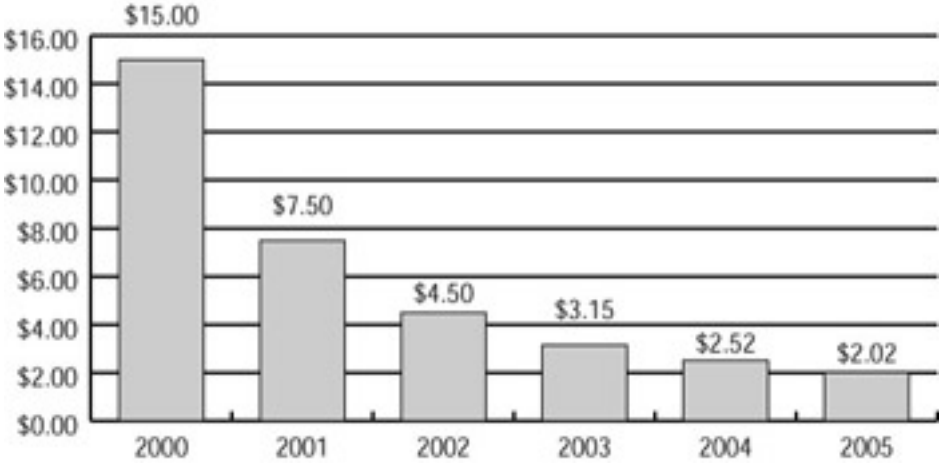

Figure 6.8: Prices for the Bluetooth chipset, through 2005 (Courtesy Merrill Lynch)

With regard to size, the Bluetooth radio is built into a small computer chip. As you can see in Figure 6.9, the radio chip is part of a slightly larger Bluetooth module—only about an inch and a half long.

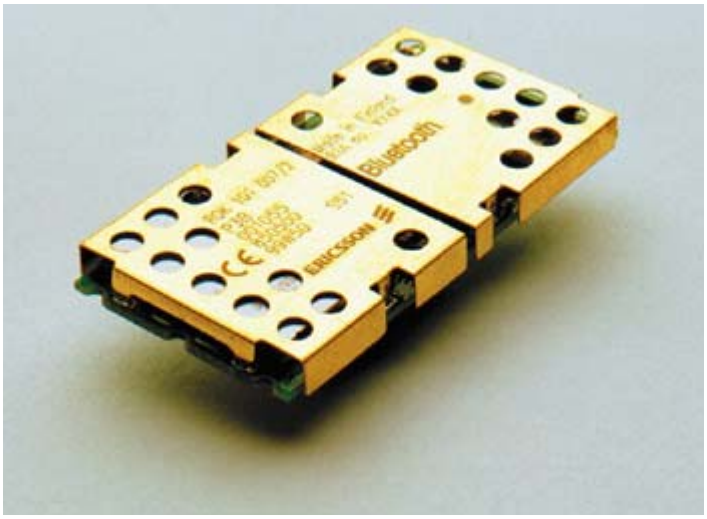

Figure 6.9: Ericsson's Bluetooth module—small enough to put in just about any portable device

Controlling the Connections

Each Bluetooth chip includes not only the Bluetooth radio, but also what is called a *Link Controller*, or LC. This part of the chip is a digital signal processor that handles all the background functions necessary to establish a Bluetooth wireless connection (also called a *link*, hence the name).

The software behind the Link Controller is called *Link Manager* (LM) software. LM software uses a specific set of commands (called the *Link Manager Protocol*, or LMP) that carries out

specific functions—including link setup, authentication, and configuration, and the sending and receiving of data.

Note For more technical information on the link management and control hardware and software used in a Bluetooth radio, see Chapter 7.

Power—Less Is More

The Bluetooth Specification actually allows for three classes of Bluetooth radios, depending on the maximum transmission range. The most common radios are in Class 3; Class 3 Bluetooth radios have a 10-meter range, and have a maximum transmit power of 1 milliwatt (mW). The most powerful radios are in Class 1, with a 100-meter range and a transmit power of 100mW. By comparison, today's most powerful mobile phones output three full watts of power—three thousand times more powerful than a Class 3 Bluetooth radio!

These output power ratings, as low as they are, represent the theoretical maximums; one nice feature of the Bluetooth Specification is that the output power of the Bluetooth radio is matched exactly to what is required. This means that two devices close together transmit with less power than do two devices further apart.

This ability to modify the radio's signal strength as necessary serves to dramatically reduce the radio's power consumption, which makes it more attractive for use in low-power portable devices. In addition, the Bluetooth radio chip automatically shifts to a low-power mode as soon as communications stop—which means the chip doesn't use any power it doesn't have to. (This low-power mode is interrupted only sporadically by very short signals used to verify the established connection.)

The result of these power-conserving features is that a Bluetooth radio consumes a very small percentage of the total power consumed by one of today's state-of-the-art mobile phones—a relatively small burden for the huge increase in usability.

The Thirty-Foot Bubble

As shown in Figure 6.10, Class 3 Bluetooth radios (the most common type, initially) have a maximum transmitting and receiving range of about 30 feet—sometimes called the *thirty-foot bubble*. Outside this bubble, devices can't communicate; inside the range, connections are automatic.

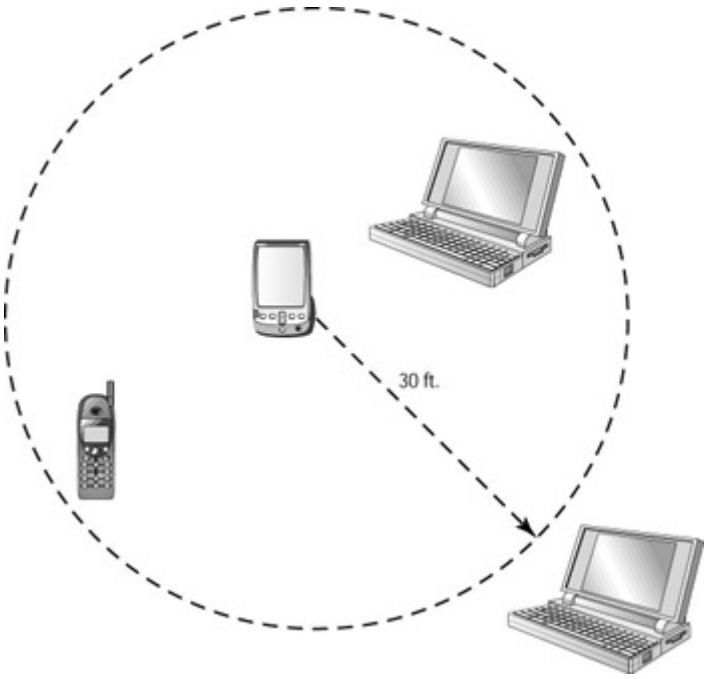

Figure 6.10: Bluetooth communications are limited to a 10-meter (30-foot) range; devices outside the range can't connect.

Why a 30-foot range? Well, it's not *precisely* 30 feet—it's 10 meters, which translates to a little over 30 feet, and 10 meters is a nice round number, internationally. (Just about every country in the world is metric, except for the U.S.) More practically, the 10-meter range was chosen to help reduce the power requirements for the Bluetooth radio. Transmitting over greater distances would require a more powerful radio, which would require a *larger* radio chip (making it impractical for smaller portable devices) and would consume too much battery power (which would reduce the battery life of portable devices). In some ways, the 10-meter range was a compromise between distance, size, and power consumption—although it works quite well for most practical applications.

That said, there is an alternative 100-meter range noted in the Bluetooth Specification, and the Radio 2.0 Working Group is considering other ways to extend Bluetooth's transmission range for the 2.0 version of the Bluetooth Specification.

It's Global…More or Less

One last thing about the Bluetooth standard—it's global. No, that doesn't mean that your Bluetooth device in California can communicate with a similar device in New Delhi. (New Delhi is more than 30 feet away from California, and 30 feet is the extent of Bluetooth's transmission range.) What it does mean is that if you traveled to New Delhi, your device could communicate with all the other Bluetooth devices in that city—no translation necessary.

By establishing a global standard, the Bluetooth SIG accomplished several things. First, it ensured that devices from multiple manufacturers could talk with each other, with no conversion or translation necessary. If you've ever tried to use a Macintosh floppy diskette in an IBM-compatible PC (or a Beta videocassette in a VHS VCR, or a CDMA mobile phone on a TDMA network), you know how inconvenient it is when different companies adopt competing technologies. For the 2000-plus companies that have adopted the Bluetooth standard, incompatibility is a nonexistent problem.

Second, Bluetooth's global strategy makes it possible for products sold in one country to be used (or to communicate) with products manufactured in a different country. This uniting of the wireless world not only enables citizens of different countries to travel freely with no artificial technological barriers, it also enables manufacturers to produce a single product that can be sold worldwide. By eliminating the need to produce dozens—or even hundreds!—of country-specific models, manufacturers should be able to produce greater quantities of a short product line, thus achieving the benefits of scale and lowering manufacturing costs. Over time, these lower costs should be passed on to you, the consumer, in the form of lower selling prices.

However, in its quest to establish a global wireless standard, the Bluetooth SIG ran across a handful of local obstacles. Three countries—Spain, France, and Japan—had previously reserved portions of the 2.4GHz range for local (primarily military) use. This could have potentially defeated the global nature of the Bluetooth standard, if devices built for these three countries had to incorporate slightly different radio technology.

Recognizing this issue, the Bluetooth SIG has worked with officials from each country to try to lift restrictions on 2.4GHz transmissions. As of January 2001, all three countries have agreed (at least in principle) to free up at least some of the reserved portions of the band in their respective regions.

This doesn't mean that the regional issue is moot, however. In Japan, for example, the usable Bluetooth range is limited to 23 1MHz frequencies between 2.471GHz and 2.497GHz—not the 79 frequencies in a larger range available elsewhere in the world. So for a Bluetooth device to operate properly in Japan, it must somehow be limited to using only this specific section of the 2.4GHz band.

Table 6.2 compares the frequency ranges available for Bluetooth use in the problematic regions with the standard 24GHz band available elsewhere in the world.

Table 6.2: Regional Bluetooth frequency limitations.

Country	**Frequency Range (GHz)**
Japan	2.471 – 2.497
France	2.4465 – 2.4835
Spain	2.445 – 2.475
Elsewhere (Europe and U.S.)	2.400 – 2.483

More Details in the Spec…

This chapter discussed the Bluetooth technology in the broadest possible terms. For many readers, that's probably all the detail you need. For the technically minded among you, however, the next two chapters cover the Bluetooth Specification in a lot more technical detail. Turn the page to find out the nitty-gritty details behind the Bluetooth wireless technology in Chapter 7, "Inside the Bluetooth Specification."

Chapter 7: Inside the Bluetooth Specification

Bluetooth wireless technology is both tremendously complex (version 1.0 of the Bluetooth Specification runs close to 1500 pages in length!) and amazingly simple. It's complex because—well, because any technology is complex to some degree, especially when even the smallest details must be described to ensure fail-proof interoperability between all devices. It's simple because the basic process of establishing a direct connection between two devices is inherently a simple one.

In Chapter 6, "A Quick Guide to the Bluetooth Technology," you learned the simple concepts that compose the Bluetooth Specification. In this chapter you learn some of the more complex technology and protocols behind the concepts. Read on to learn how, in somewhat technical terms, the Bluetooth wireless technology works.

Bluetooth Architecture

The Bluetooth Specification defines all aspects of the Bluetooth technology—including hardware and software components and shared processes and procedures. Before we delve into the technical protocols and processes of the Bluetooth Specification, let's look at the Bluetooth architecture itself—what goes into making a Bluetooth-enabled device.

The Bluetooth Device

In general terms, a Bluetooth device is any complete electronic product that incorporates a Bluetooth radio. The radio itself (discussed next) is not the device, it's only a component of the device.

In practical terms, a Bluetooth device could be a mobile phone, or a personal digital assistant (PDA), or a portable computer, or even a printer or a scanner or a headset. As long as the complete product incorporates Bluetooth technology (in the form of a Bluetooth radio and corresponding operating software, as shown in Figure 7.1), the item can be called a Bluetooth device.

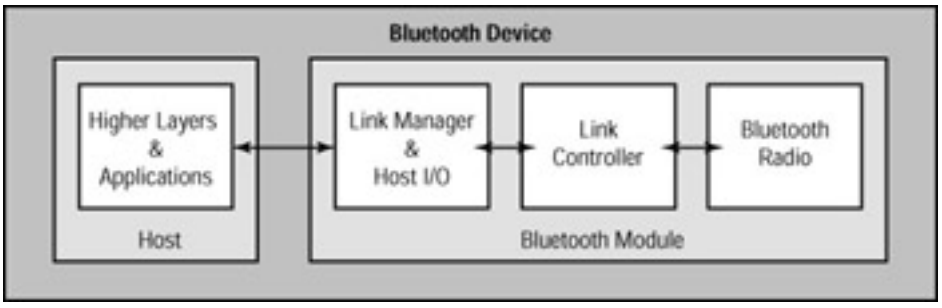

Figure 7.1: The architecture of a Bluetooth device

Naturally, any Bluetooth device incorporates more technology than just the Bluetooth radio. Every device has its own distinct purpose—a printer is supposed to print, a mobile phone is supposed to send and receive calls, and so on. The technical challenge, then, is getting the Bluetooth technology to talk to and interact with the device's native technology.

In Bluetooth terminology, the non-Bluetooth part of a device is called the *host;* all of the Bluetooth components (hardware and software) are combined into the *Bluetooth module*. Communications between the host and the Bluetooth module are handled by the Bluetooth Link Manager software (discussed later in this chapter) and the Host Controller of the Bluetooth module.

The Host Controller

The *Host Controller* (HC) is that part of the Bluetooth module that manages all communication and interaction between the Bluetooth module and the host device. The connection between the two parts can be hardwired (that is, the Bluetooth module can be built into the host device's main circuit board) or modular (with the Bluetooth module attached to the host device as an add-on accessory or plug-in card).

The Host Controller interprets the data received from the host and directs it to the appropriate component(s) of the Bluetooth module. It also interprets the data coming from the Bluetooth module, and sends it on its way to the appropriate function in the host device.

To insure interoperability of Bluetooth modules from various manufacturers, the Bluetooth Specification defines a standard interface (and communications protocol) that can be used by all Bluetooth modules, and by all host devices that incorporate the Bluetooth technology. This *Host Controller Interface* (HCI), while not a mandatory component of the Bluetooth Specification (it's not completely necessary if the Bluetooth module is fully integrated into the design of the host device), is useful for those Bluetooth devices that are meant to be used in an add-on or accessory fashion.

Within the Bluetooth module, the Host Controller interfaces directly with the Link Controller hardware. See the "Making—and Controlling—the Connection" section later in this chapter for more information on the Link Controller and Link Manager.

The Bluetooth Radio

The core of any Bluetooth device, of course, is the Bluetooth radio. The Bluetooth radio is just like any broadcasting radio—except a whole lot smaller and less powerful. Where a typical AM radio station utilizes roomfuls of transmitting equipment and a sky-high antenna tower to broadcast at 10,000 watts or more, a Bluetooth radio is small enough to fit between the gap in your two front teeth and broadcasts a minuscule 1 milliwatt.

As described in Chapter 6, the Bluetooth radio transmits over the 2.4GHz RF band, utilizing spread spectrum frequency hopping and Time Division Duplexing (TDD) technologies. A Class 3 Bluetooth radio (the most common type of device) can function over a 10-meter (approximately 30-foot) range.

The Bluetooth radio interfaces directly to the Link Controller (via the Link Manager and the Link Manager Protocol), which then interfaces with the Host Controller, which interfaces (via the HCI) to the host device. Even though it sounds complicated, it's really a quite straightforward process.

Radio Operations

Unlike the radio in your audio system, the Bluetooth radio functions both as a transmitter and a receiver. The radio's transmit operations include both carrier generation and carrier modulation, as well as controlling transmit power and signal strength. The receive operations include the ability to tune to the proper carrier frequency and to adapt to the strength of the signal received.

Figure 7.2 details the core operations of the Bluetooth radio.

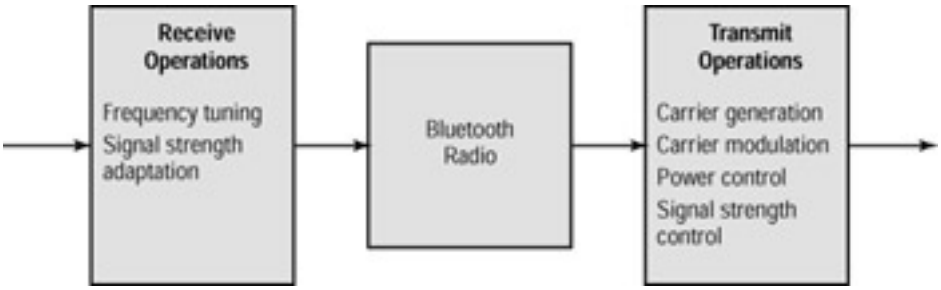

Figure 7.2: Bluetooth radio operations

Note The Bluetooth radio transmitter uses Gaussian Frequency Shift Keying (GFSK) to modulate its signal. With GFSK, a binary one is represented by a positive frequency deviation, while a binary zero is represented by a negative frequency deviation.

As you can see in Table 7.1, there are actually three different classes of Bluetooth radios defined in the Bluetooth Specification; power output (and thus send/receive range) is the differentiator between the classes. Class 3, which defines a 1 milliwatt (mW) output (and a 10-meter range), is the "default" class for Bluetooth devices.

Table 7.1: Output Power for Each Bluetooth Power Class

Power Class	Maximum Output Power	Minimum Output Power
1	100mW (20dBm)	1mW (0dBm)
2	2.5mW (4dBm)	0.25mW (-6dBm)
3	1mW (0dBm)	N/A

Note dBm (decibel relative to one milliwatt) is an alternate measurement of output power.

Radio and Controller Chips

Initial Bluetooth implementations use two separate integrated circuit (IC) chips. The first chip, shown in Figure 7.3, is the Radio Modem. This chip is the core of the radio, and—in addition to being a fully integrated radio transceiver—performs modulation/demodulation, frame timing recovery, and frequency-hopping functions. As you can see in the figure, it also connects directly to the small, extremely efficient antenna necessary to broadcast and receive the Bluetooth wireless signals.

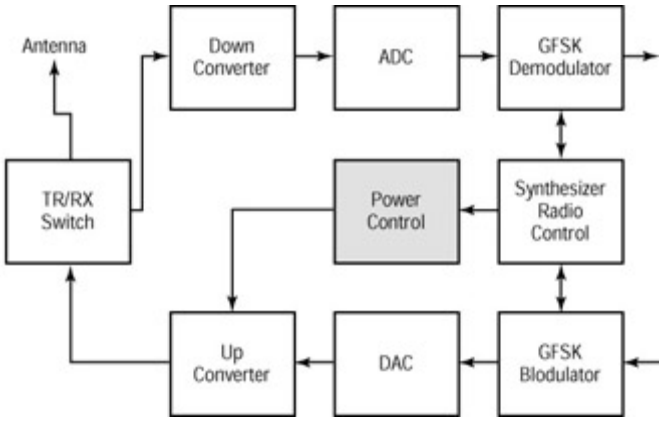

Figure 7.3: Functions of the Bluetooth Radio Modem IC

The second of the two chips in the initial Bluetooth chip set is the Bluetooth Controller IC. This chip implements the Bluetooth Baseband protocol and functions—and contains the Link Controller, which performs basic connection and configuration activities, as described in the next section.

It is assumed that future versions of the Bluetooth radio will combine the Radio Modem and the Controller on a single, lower-priced chip.

Making—and Controlling—the Connection

In Bluetooth lingo, a connection between two devices is called a *link*. As you can easily understand, link management and control—the management of Bluetooth connections—is an essential function of any Bluetooth device. This section will provide some detail on how Bluetooth devices establish links, and how they control the multiple links inherent in a multi-device piconet.

The Link Manager and the Link Controller

Connections between Bluetooth devices are handled by a combination of software and hardware. The software is called the Link Manager (LM); the partner hardware is called the Link Controller (LC).

LM software carries out link setup, authentication, configuration, and other activities necessary to establish a link between two Bluetooth devices. In essence, the LM discovers other devices running the same LM software, and then communicates with them via the Bluetooth Link Manager Protocol (LMP).

To perform this role, the LM software must use the services provided by the underlying LC hardware. The LC facilitates sending and receiving data, setting up connections, and other related activities.

It's easy to confuse the Link Manager and the Link Controller, although in reality they're totally interdependent. As you can see in Figure 7.4, the LM software runs on the LC hardware, using the LMP. If you can get past all the L-lettered acronyms, it's pretty simple to understand.

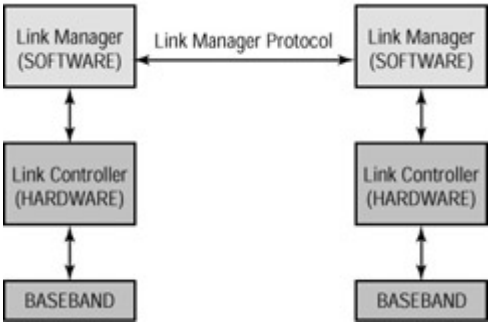

Figure 7.4: Bluetooth link management and control

Once a link is established between two Bluetooth devices, the Link Managers of each unit communicate with each other via the Link Manager Protocol. The messages sent between these two units take the form of what Bluetooth calls Protocol Data Units (PDUs). Since these short system-level messages are key to maintaining the link between the two devices, they have a higher priority than user data or voice communications.

There are actually 55 different PDUs defined in the Bluetooth Specification. When you see a PDU, it looks like something out of a piece of programming code. For example, the PDU LMP_encryption_mode_req is used to request an encryption mode; LMP_version_res is used to send a device's version number, company ID, and sub-version number.

Since PDUs represent a common language, any Bluetooth device will immediately understand and answer to a PDU sent by another device. While some of the 55 PDUs are currently reserved for future use, there is no provision in the Bluetooth Specification for companies to use proprietary PDUs for their devices; all PDU use must be universal.

Higher-Level Control

Beyond the basic link information conveyed via the Link Manager Protocol, the Bluetooth Specification defines a higher level of control called the Logical Link Control and Adaptation Protocol (L2CAP). L2CAP comes into play once the initial link between two devices has been established via LMP.

L2CAP handles a variety of higher-level functions between two Bluetooth devices, including protocol multiplexing, packet segmentation and reassembly, and Quality of Service (QoS) information. In addition, L2CAP interfaces with other communication protocols, including SDP, RFCOM, and TCS-BIN.

Just as LMPs communicate with each other via PDUs, the L2CAP layers in connected units communicate via their own series of messages, called *events*. Event messages look a lot like PDUs (for example, L2CAP_DisconnectReq indicates that a disconnection request packet has been received), but represent their own discrete "language."

Defining Protocols

Key to all these connections and communications is some sort of software to manage all this activity. In the Bluetooth Specification, this software takes the form of standardized protocols that are used to implement various procedures and processes. Some of these protocols are unique to Bluetooth; others are existing protocols used by other technologies and applications.

Understanding which protocols are used—and how—is essential to understanding how Bluetooth technology works.

Understanding Communications Protocols

A *protocol* is simply a predefined rule that sets out a specific way for devices to communicate with each other. Every type of communications and networking technology includes its own unique set of protocols that describe precisely how data is passed in various situations. Protocols define the data format, and how that data is to be sent and received.

Think of a protocol as you would a traffic law. If you're a pedestrian, there are specific laws that define where you should cross a street, when to cross, and how to cross. If you're a driver, there are laws that define how you should behave at various types of intersections and when driving down various types of roads. These real-world laws serve the same functions as technology protocols—they tell you the important whats, wheres, whens, and hows that keep people and things flowing smoothly.

Since many communications and networking technologies perform similar functions, it is not uncommon to see protocols established for one technology to be adopted by other, similar technologies. This ability to reuse or share protocols is practical for two reasons. One, it's efficient—there's no need for a new technology to spend a lot of time and energy "reinventing the wheel" if it can simply use a protocol that is already in existence. Second, sharing protocols results in some degree of interoperability between different technologies and devices; it's generally a good thing for different applications to share some sort of common language and rules.

The Bluetooth Protocol Stack

In most instances, the different protocols used in a specific technology fall into a predefined hierarchy. The base layer of the hierarchy typically contains protocols that are used in all applications of the technology. Other layers are stacked on top of this base layer, containing protocols that define increasingly vertical functions.

This layering of protocols creates what is called a *protocol stack*. In the Bluetooth Specification, there is one overall protocol stack that includes every possible protocol that can be used in every conceivable application; each individual application also has its own unique protocol stack, containing only those protocols that are used in that application. In Bluetooth terminology, that requires a separate protocol stack for each Bluetooth profile.

The complete Bluetooth protocol stack is shown in Figure 7.5. Naturally, not all applications make use of all the protocols in the master stack; instead, individual applications run over one or more of the vertical slices within the stack, as will be discussed in short order.

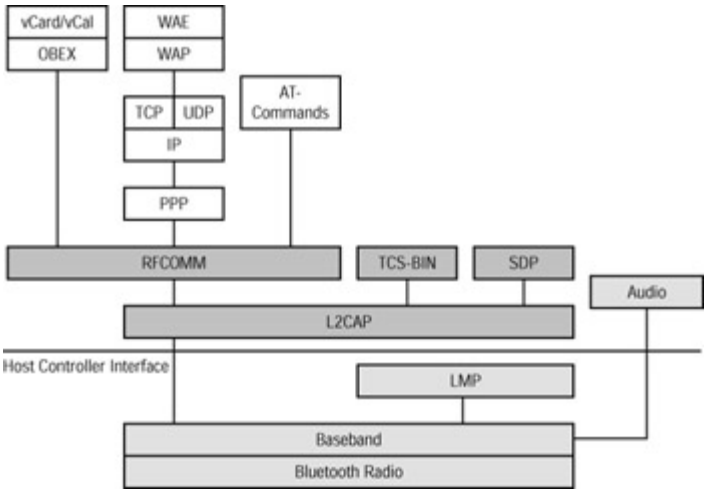

Figure 7.5: The complete Bluetooth protocol stack

The Bluetooth protocol stack can be divided into four main layers, according to function. Table 7.2 details the different protocol layers, and the specific protocols included in each layer.

Table 7.2: Layers of the Bluetooth Protocol Stack.

Protocol Layer	**Protocols Utilized**
Core Protocols	Baseband
	Link Manager Protocol (LMP)
	Logical Link Control and Adoption Protocol (L2CAP)
	Service Discovery Protocol (SDP)
Cable Replacement Protocol	RFCOMM
Telephony Control Protocols	Telephony Control Specification—Binary (TCS-BIN)
	AT-Commands
Adopted Protocols	Point-to-Point Protocol (PPP)
	Transport Control Protocol/Internet Protocol/User Datagram Protocol (TCP/IP/UDP)
	Object Exchange Protocol (OBEX)
	Infrared Mobile Communication (IrMC)
	Wireless Application Protocol (WAP)
	Wireless Application Environment (WAE)
	vCard, vCalendar, vMessage, and vNote (content formats)

The complete protocol stack includes both Bluetooth-specific protocols (such as LMP and L2CAP) and non-Bluetooth protocols (such as OBEX and PPP). As is typical when developing new technologies, not only was it more efficient to work with existing protocols, it also served to ensure some degree of interoperability between Bluetooth and other communication technologies.

In general, the Core protocol layer includes Bluetooth-specific protocols developed by the Bluetooth SIG. The other three layers—Cable Replacement, Telephony Control, and Adopted

protocols—comprise protocols that enable specific applications to run over the Bluetooth Core protocols. In addition, the Bluetooth Specification is open to the degree that additional protocols can be accommodated in an interoperable fashion on top of either the Bluetooth-specific Core protocols or the application-oriented protocols.

Core Protocols

Bluetooth Core protocols are utilized in every Bluetooth profile and provide transport and link management functions to all applications. Each of these protocols was developed specifically for Bluetooth use by engineers in the Bluetooth SIG.

Note As you work your way through the Core protocol layer, it's important to remember that under the Bluetooth Specification, all data is transmitted in small packets. A packet can include either binary (computer) data or audio signals.

Baseband

The Baseband protocol enables the physical RF connection (called a *link*) between the two or more Bluetooth units that form a piconet. This protocol also synchronizes the transmission-hopping frequencies and clocks of the individual Bluetooth devices in a piconet.

There are two different types of physical links provided by the Baseband protocol. With a *Synchronous Connection-Oriented* (SCO) link, packets can contain a combination of audio and data, or just audio only. With an *Asynchronous Connection-less* (ACL) link, packets are reserved for data only.

The Baseband protocol allows for significant flexibility in the link types used. For example, different master-slave pairs on the same piconet can use different link types, and the link type may change arbitrarily during a session. The master unit controls the bandwidth used by each link. (It also decides how much bandwidth is given to each slave unit.)

The Baseband protocol also allows for all types of packets (audio, data, or combination) to be provided with different levels of FEC or CRC error correction. Optional data encryption, for further security, is also part of the protocol.

While binary data is typically transferred from the Baseband layer to either the LMP or L2CAP layers, audio is routed directly from the application to the Baseband layer, bypassing the other layers. This essentially establishes a direct audio link between two Bluetooth devices.

Link Manager Protocol

Just above the Baseband protocol in the stack is the Link Manager Protocol (LMP). The LMP is responsible for link setup and control between two or more Bluetooth devices. This includes a number of security aspects, such as authentication and encryption, and the control and negotiation of Baseband packet sizes. The LMP also controls the power modes and duty cycles of the Bluetooth radio, as well as the connection states of the Bluetooth device when attached to a piconet.

It's interesting to note that messages originating from the LMP have priority over user messages in a connection. If the Link Manager needs to send a message, it takes precedence over traffic from the L2CAP.

Logical Link Control and Adoption Protocol

The Logical Link Control and Adoption Protocol (L2CAP) works in parallel with the LMP to transfer upper-level data to and from the Baseband layer. The big difference between L2CAP and LMP is that L2CAP provides services to the upper layer, which LMP does not.

While the Baseband protocol provides both SCO and ACL link types, L2CAP supports only ACL links. L2CAP data packets can be up to 64Kb in length.

Service Discovery Protocol

Discovery services enable two different Bluetooth devices to recognize and establish connections between each other, and provide the basis for each individual Bluetooth profile. The Service Discovery Protocol (SDP) provides for one device to query another about device information, services, and characteristics of those services. It also enables the establishment of a connection between those two devices.

Cable Replacement Protocol

The Bluetooth Specification includes just one protocol that addresses the wireless emulation of data typically sent over wire-based links—RFCOMM.

RFCOMM

RFCOMM is a protocol that emulates an RS-232 serial connection between two devices. In simple language, this is the cable-replacement protocol. RFCOMM allows for the emulation of RS-232 control and data signals over the Bluetooth Baseband, and also provides transport capabilities for upper-level services that would otherwise use a serial connection as their transport mechanism.

While the RFCOMM protocol was developed by engineers in the Bluetooth SIG, it is based on a subset of an existing protocol. This previous protocol, TS 07.10, was defined by the European Telecommunications Standards Institute (ETSI), primarily for use with GSM portable phones.

Telephony Control Protocols

The Telephony Control protocols enable Bluetooth devices to handle voice and data calls from Bluetooth-enabled devices. For a Bluetooth device to function as either a telephone or a modem, one of the two Telephony Control protocols must be implemented in a profile's protocol stack.

Telephony Control Specification—Binary

Telephony Control Specification—Binary (also called TCS-BIN) defines the call control signaling necessary to establish voice and data calls between Bluetooth devices. It also defines the mobility management procedures used to handle groups of Bluetooth devices.

TCS-BIN is another new protocol (developed by the Bluetooth SIG) that is based on an existing protocol. In this case, TCS-BIN is based on Recommendation Q.931 of the International Telecommunication Union–Telecommunications (ITU-T), which is an agency of the United Nations responsible for coordinating standards for global telecommunication networks and services.

AT Commands

All telephones and modems are controlled by a set of audio/telephony (AT) commands. AT commands are typically used to control all the functions capable of being performed by a telephone or data modem, and are common among various devices and manufacturers.

Bluetooth's AT commands are used when a profile requires a Bluetooth device to be employed as either a phone or modem when connecting to a landline or cellular telephone system. The AT command set used in the Bluetooth protocol is based on established commands used by both the ETSI and ITU-T.

Adopted Protocols

In addition to the previous protocols, a number of protocols established in other industries have been adopted for use in the Bluetooth protocol stack. This enables older applications to work with the newer Bluetooth technology—and for Bluetooth devices to connect with global communications networks.

PPP

The Point-to-Point Protocol (PPP), developed by the Internet Engineering Task Force (IETF), defines how Internet Protocol (IP) data is transmitted over serial point-to-point links. This protocol is typically employed in dial-up Internet connections, or when accessing a network router over a dedicated line.

In the Bluetooth world, PPP runs over the RFCOMM protocol to establish point-to-point connections between Bluetooth devices. You find the PPP protocol used in the LAN Access, Dial-Up Networking, and Fax profiles.

PPP is itself composed of three main components, two of which are protocols in and of themselves. These three components of PPP are:

- Encapsulation
- Link Control Protocol (LCP)
- Network Control Protocols (NCPS)

TCP/IP/UDP

These three protocols—TCP, IP, and UDP—are established protocols that define the majority of Internet-based and network-related communications, as well as communications between other types of computing devices and peripherals. Bluetooth has appropriated these protocols to facilitate communication with any other device connected to the Internet.

All three of these protocols define similar functions, as follows:

TCP

The Transport Control Protocol (TCP) defines the procedures for breaking data into packets and then reassembling them on the other end of the transmission.

IP

Internet Protocol (IP) defines how data is sent through routers to different networks, by assigning unique IP addresses to different devices.

UDP

The User Datagram Protocol (UDP) is less widely used than TCP/IP, as it passes individual messages to IP on a best-efforts basis only, without guaranteed delivery.

OBEX

Objects—or what the rest of us would call data—are typically exchanged between two devices that utilize a client/server model. (That is, one device functions as a server and "serves" the data objects to the other, client, device.) Bluetooth has adopted the Object Exchange (OBEX) protocol initially defined by the Infrared Data Association (IrDA) to facilitate the exchange of data objects between different devices.

Note The IrDA called this protocol IrOBEX—for Infrared Object Exchange—but in its more universal form the protocol is more correctly called OBEX.

The OBEX protocol not only enables data exchange between two devices, but also defines a folder-listing object, which can be used to browse the contents of folders that reside on a remote device. This protocol is further enhanced by Bluetooth's adoption of the vCard, vCalendar, vMessage, and vNote content formats, which are open standards used to exchange business cards, personal calendar entries, messages, and notes.

IrMC

The Infrared Mobile Communications (IrMC), also developed by the IrDA, works in conjunction with OBEX to synchronize the exchange of data objects between different devices.

WAP

The Wireless Application Protocol (WAP) is used to implement Internet services on digital cellular telephones and other small wireless devices. If you own an Internet-enabled mobile phone (commonly called a *Web phone*), you're already familiar with WAP; it's the protocol behind the Web phone's ability to browse the Web and retrieve e-mail and other Internet-based information.

Per specifications, information sent to WAP-enabled devices must be delivered in a text-based, "no-frills" format that is customized for the small screens common in wireless devices. Web sites customized for WAP are created with WML (WAP Markup Language), a WAP-friendly version of HTML code.

Note Normal Web pages are developed with a type of programming code called the Hypertext Markup Language (HTML). The version of HTML used to develop WAP-friendly Web pages is called the WAP Markup Language (WML).

WAP, like Bluetooth, has its own unique protocol stack. Protocols unique to WAP include Wireless Application Environment (WAE, discussed next), Wireless Session Protocol (WSP), Wireless Transaction Protocol (WTP), Wireless Transport Layer Security (WTLS), and Wireless Datagram Protocol (WDP). A pure WAP device would use all these protocols, as well as UDP/IP and other common protocols.

All Bluetooth-enabled phones and PDAs engineered for Internet connectivity incorporate WAP.

WAE

The Wireless Application Environment (WAE) provides a variety of software applications for use in WAP-enabled phones and PDAs. Applications can be either client-based (called WAE User Agents) or server-based (called Content Generators). An example of a client-based WAE application would be a WML-compatible Web browser.

Security and Authentication

Security is important to the Bluetooth Specification, especially if one expects Bluetooth-enabled devices to drive m-commerce payment schemes and provide keyless door entry. If the personal information stored in or transmitted by a Bluetooth device can be easily hijacked, this new technology simply won't be adopted.

Basic Bluetooth Security

As defined in the Bluetooth Specification, there are three possible security modes for a Bluetooth device:

Security Mode 1: Non-Secure In this mode, no security measures are implemented. The device is effectively not secure.

Security Mode 2: Service-Level Enforced Security In this mode, the Bluetooth device initiates security procedures after the connection is established.

Security Mode 3: Link-Level Enforced Security In this, the most secure mode, the Bluetooth device initiates security procedures before the connection is established.

Just what security procedures are defined for modes 2 and 3? There are three basic security mechanisms in the Bluetooth Specification—Key Management, Device Authentication, and Packet Encryption. We'll look at each of these mechanisms separately.

Key Management

Bluetooth's Key Management works by using three basic types of keys:

PIN Code The personal identification number (PIN) is selected by the user. It must be a 48-bit (4-digit) number. The Bluetooth Specification addresses security issues in a number of ways.

Note While PIN authentication is a very effective security measure, the constant prompting to input PINs is annoying to many users. For that reason—even though it effectively defeats the authentication—many Bluetooth devices are expected to allow storage of the user's PIN in the device's memory, for either automatic or one-key recall.

Private Link Key A Bluetooth device can use one of four different types of *link keys* (also called *authentication keys*). All are either temporary or semi-permanent 128-bit random numbers, newly generated for each transmission. A *unit key* is derived by the single Bluetooth device. A *combination key* is derived from a pair of devices, and is more secure than a unit key. A *master key* is used when the master device in a piconet wants to transmit to several devices at once, and overrides the current link key for one session. Finally, an *initialization key* is used in the device initialization process, and protects initialization parameters when they are transmitted.

Private Encryption Key The *encryption key* is derived from the link key currently in use. Each time encryption is needed, the encryption key is automatically changed. The encryption key can vary between 8 and 128 bits in length. (It has to vary in length to stay "legal" with various countries' technology export restrictions.)

Note In addition, each individual Bluetooth device has its own unique 48-bit *device address*, assigned by the Institute of Electrical and Electronics Engineers (IEEE). The various keys, along with the device address, are used to generate other "secret" keys for each link in the connection, to ensure that other Bluetooth devices (either in or outside the device's current piconet) cannot eavesdrop on a Bluetooth connection.

Bluetooth's Key Management utilizes these three types of keys in the key control process. The process goes something like this:

1. The user (or the device) enters a PIN.
2. The device generates a private link key and authenticates it with the second device.
3. The device derives a private encryption key from the link key, and then authenticates it with the second device.

As you can see in Figure 7.6, if all the keys check out, the two devices connect. If not, the connection is aborted.

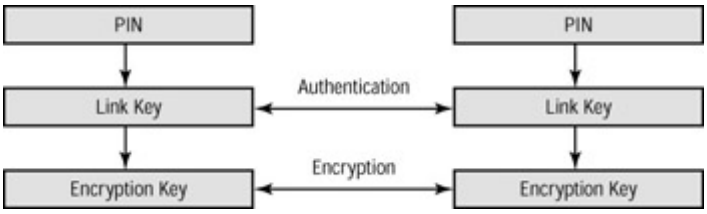

Figure 7.6: Key control security between two Bluetooth devices

Device Authentication

In addition to the key control security scheme, the Bluetooth Specification also defines an authentication scheme. This is essentially a "challenge and response" scheme, where a special security protocol is used to check whether the other device knows a shared secret key (called a *symmetric key*). If the two devices know the same key, authentication is successful; if either device doesn't know the key, the connection is aborted.

Which device sends out the "challenge" message is determined by the particular Bluetooth application; it isn't necessarily the master device that starts the process. Some applications require only one-way authentication, while others can demand mutual authentication. If the authentication fails, there is a *waiting time* that must pass before a new attempt at authentication is made.

Packet Encryption

The Bluetooth Specification calls for a systematic encryption of each packet that is transmitted. There are three encryption modes defined, as follows:

Encryption Mode 1 In this mode, no packets are encrypted.

Encryption Mode 2 In this mode, point-to-point traffic (data sent to a specific device address) is encrypted, but point-to-multipoint traffic is not.

Encryption Mode 3 All traffic is encrypted.

Security Concerns

Even with Bluetooth's rather robust security measures, some experts claim that the Bluetooth technology contains some serious security gaps.

Late in 2000, Markus Jakobsson and Susanne Wetzel, researchers from Lucent Technologies' Bell Labs, claimed that conversations initiated via Bluetooth-enabled mobile phones were capable of being bugged, and that Bluetooth's encryption procedures could be easily defeated.

Their first concern centers around the use (common in many other applications) of a four-digit customer PIN. While a PIN is only as secure as its user (the vast majority of PINs remain set to the factory default of "0000," unfortunately), security can be further compromised when the capability exists to store the PIN in the memory of a Bluetooth device. Storing a PIN for

one-key recall significantly increases the convenience of using a device (who can remember all their PINs and passwords these days?), but also significantly reduces the device's security.

The second vulnerability they identified concerns what they call a "location attack" on the user of a Bluetooth device. This can come about when a third party obtains the device address of a specific Bluetooth device. With this address, a third party can physically trace the device, and potentially compromise the security of the device's user.

The third concern centers around the Bluetooth encryption key. It is possible, the Lucent researchers claim, for an electronic eavesdropper to utilize a relatively common bugging device to obtain encryption keys from Bluetooth devices used in public places. (The problem, apparently, is not in the encryption formula used in the Bluetooth Specification, but rather in the protocol used by the two devices to obtain the 128-bit random number key.) With this key in hand, the eavesdropper could use a third Bluetooth device to listen in on the conversation between the first two devices.

As might be expected, these warnings were downplayed by other members of the Bluetooth SIG. Intel's Simon Ellis, Chairman of the Bluetooth SIG, commented that "in this example, analysis was done on the systems to understand what levels of protection Bluetooth provides and what additional levels of protection will be needed."

In other words, they went looking for potential problems, and it's good that they found them—sooner rather than later.

Ellis' comments are confirmed by the fact that the Lucent researchers (in the same document!) also suggested several simple countermeasures that could be taken to alleviate the vulnerabilities they discovered. These countermeasures include:

- Somehow ensure that users choose their PINs often and at random.
- Increase the PIN length. (A 64-bit PIN appears to be secure, the researchers said.)
- Adopt certificate-based security methods.
- Develop new policies within the Specification to better define master-slave relationships. (This helps to defend against so-called "middle person" attacks, where a third party somehow convinces the other devices in a connection to become either a master or a slave.)
- Develop a better form of physical shielding to prevent third parties from detecting signals from Bluetooth devices.
- In place of the predefined device addresses, utilize randomly generated pseudonyms for each device.

How serious are these security concerns? At one extreme, Juha T. Vaino of the Helsinki University of Technology, after researching Bluetooth's security procedures, said that the technology "is adequate for small applications, but any sensitive data should not be sent with Bluetooth."

On the other hand, it's probably safe to say that no technology—Bluetooth included—can be completely secure. It's also probably safe to say that any identified security issues will likely be patched by the time a large number of Bluetooth devices hit the market.

Note It's worth noting that similar security concerns have been raised about 802.11 and other

wireless networking technologies. In February 2001, researchers at the University of California at Berkeley identified four specific types of attacks that can compromise the security of an 802.11 network, which relies on the Wired Equivalent Privacy (WEP) protocol.

Chapter 8: Usage Models and Profiles

In the previous two chapters you learned, in various degrees of technical complexity, how the Bluetooth wireless technology works. Now it's time to examine specific applications of that technology and the technical requirements to make each application work in the real world.

To that end, this chapter presents the Bluetooth usage models that were used to build version 1.0 of the Bluetooth Specification, as well as the Bluetooth profiles detailed in the Specification. In short, this chapter is where it all comes together—the applications and the technology used to implement them.

Common Usage Models

A Bluetooth *usage model* is simply a description of a potential application of the Bluetooth wireless technology. Usage models themselves are not technical; they're more marketing-oriented in their focus, and use common everyday language to describe specific tasks that consumers might undertake with Bluetooth-enabled devices.

Bluetooth engineers utilized these usage models as targets as they were developing version 1.0 of the Bluetooth Specification. The implementation of each usage model was described in extreme technical detail, in what was called a Bluetooth *profile*. In other words, each profile is paired to a specific usage model; the usage model is realized when engineers execute the technical details of a profile within a Bluetooth-enabled device.

Profiles are discussed in the second half of this chapter. In this section we'll look at the usage models that inspired the profiles.

Note The profiles listed here are the official—or, in some cases, unofficial but widely adopted—usage models for version 1.0 of the Bluetooth Specification. New usage models are envisioned for version 2.0 of the Specification; these future usage models are discussed in Chapter 11, "Bluetooth in the Future."

The Cordless Desktop

The Cordless Desktop usage model (sometimes called the Cordless Computer model) describes how you connect any type of peripheral to your desktop or portable computer, without cables. All connections are via Bluetooth wireless technology, and the envisioned peripherals include printers, mice, keyboards, scanners, and network connections, as shown in Figure 8.1.

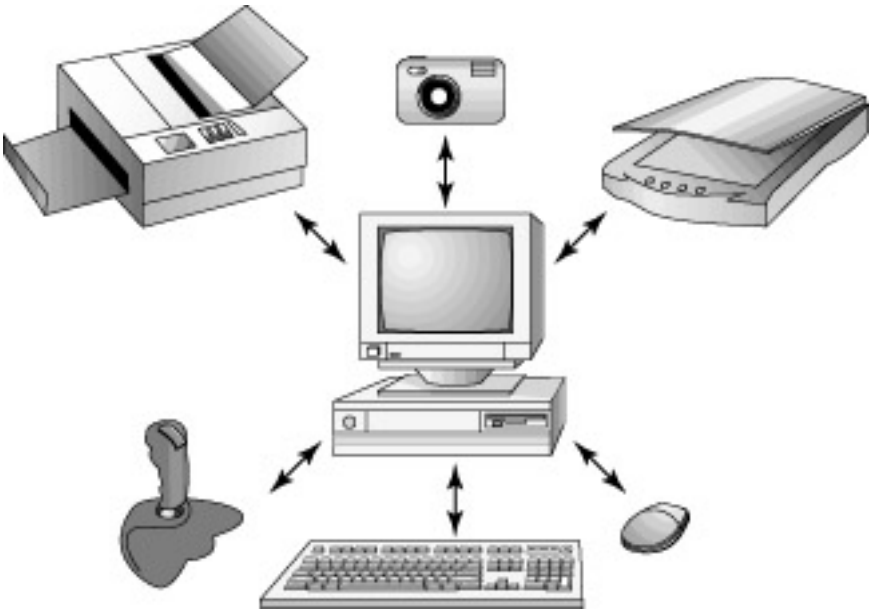

Figure 8.1: The Cordless Desktop usage model

The Cordless Desktop model is easy to envision in your current computing environment. Your printer sits where it always has, but without the thick cable running to the back of your PC. Your keyboard can now be laid on your lap as you lean back in your office chair, because there is no longer a cable running from it to the back of your PC. The same thing with your mouse—it's now totally wireless. Your scanner—which is sitting on the other side of the room, the only place you had a spare surface—is easily connected to your PC without the fuss and bother of running cables from here to there. You're not even plugged into the office network; that connection is also wireless, using Bluetooth.

One nice thing about this model is that whenever you add a new peripheral, all you have to do is bring it into the room; Bluetooth not only connects the peripheral, wirelessly, but automatically synchs it to and configures it for your computer. So if you head over to CompUSA and buy a new Web cam, all you have to do is plug it into a power outlet and sit it on top of your PC; Bluetooth handles the rest of the connection and installation procedure, automatically.

Another benefit of the Cordless Desktop is that you're no longer limited to placing all your peripherals within a cable's length from your PC. Now you can place your printer, scanner, keyboard, mouse, joystick, speakers, and other peripherals wherever they work best for you; you don't have to worry about how to run the connecting cable from here to there.

The Internet Bridge

The thrust of the Internet Bridge usage model is to enable portable devices to surf the Internet from any location. Whether you're using a PDA, a portable computer, or a mobile phone, you will utilize Bluetooth wireless technology to access an Internet connection.

There are two different ways that the Internet Bridge will work in the real world. The first implementation, shown in Figure 8.2, is based on a connection to a traditional dial-up network. In this scenario, your laptop PC connects via Bluetooth to either a mobile phone or a traditional landline phone, which is then used to dial into your Internet service provider.

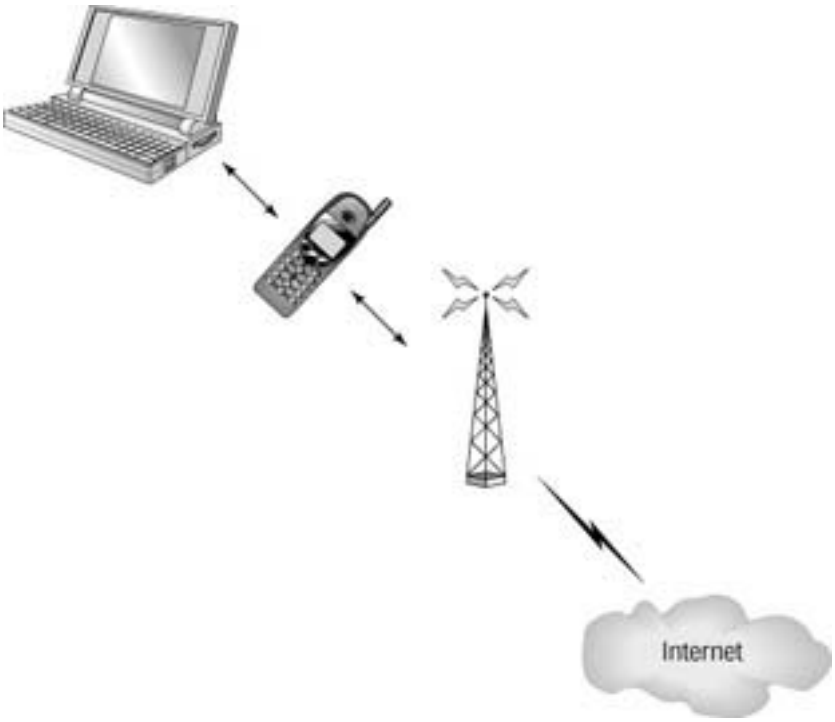

Figure 8.2: The Internet Bridge usage model, via mobile phone connection

The second implementation of the Internet Bridge, shown in Figure 8.3, is based on a connection to a local area network (LAN). In this scenario, your laptop PC connects via Bluetooth to your office LAN, which is then connected to the global Internet.

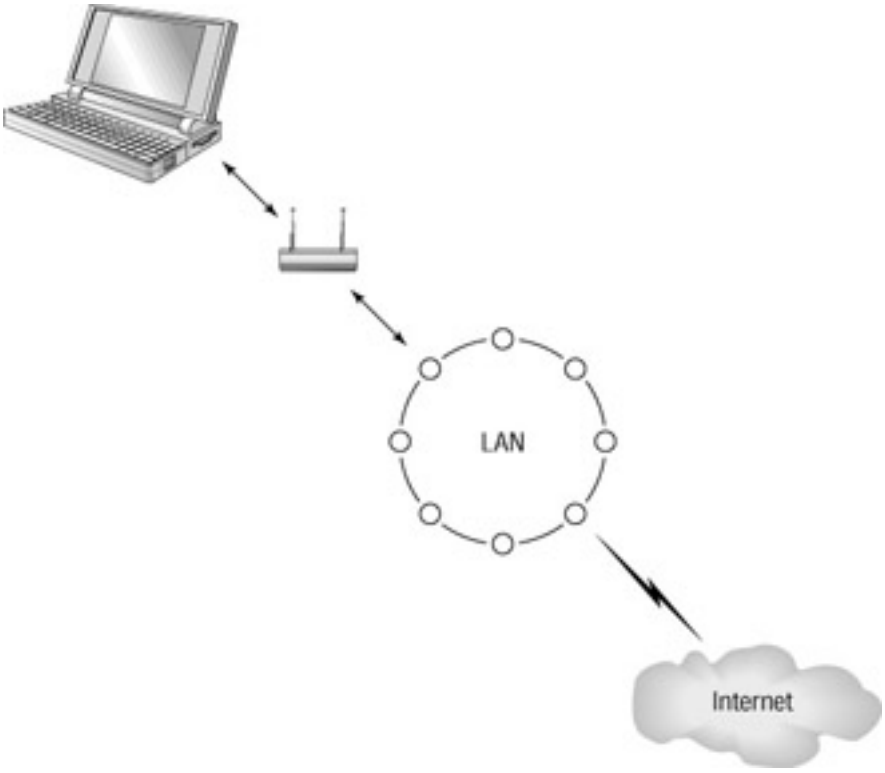

Figure 8.3: The Internet Bridge usage model, via LAN connection

Whether you connect via dial-up or LAN, the Internet Bridge enables you to have Internet access virtually anywhere you go, without the need for connecting cables. You can sit in your

local coffee shop and browse the Web, with your laptop on your lap and your cell phone in your pocket; all the connections are wireless, and happen in the background. Or you can sit in your corporate boardroom and check your e-mail; you don't have to run a cable across the room from your PC to a network connector, because the connection is wireless.

Most experts envision that the Internet Bridge will be one of the most-used Bluetooth models—among computer users, anyway.

LAN Access

The LAN Access usage model describes how you connect to a traditional local area network with a Bluetooth wireless device. (The LAN Access model is actually incorporated in one implementation of the Internet Bridge model, discussed previously.) As you can see in Figure 8.4, the LAN Access model relies on a series of *LAN access points* (LAPs) installed throughout an office at 30-foot intervals. Your laptop PC connects to the office network through one of these LAPs, with Bluetooth automatically handling the connection and synchronization.

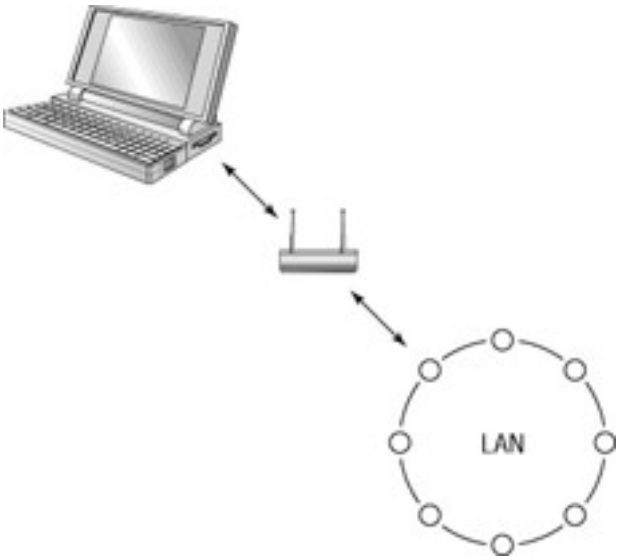

Figure 8.4: The LAN Access usage model

Let's look at the LAN Access model in a real-world scenario. You're an outside salesperson who works at home or is on the road most of the time, but today is your day to visit the home office. Your boss sticks you in a vacant cube and tells you to get to work. You open your ever-present laptop computer and turn it on; your laptop's built-in Bluetooth radio automatically senses the presence of your office network and connects to the LAN through the nearest LAN access point. All you had to do was turn on your PC; everything else happened seamlessly, in the background.

(Compare this to the current scenario, where you have to hunt for a network jack, beg the IT guys for a spare Ethernet cable, and then go through all manner of contortions to get the network to recognize your laptop's Ethernet card. This is definitely an instance where Bluetooth will make your life easier!)

File Transfer

The File Transfer usage model, illustrated in Figure 8.5, generically describes how to transfer data files from one Bluetooth device to another. File transfer can be either manual or automatic; automatic (background) file transfer is used in several other usage models, including the Forbidden Message, Briefcase Trick, Interactive Conference, and Automatic Synchronizer models.

Figure 8.5: The File Transfer usage model

There are several different ways that this usage model can be applied in the real world. A typical example has you sitting in a meeting and needing to share a research report (in Microsoft Word's .doc file format) with the person sitting at the other end of the table. Once your laptops are connected via Bluetooth, pressing a button sends the file—no cables necessary.

The Forbidden Message

The Forbidden Message usage model is named as such because it enables you to compose e-mail messages in places where you were previously forbidden to, due to the historical lack of enabling technology. You compose your e-mail on the sly, and then—when you walk back into an area served by Bluetooth technology—your PDA or laptop PC automatically connects to and synchs up with a Bluetooth network and sends your forbidden messages on their way. (Alternately, you can choose to turn on your mobile phone and send your e-mail messages that way—still using Bluetooth wireless technology, of course.) Figure 8.6 shows how this usage model works.

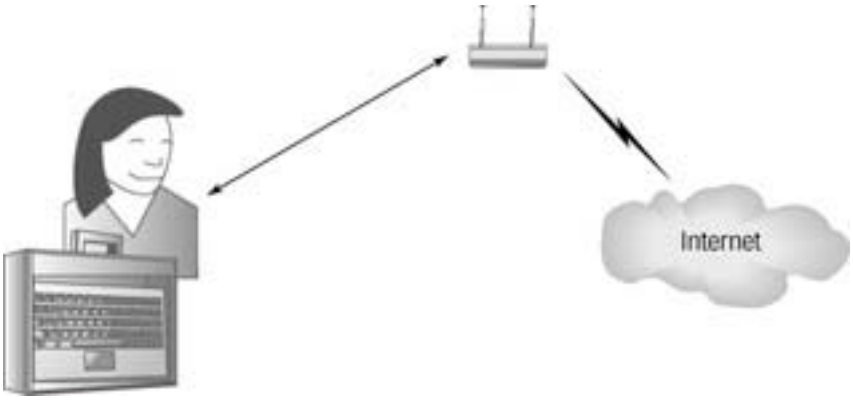

Figure 8.6: The Forbidden Message usage model

The most common application of the Forbidden Message usage model will no doubt be on airplanes. Imagine that you're on a long flight, and the in-flight movie is, for some unknown reason, *Mermaids*. Since you've already seen this movie a dozen times (and you don't know why…), you pull out your notebook PC and start typing a slew of e-mail messages to your friends and colleagues. When the plane lands, you pack your PC back into your briefcase and walk down the jetway into the airport concourse. Installed throughout the concourse are

hundreds of Bluetooth wireless radios, each connected to a cellular telephone network, which in turn is connected to the Internet. When you walk by one of these Bluetooth access points, your notebook PC awakens and automatically connects, then sends all the messages waiting in your e-mail outbox. (It also gathers new messages in your inbox, of course.) So, faster than you can pick up your bags from the luggage carousel, you've sent and retrieved all your e-mail messages—without even having to remove your PC from your briefcase.

The Briefcase Trick

As you can see in Figure 8.7, the Briefcase Trick usage model is similar to the Forbidden Message model. In this model, your notebook PC stays packed in your briefcase, but awakens periodically to receive any incoming e-mail messages—and then send them to your mobile phone (using Bluetooth wireless technology, of course).

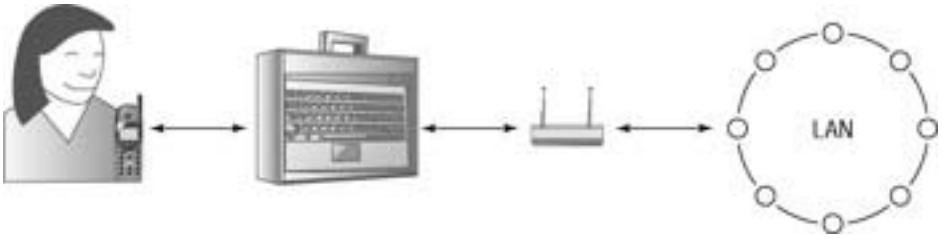

Figure 8.7: The Briefcase Trick usage model

This is some trick, and here's how it will work. You're in a meeting with an important client. Naturally, you've brought your notebook PC with you, but you haven't unpacked it from your briefcase. It's parked in standby mode, however, just waiting for new messages to come through. When a message is sent your way, your notebook is alerted (via one of the Bluetooth radios embedded in the building) to retrieve your e-mail, which it does. The notebook, now with a message in your inbox, sends out another Bluetooth signal to your mobile phone, which you wear clipped on your belt. Your phone beeps at you, you open it up, and you see the list of new e-mail messages sitting in your inbox—which have been beamed there from your notebook PC. You select the messages you want to read, and (via Bluetooth signals) the contents of those messages are shown on your cell phone's display.

The Interactive Conference

In the Interactive Conference usage model, all participants in a meeting or conference are connected via Bluetooth wireless technology for instant data exchange. In addition, this usage model allows for the cordless control of a master PC or data projector, to run a computer-based presentation. Figure 8.8 shows both applications of this usage model.

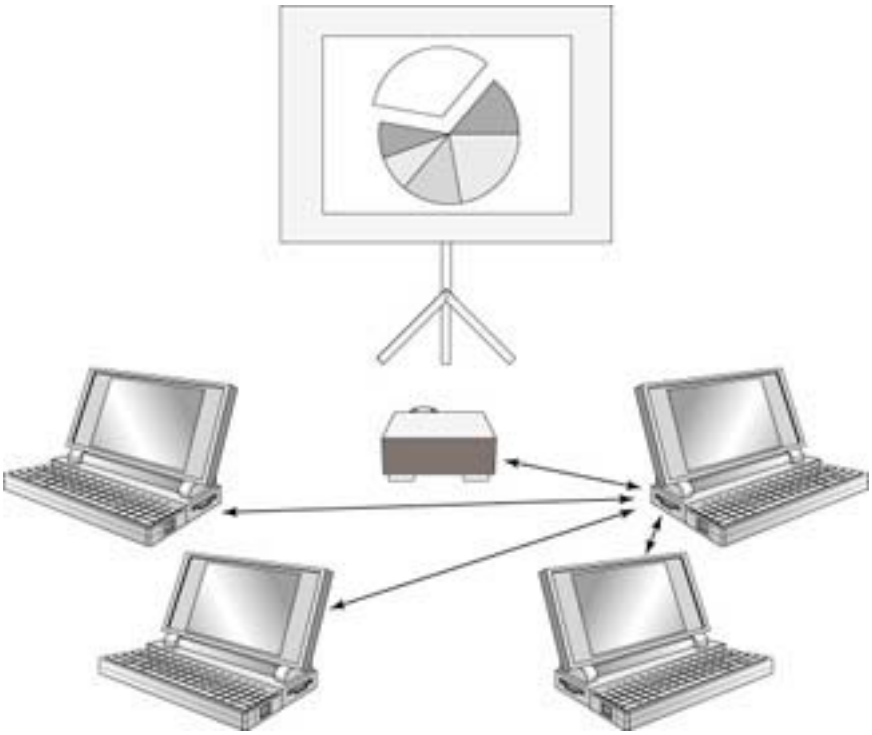

Figure 8.8: The Interactive Conference usage model

Let's envision this usage model in action. You and a dozen of your colleagues are seated around a conference table; a desktop PC is at the end of the table, connected to a data projector that is aimed at a pull-down screen at the back of the room. All of your colleagues have either notebook PCs or PDAs in front of them; you have your notebook open and running on the table in front of you, as well.

You begin the meeting by using your notebook PC to connect to the desktop PC and launch a PowerPoint presentation. The presentation is projected on the pull-down screen, and you control the pace of the presentation with your notebook. During the course of the presentation, you introduce an Excel spreadsheet with next year's projected financials; you use Bluetooth to beam copies of this spreadsheet to all the other participants.

As the meeting progresses, one of your colleagues takes notes and prepares a to-do list in Microsoft Word. At the end of the meeting, he beams his Word document to everyone else in the meeting. Then, because some of the participants are new to the company, you use Bluetooth to synch up everyone's contact lists, so that the names and addresses of the new employees are automatically added to everyone's address books.

The Automatic Synchronizer

The key to the Automatic Synchronizer usage model (sometimes called the Hidden Computing model) is the capability of automatic background synchronization between various types of devices, including desktop computers, portable computers, PDAs, and mobile phones. As shown in Figure 8.9, many different types of items can be synchronized, including address books, contact lists, calendars, schedules, and so on.

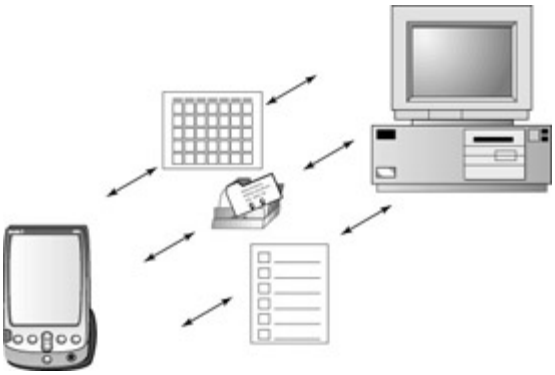

Figure 8.9: The Automatic Synchronizer usage model

Here's one example of the Automatic Synchronizer model in use. You've just come from a road trip, where you've added several new names and addresses to your contact list, which you keep on your PDA. While you've been gone, your secretary has added two new appointments to your schedule, which she keeps on your desktop computer. When you return to your office, your PDA and your desktop PC automatically connect to each other, wirelessly, and begin to synchronize their information. The new contacts in your PDA are transferred to your address book on your desktop PC, and the new appointments on your desktop PC are transferred to your personal information manager (PIM) software on your PDA. All of this happens automatically and in the background, without any awareness or intervention on your part.

The Instant Postcard

The Instant Postcard usage model (sometimes called the Internet Postcard model) describes how you can connect a digital still camera or digital video camera to a notebook PC and beam pictures and movies anywhere in the world, via the Internet. As shown in Figure 8.10, this is a two-step model; your camera is connected to your PC via Bluetooth wireless technology, then your PC is connected to the Internet via the Internet Bridge usage model.

Figure 8.10: The Instant Postcard usage model

Here's how this model will work. You're at Disney World on vacation, your digital still camera in hand. You spend the day riding the rides and taking pictures, which are stored electronically in your camera. When you return to your hotel room, you power up your handy

notebook PC, which then connects (wirelessly) to your digital still camera and automatically downloads all the pictures you've stored. Then, by pressing a few buttons, you send your pictures via e-mail to your friends and family; your notebook PC is connected to the Internet using the Internet Bridge usage model.

The Three-in-One Phone

As described in the Three-in-One Phone usage model (and shown in Figure 8.11), a three-in-one phone is a single phone handset that can connect to three different types of providers:

- The public switched telephone network, as a cordless phone
- A cellular phone network
- Other phones, as a type of "walkie-talkie" or handset extension

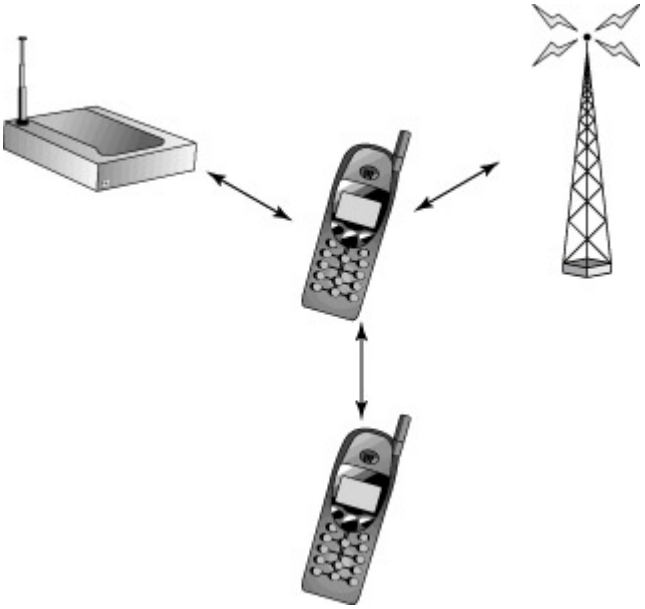

Figure 8.11: The Three-in-One Phone usage model

The key benefit of the Three-in-One Phone usage model is that you no longer have to juggle multiple phones for your different types of usage. Instead of a separate cordless phone at home, wired phone at work, and cellular phone for when you're on the go, you'll carry a single Bluetooth-enabled handset with you throughout your entire day, and it will figure out (automatically) to which provider it should connect at any given time.

Here's a typical example of this usage model at work. In your home, you have a cordless phone handset, sitting in a recharging cradle. When the phone rings you pick up the handset, and the phone connects to your local phone system, through its base station. (That's usage number one.) Then you head off to the store to buy some lettuce for dinner, and take your handset with you; while you're in the store, you use the handset to phone your mother (via a cellular connection) and wish her a happy birthday. (That's usage number two.) Later that evening, back at home, you need to tell your teenaged daughter to turn off the Backstreet Boys and do her homework; you do this by using your handset to message her handset in her bedroom. (That's usage number three.)

One handset, three uses.

Note Interestingly, this usage model was almost called the Two-in-One Phone, as several members of the Bluetooth SIG weren't convinced of the need for phone-to-phone (walkie-talkie) operation. It was eventually decided that adding this functionality to the corresponding profile could be done quickly and easily, even if this would be the least-used of the phone's modes.

The Ultimate Headset

As described by this usage model (and shown in Figure 8.12), a so-called Ultimate Headset is one that connects to a telephone handset or base station without any cables or wires, with complete call privacy. This usage model also envisions using the wireless headset to connect to a personal computer, for audio input and output.

Figure 8.12: The Ultimate Headset usage model

Note The Ultimate Headset model does *not* address the high-fidelity headphones common in audio and audio/video systems, since the signals passed in this model are not of high enough quality to accurately reproduce CD-quality music. A new usage model specifically for A/V systems is currently under development for version 2.0 of the Bluetooth Specification.

Real-world use of the Ultimate Headset is easy to envision. Today you send and receive dozens of calls a day on your cellular phone, and your neck is permanently cocked at a 45-degree angle from cradling your cell phone on your shoulder. Thanks to Bluetooth, you can buy a small wireless headset that fits over one ear, light enough to wear all day in total comfort. When you get a call on your cell phone, you hear the ringing in your earpiece and touch a small button on the side of the headset to answer the call—you don't even have to open up your cellular phone. To place a call, you can either open up your cell phone and dial or (at some future point) use voice-activation to dial the number by speaking.

This usage model is particularly appealing for those who make their living with the telephone. Since you can use an Ultimate Headset with any type of phone—mobile, cordless, or corded—you're now free to stand up and walk around while you're talking. And, since the Ultimate Headset can also initiate outbound and receive incoming calls, you really don't need your old-style phone for anything more than dialing. (And not even that, once voice-activated dialing becomes common.)

There's a side benefit of the Ultimate Headset for those who worry about the effect of microwave radiation from too much cell phone use. Since the Bluetooth radio's power output is just 1 milliwatt (compared to a cell phone's 3 watt output), wearers of Ultimate Headsets

will be exposed to much less radiation than they would be by holding the cell phone up to their ears in the traditional fashion.

The PC Speaker Phone

The PC Speaker Phone usage model (sometimes called the Speaking Laptop model), is an extension of the Ultimate Headset model. As shown in Figure 8.13, this usage model describes how you can connect your telephone to your laptop or desktop PC (wirelessly, of course) and use the computer's built-in speaker as a speaker phone for group conversations and conference calls.

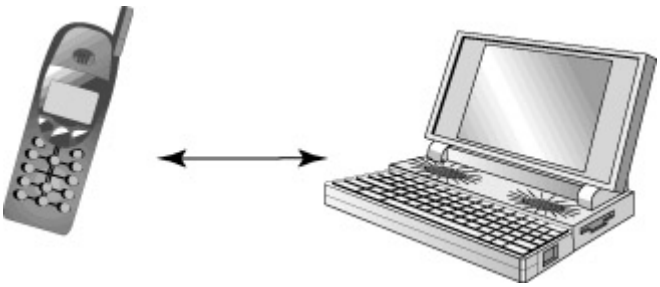

Figure 8.13: The PC Speaker Phone usage model

As an example of the PC Speaker Phone model, imagine sitting in a group meeting in your company's conference room. At some point you decide to call a colleague on the other coast, which you do with your Bluetooth-enabled mobile phone. When it becomes obvious that your remote colleague needs to take part in the overall meeting, you're faced with a choice: You can either hang up your cell phone and redial the colleague on the conference room's main speaker phone, or you use Bluetooth technology to connect your cell phone to your ever-present laptop computer, and let your PC's built-in speaker (and microphone) perform the speaker phone function.

Which would you choose?

The Hands-Free Car Kit

The Hands-Free Car Kit usage model is another variation of the Ultimate Headset model, with a little of the Three-in-One Phone thrown in for good measure. In this usage model, shown in Figure 8.14, a traditional hands-free car kit for your cellular phone (which connects via wires and cables) is replaced by a completely wireless Bluetooth connection.

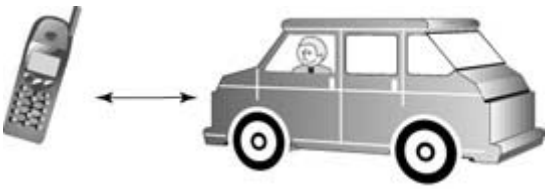

Figure 8.14: The Hands-Free Car Kit usage model

Here's how the Hands-Free Car Kit model will work in the real world. You head out the front door, carrying your new Three-in-One Bluetooth telephone handset. When you settle into the front seat of your car, you sit your Bluetooth handset into a special cradle below your dashboard. At this point, two things happen. First, the handset automatically connects (no wires involved) to a microphone and speaker that were previously installed in your car's dash.

Second, your handset automatically switches into mobile phone mode and connects to your cellular phone provider. All this happens automatically, of course—you're not even aware of all the technology switching going on in the background.

Bluetooth Profiles

If a Bluetooth usage model is a non-technical description of a particular user application, a Bluetooth profile is the technical description of how to make that application actually work. Bluetooth profiles are extremely technical, and go to great lengths to describe all the protocols and procedures necessary to execute the series of very specific actions necessary to implement a specific user activity.

As noted previously, each profile is matched to a particular usage model. Before we get into the specific profiles, however, a presentation of how each profile is constructed is in order.

Understanding Profiles

The first half of this chapter presented the various usage models of the Bluetooth technology, as envisioned by members of the Bluetooth SIG. Now it's time to figure out how to implement those usage models—which is done by defining highly technical profiles that must be adhered to by Bluetooth manufacturers.

A Bluetooth profile defines the procedures and protocols necessary to implement a specific application or usage model. Most (but not all) profiles match with specific usage models, and include both mandatory and optional features for the designated application.

Protocols and Procedures

In Chapter 7, "Inside the Bluetooth Specification," you learned about the different protocols used by and with the Bluetooth wireless technology. These protocols are the key to the different Bluetooth profiles; each profile uses a specific combination of protocols, in a specified fashion, to implement the designated usage model.

All profiles are built on a core layer of common protocols. Referring to the protocol stack discussed in Chapter 7, you find that all Bluetooth profiles start with the same lower protocol layer, including both the Bluetooth Radio and Baseband layers. Above the Baseband are layered the specific protocols necessary for the application at hand.

In addition to identifying protocols, each profile also defines procedures and messages that must (or, in some cases, may) be used to implement a specific application. As defined in the Bluetooth Specification, each procedure is identified as being either *mandatory* (must be used), *optional* (may be used, but doesn't have to be), *conditional* (must be used under specific conditions), *excluded* (must never be used), or *not applicable* to the current profile.

Grouping the Profiles

There are 14 distinct profiles in version 1.0 of the Bluetooth Specification. As you can see in Figure 8.15, these profiles form a "family tree" of sorts, and map to specific usage models.

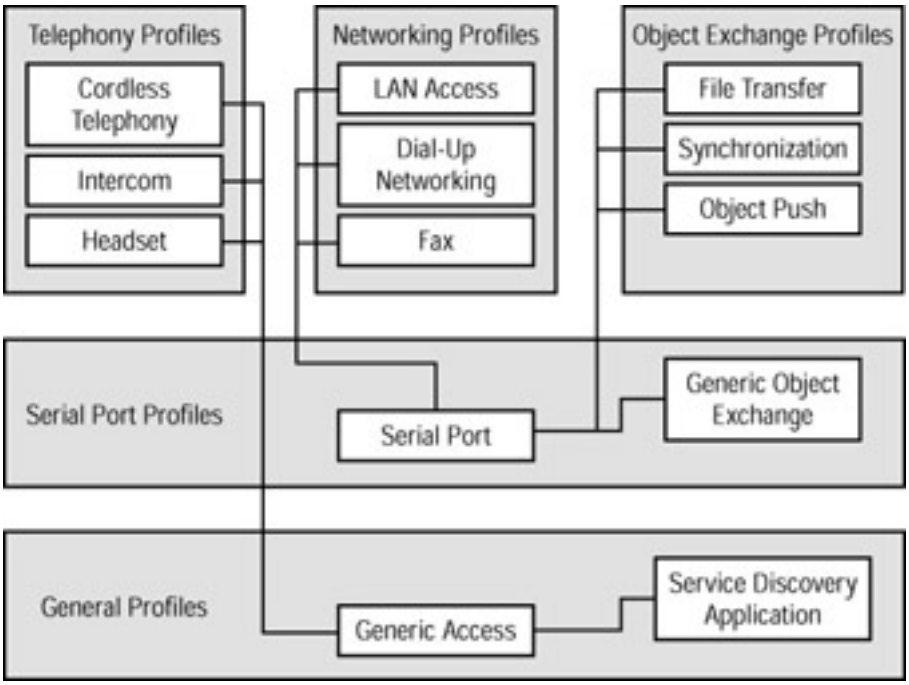

Figure 8.15: The Bluetooth profile family tree

The 14 version 1.0 profiles can be organized into five general groups, as follows:

General

Generic Access Profile (GAP)

Service Discovery Application Profile (SDAP)

Serial Port

Serial Port Profile (SPP)

General Object Exchange Profile (GOEP)

Telephony

Cordless Telephony Profile (CTP)

Intercom Profile (IntP)

Headset Profile (HSP)

Networking

LAN Access Profile (LAP)

Dial-Up Networking Profile (DUNP)

Fax Profile (FaxP)

Object Exchange

File Transfer Profile (FP)

Synchronization Profile (SP)

Object Push Profile (OPP)

The balance of this chapter is devoted to explaining and detailing these individual profiles.

General Profiles

The first two Bluetooth profiles are called general profiles, because they're essential to all forms of Bluetooth communication. Unlike some of the profiles that are more closely tied to specific usage models, the general profiles are expected to be implemented by all Bluetooth-compatible devices.

Generic Access Profile (GAP)

The Generic Access Profile (GAP) defines modes and procedures common to all other profiles. Essentially, the GAP is the base on which all other profiles are built.

In general, the GAP deals primarily with three types of items: *dictionary* (a collection of terms and their definitions, so that all manufacturers are using the same terminology), *connectivity* (operations that enable a Bluetooth device to connect to and authenticate with other devices), and *personalization* (elements that identify and customize individual Bluetooth devices). The following functions are defined in the GAP:

Device Class The GAP defines the type of device and the types of services supported by that device type.

Device Name The GAP permits Bluetooth devices to have user-friendly names up to 248 bytes in length—even though some Bluetooth devices, because of display limitations, may not be able to display the full name.

Bluetooth PIN The GAP establishes that a personal identification number (PIN) may be entered by the device's user, to be used in the authentication process.

Discovery Modes The GAP defines three different modes for device discovery: *general discoverable* (continuously available to other devices), *limited discoverable* (available only for a limited period of time or under specific conditions), and *nondiscoverable* (not available to other devices).

Connectivity Modes The GAP defines policies for establishing device communications, using one of two modes: *connectable* (will respond to paging) or *nonconnectable* (will not respond to paging).

Pairing Modes Pairing is an initialization procedure where two devices establish a common link key for subsequent authentication; there are two different pairing modes, *pairing* (accepts pairing) or *nonpairing* (doesn't accept pairing).

Security Modes The GAP defines three different security modes for Bluetooth devices. These modes include *security mode 1* (no security barrier), *security mode 2* (includes a security barrier at the L2CAP layer), and *security mode 3* (incorporates a security barrier at the Link Manager layer).

Idle mode procedures The GAP defines several idle mode procedures for Bluetooth devices, including *general inquiry* (provides device address, clock, class, and page scan mode for general discoverable devices), *limited inquiry* (provides the same information for limited discoverable devices), *name discovery* (provides device name only), and *device discovery* (provides device address, clock, class, page scan mode, and device name).

Bonding The GAP provides for two types of relationships between Bluetooth devices, based on a common link key (called a *bond*): *dedicated bonding* (devices create and exchange a common link key—and no other information) and *general bonding* (devices go through full channel and connection establishment procedures).

Establishment Procedures The GAP defines the procedures necessary to establish *links*, *channels*, and *connections* between two Bluetooth devices.

By insisting that all devices conform to the Generic Access Profile, basic interoperability between all Bluetooth devices is ensured—regardless of the individual application(s) supported by each device.

This profile makes use of the following protocols:

- OBEX
- TCS-BIN
- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.16 details the GAP protocol stack.

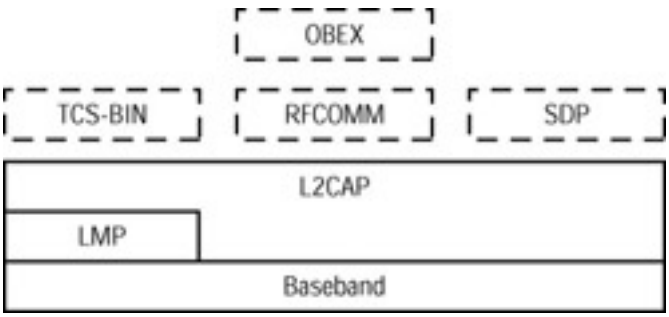

Figure 8.16: Protocol stack for the Generic Access Profile

Service Discovery Application Profile (SDAP)

As discussed in Chapter 7, service discovery is the process by which Bluetooth devices can locate, retrieve information about, and make use of services registered in other Bluetooth devices. The Service Discovery Application Profile (SDAP) defines a standard method for

performing service discovery, using the Bluetooth Service Discovery Protocol (SDP). Like the GAP, the SDAP is designed to be incorporated into virtually every Bluetooth device.

This profile makes use of the following protocols:

- SDP
- L2CAP
- LMP
- Baseband

Interestingly, the SDAP does not describe how service discovery is to be performed; it relies on the SDP for that. Instead, the SDAP describes how SDP should be used within an application, and how that application should behave during the service discovery process.

In Bluetooth terminology, a device can be either *local* or *remote*. The device that initiates the service discovery process is labeled as the local device; the device that responds to the service inquiries is the remote device. This process puts the local device in the role of the server in a client/server process, as the remote device is now charged with "serving" information about itself to the initiating device. The result is that, as you can see in Figure 8.17, the protocol stack for the local device is slightly different from the protocol stack for the remote device. (Only the local, or client, device uses the Service Discovery Application.)

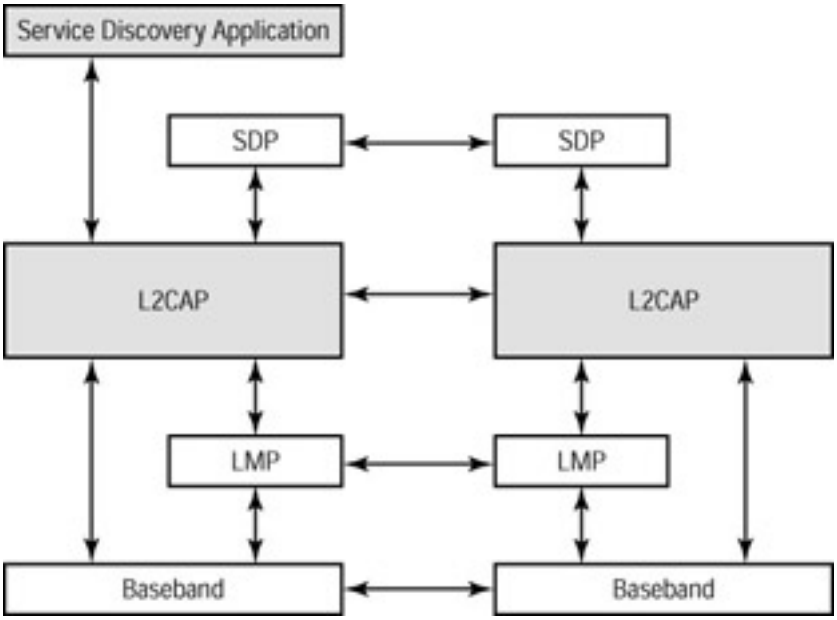

Figure 8.17: Local and remote protocol stacks for the Service Discovery Application Profile

Serial Port Profiles

The serial port profiles—sometimes called the *transport* profiles—define specifications for applications that must transfer data from one device to another, typically utilizing the RS-232 serial protocols historically used by computing devices.

Serial Port Profile (SPP)

The Serial Port Profile (SPP) was written primarily to implement the Cordless Desktop usage model, although it is incorporated as part of any profile that must access a computing device via the serial port. As such, it defines peer device roles for serial communication. (In this profile, the master/slave relationship doesn't exist; all devices are equal where serial communications are concerned.)

This profile makes use of the following protocols:

- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

A key component of the SPP is the RFCOMM protocol. RFCOMM is a simple transport protocol that emulates the RS-232 serial port; it is used to transport user data, modem control signals, and general configuration commands. Figure 8.18 shows the protocol stacks for two devices emulating a serial cable connection.

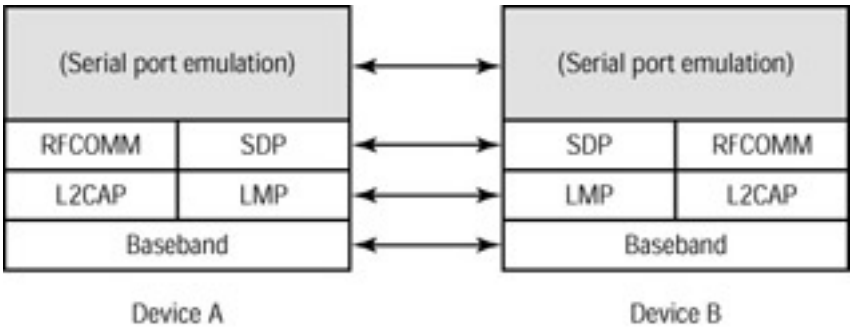

Figure 8.18: Protocol stacks for the Serial Port Profile

Establishing a serial connection via Bluetooth is a relatively simple operation. In most cases, it should go something like this:

1. The local device's SDP queries the remote device for its server channel number.
2. The remote device responds with its server channel number.
3. Any necessary authentication takes place.
4. An L2CAP connection is established.
5. An RFCOMM connection is established on the server channel.

General Object Exchange Profile (GOEP)

The General Object Exchange Profile (GOEP) defines how Bluetooth devices implement the usage models that incorporate some form of data transfer—such as the File Transfer, Automatic Synchronizer, and related models. The GOEP is also incorporated in other profiles, as it defines the interoperability requirements for those profiles that use Object Exchange (OBEX) capabilities.

Note The GOEP is grouped with the SPP because most data transfers involve computing

devices and would normally utilize an RS-232 serial connection.

The GOEP makes use of the following protocols:

- OBEX
- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

This profile, like the SDAP (and unlike most other Bluetooth profiles and operations), operates on a client/server model, rather than a peer-to-peer model. The device that initiates the connection is defined as the client, while the other device is identified as the server. Once this relationship has been established, the GOEP provides for three main operating features:

Establishing an OBEX Session

This feature is used to establish an Object Exchange session between a client and a server device.

Pushing a Data Object

This feature is used if data needs to be transferred from the server device to the client device.

Pulling a Data Object

This feature is used if data needs to flow in the other direction—in other words, to be transferred from the server to the client device.

As you can see in Figure 8.19, both the client and the server devices share the same protocol stack.

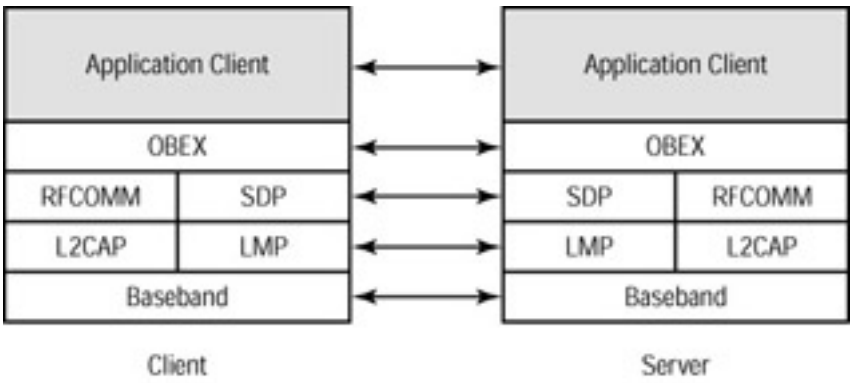

Figure 8.19: Protocol stack for the General Object Exchange Profile

Telephony Profiles

The profiles in the telephony group are all based, to one extent or another, upon general telephony functions. With the exception of the Fax Profile, these profiles all incorporate the

transmission of voice signals, and are likely to be widely used in Bluetooth devices manufactured by telecommunications companies.

Cordless Telephony Profile (CTP)

The Cordless Telephony Profile (CTP) was written specifically to implement part of the Three-in-One Phone usage model. (The other component of the Three-in-One Phone is implemented in the Intercom Profile.) This profile enables you to use a cordless handset to make calls via a voice base station to the public switched telephone network (your local phone service provider), and to connect directly to a cellular phone network.

The CTP makes use of the following protocols:

- TCS-BIN
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.20 shows the required protocol stack for the CTP. As noted in the figure, the audio stream for this profile is directly connected to the Baseband protocol, bypassing the normal L2CAP protocol.

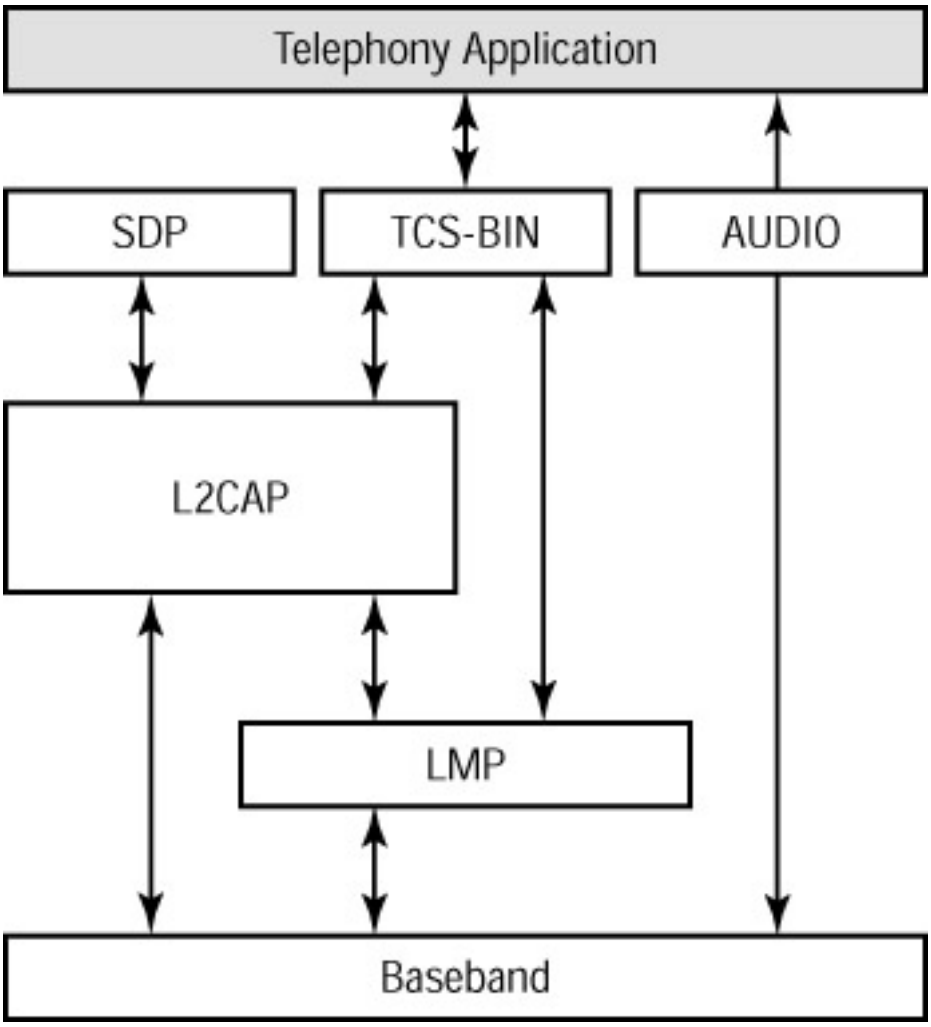

Figure 8.20: Protocol stack for the Cordless Telephony Profile

Note The CTP uses the exact same protocol stack as does the Intercom Profile, discussed next.

The CTP defines the following features that are available to all devices implementing cordless telephony:

Calling Line Identification Presentation (CLIP) CLIP (aka Caller ID) enables users to view the phone number of the calling party before answering the call.

Call Information This feature enables the device to provide additional information about the call while the call is in process, such as call duration.

Connection Management Connection management enables devices to request and/or accept non-voice connections for the purpose of enabling TCS-BIN procedures.

DTMF Signaling This feature enables a device to send a DTMF signal over an external network, to call another party.

Incoming External Call This feature enables the device to accept calls originating from an external network.

Initialization This feature enables the device to gain access rights to an external network, via a gateway.

Intercom Call This feature (utilized in the Intercom Profile) enables a device to place and receive calls directly from other devices without accessing an external phone network.

Multi-Terminal Support This feature enables a gateway to handle multiple active terminals (phone devices).

On Hook This feature enables a device to terminate a call. (Part and parcel of every telephone, of course, but a new feature to wireless headsets.)

Outgoing External Call This feature enables a device to place a call on an external telephone network, through a gateway.

Post-Dialing This feature enables a device to send dialing information after the outgoing call request setup message has been sent.

Register Recall This feature activates the "flash hook" feature common on most of today's telephones.

With the exception of Post-Dialing, Multi-Terminal Support, and Call Information (which are optional features), all these features are mandatory on any Bluetooth telephone incorporating the Cordless Telephony Profile.

Intercom Profile (IntP)

The Intercom Profile (IntP) was written—along with the Cordless Telephony Profile—to implement the Three-in-One Phone usage model. It explains how a cordless telephone handset can connect directly to other handsets as either a walkie-talkie or a handset extension.

Note The rather unusual acronym for the Intercom Profile (IntP) was used because the more obvious *IP* acronym was already used for the computer-related *Internet protocol*.

The IntP makes use of the following protocols:

- TCS-BIN
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.21 shows the required protocol stack for the Intercom Profile. As you can see, this is the same protocol stack used in the Cordless Telephone Profile. The IntP also supports the exact same feature set supported in the CTP.

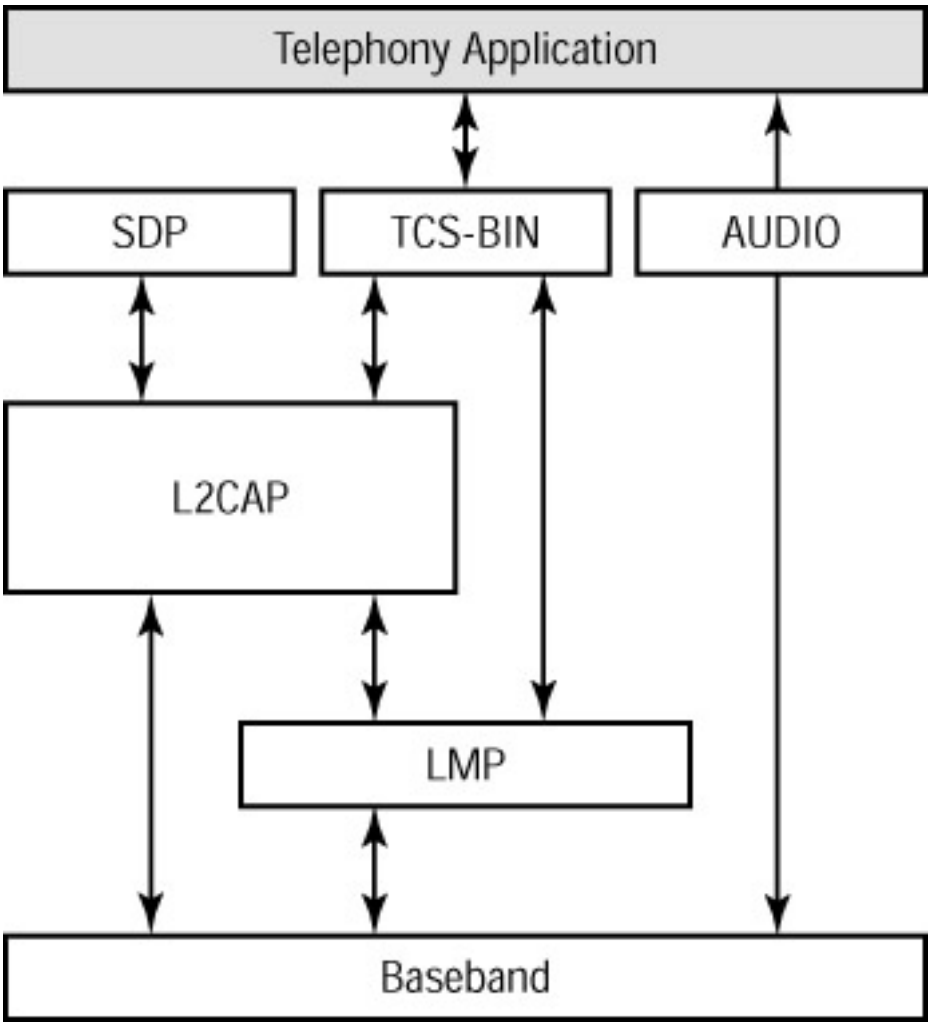

Figure 8.21: Protocol stack for the Intercom Profile

Headset Profile (HSP)

The Headset Profile (HSP) was written to implement the Ultimate Headset usage model, and enables the wireless connection of a headset (containing both speaker and microphone) to a telephone handset or base station or to a personal computer.

The HSP makes use of the following protocols:

- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

New to this profile is the capability to send AT commands and receive result codes. This capability is necessary for incoming calls to be answered and terminated by the headset without physically manipulating the telephone handset or base station.

Figure 8.22 shows the required protocol stack for the Headset Profile. As with other telephony profiles, the audio stream is directly connected to the Baseband protocol, bypassing the L2CAP layer.

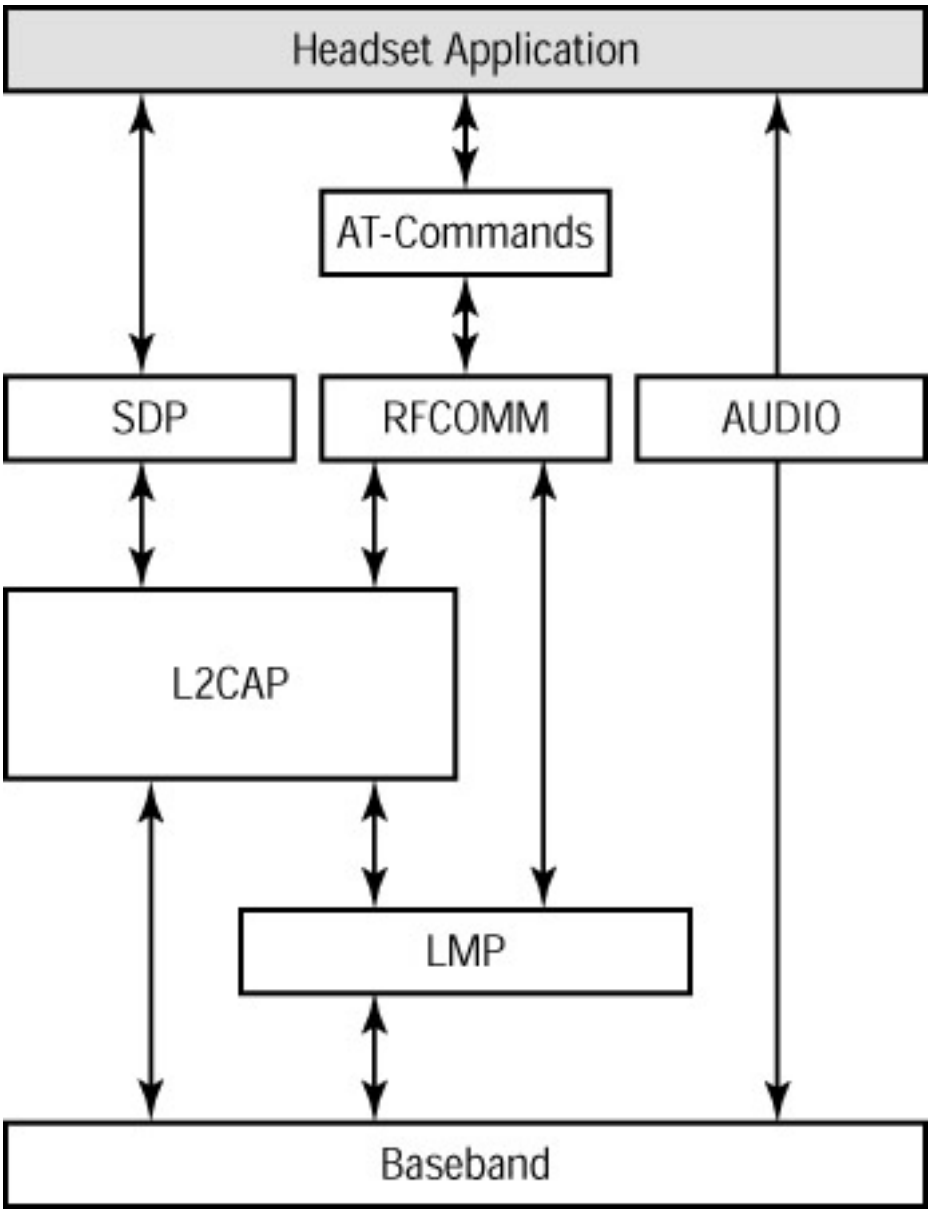

Figure 8.22: Protocol stack for the Headset Profile

Networking Profiles

There are three profiles in the networking category—the LAN Access, Dial-Up Networking, and Fax profiles. Each of these profiles is built on the Serial Port Profile, and the LAN Access and Dial-Up Networking profiles also incorporate ingredients of the Cordless Telephony Profile (even though they're primarily intended for data transfer).

LAN Access Profile (LAP)

The LAN Access Profile (LAP) was written to implement the LAN Access usage model. It is also used for the LAN-based implementation of the Internet Bridge model.

In this profile, multiple data terminals use a LAN access point as a wireless connection to a local area network. Once connected, the data terminals operate as if they were connected to

the LAN via traditional dial-up networking, and can access all of the services provided by the network.

Protocols used in this profile include:

- TCP
- UDP
- IP
- PPP
- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.23 shows the required protocol stack for the data terminal (remote Bluetooth device) part of the LAP.

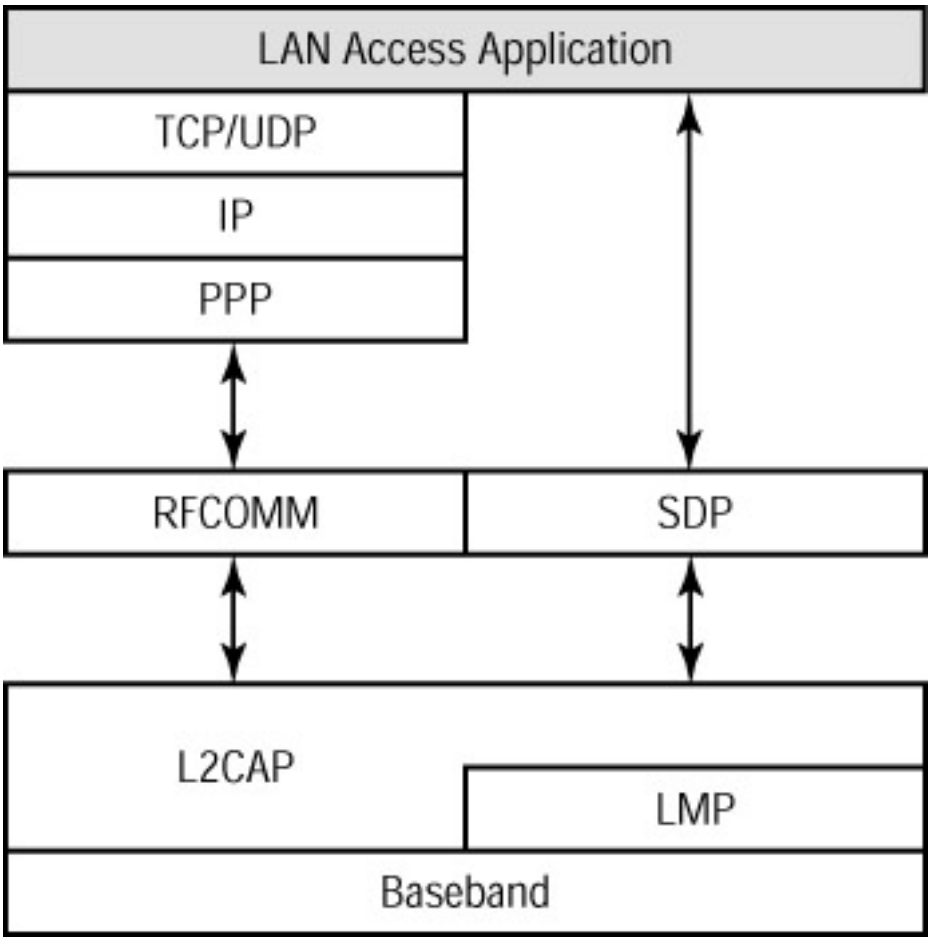

Figure 8.23: Protocol stack for the LAN Access Profile

Dial-Up Networking Profile (DUNP)

The Dial-Up Networking Profile (DUNP) was written to implement the dial-up component of the Internet Bridge usage model. In this profile, a mobile phone or cordless modem acts as a

modem for a personal computer or PDA, providing dial-up networking capabilities without a dedicated physical connection.

The protocols used in the DUNP include:

- AT Commands
- PPP
- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.24 shows the required protocol stack for the DUNP. This is actually a two-piece protocol stack; the AT commands necessary to control the mobile phone/modem are one part of the stack, while the PPP commands necessary to transfer data packets form the second part.

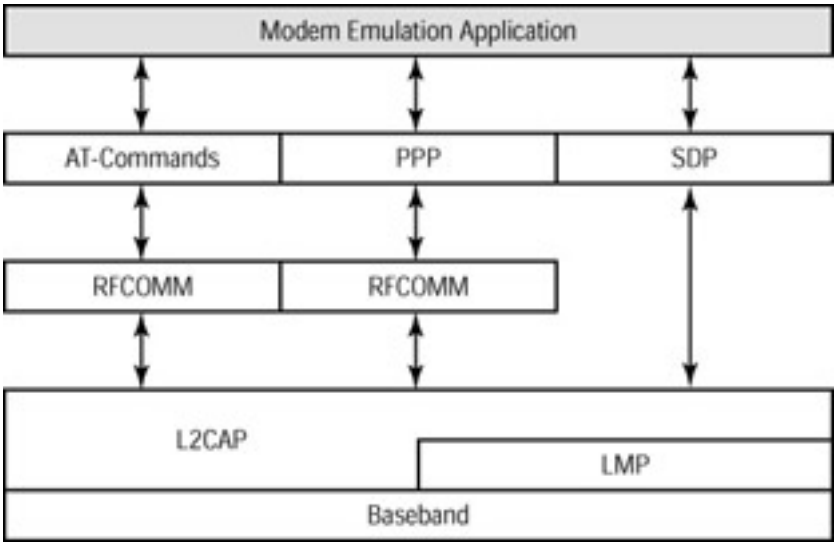

Figure 8.24: Protocol stack for the Dial-Up Networking Profile

Fax Profile (FaxP)

The Fax Profile (FaxP) is best viewed as a subset of the Dial-Up Networking Profile. As there are slight differences between faxing and transmitting/receiving computer data (think of the slight differences between a fax/modem and a straight data modem), a separate profile was deemed necessary—even though the protocol stacks look identical.

The protocols used in the FaxP include:

- AT Commands
- PPP
- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.25 shows the required protocol stack for the Fax Profile.

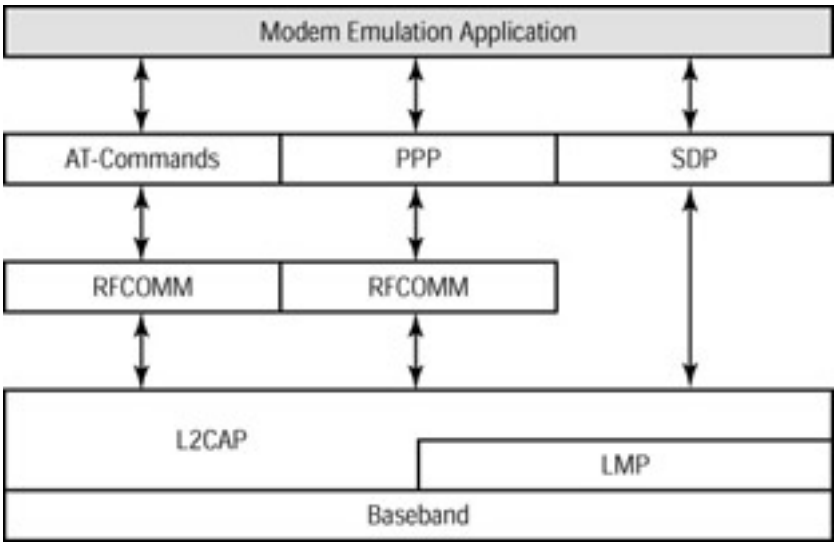

Figure 8.25: Protocol stack for the Fax Profile

Object Exchange Profiles

The three object exchange profiles all deal with transmitting and receiving data objects—typically in the form of computer files. All three profiles incorporate the Serial Port Profile, as computer files have been traditionally transmitted via a PC's serial ports.

File Transfer Profile (FP)

The File Transfer Profile (FP) was written to implement several different usage models—the File Transfer, the Forbidden Message, and the Briefcase Trick. This profile defines how to transfer data objects from one device (computer, PDA, smart phone, etc.) to another. For the purposes of this profile, objects include, but are not limited to, various types of data files (such as .doc, .xls, .txt, .ppt, .jpg, and so on), entire folders or directories of files, and streaming media files. Also included in this profile is the ability to browse the contents of files from a remote device.

Note Bluetooth engineers decided to go with a two-letter acronym (FP) for a three-word phrase (File Transfer Profile) because the more obvious *FTP* acronym was already used for the Internet-based *file transfer protocol.*

As with several of the other profiles, there is no peer-to-peer relationship in the FP; instead, the device initiating a transaction is identified as the client, and the other device is set as the server. In this client/server relationship, the server device "serves" data (in the form of files) to the client device.

There are several distinct operations defined by the FP, all familiar to the average computer user. These operations include:

- Pulling (downloading) files and folders from the server
- Pushing (uploading) files and folders to the server
- Browsing and navigating folders on the server

- Deleting files and folders on the server
- Creating new folders on the server

The FP utilizes the following protocols:

- OBEX
- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.26 shows the required protocol stack for the File Transfer Profile.

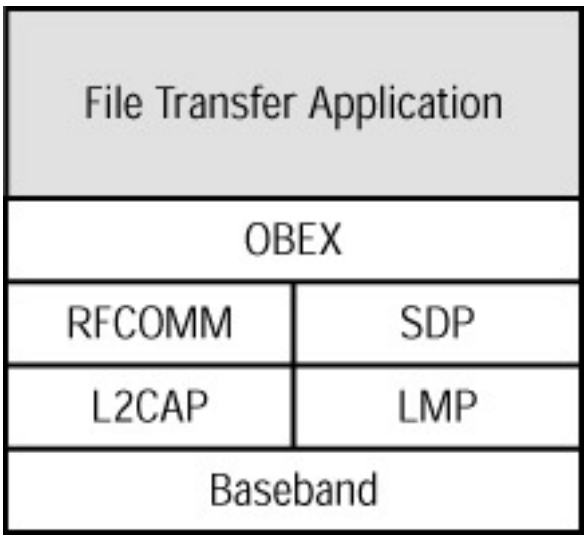

Figure 8.26: Protocol stack for the File Transfer Profile

Synchronization Profile (SP)

The Synchronization Profile (SP) was written to implement the Automatic Synchronizer usage model. This profile provides device-to-device synchronization of the type of information typically found in PIM software, including names, addresses, phone numbers, e-mail addresses, calendars, appointments, tasks, and notes. The synchronization process requires this information to be transferred and processed by various types of devices—including PDAs, computers (both portable and desktop), and mobile phones—utilizing a common protocol and data format.

The SP is an adaptation of the Infrared Object Exchange (IrOBEX) protocol standardized by the Infrared Data Association (IrDA) and incorporated into many of today's PDAs and laptop computers. As such, it embraces a client/server relationship between two devices, and utilizes the previously developed Infrared Mobile Communications (IrMC) client and server applications.

The protocols utilized by the SP include:

- IrMC
- OBEX

- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.27 shows the required protocol stack for the Synchronization Profile.

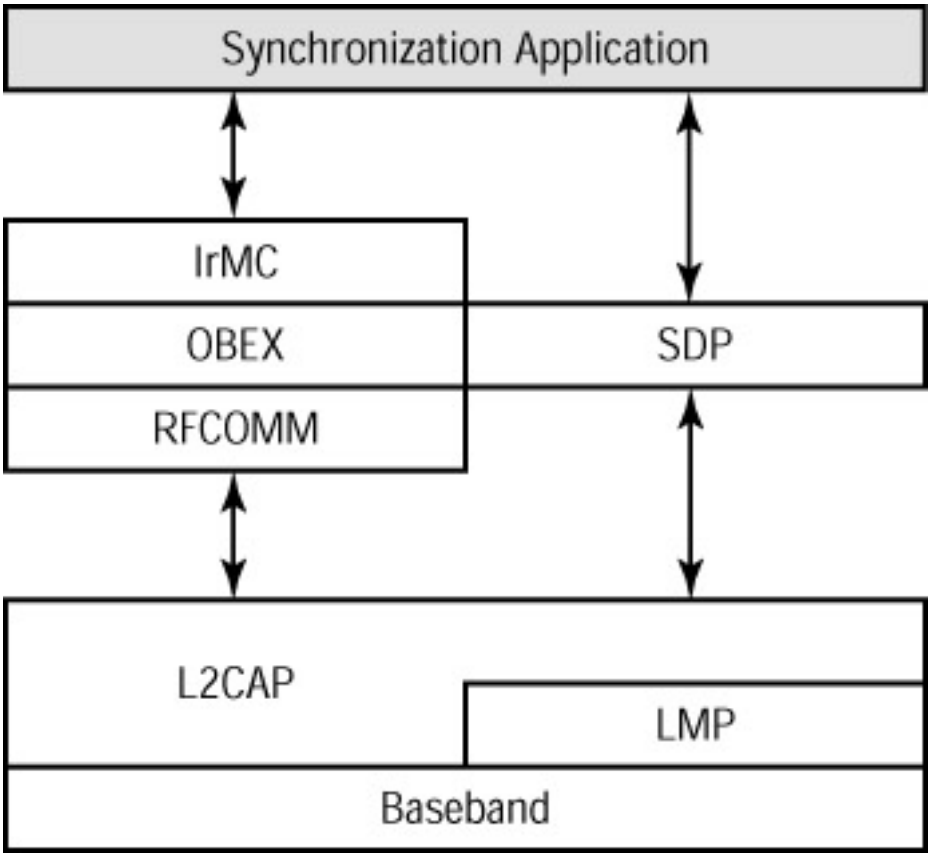

Figure 8.27: Protocol stack for the Synchronization Profile

Object Push Profile (OPP)

The final Bluetooth profile, the Object Push Profile (OPP), was written to implement a specific subset of the File Transfer usage model—the simple act of exchanging digital information (data objects) between two devices. This profile addresses the ability to both push data from one device to another and to pull data from the other direction. Simultaneous pushing and pulling (a data exchange) is also addressed.

The most typical use of the OPP is to exchange digital business cards (in the vCard format). This operation requires user initiation; in this profile, data exchange is *not* automatic.

The three key functions supported by the OPP are:

Object Push This function initiates a process that pushes one or more data objects from the client (the initiating device) to the server.

Business Card Push This function initiates a process that pulls one or more data objects from the server to the client (the initiating device).

Business Card Exchange This function initiates a process that transfers data objects simultaneously between the two devices.

The protocols utilized in the OPP include:

- OBEX
- RFCOMM
- SDP
- L2CAP
- LMP
- Baseband

Figure 8.28 shows the required protocol stack for the Object Push Profile.

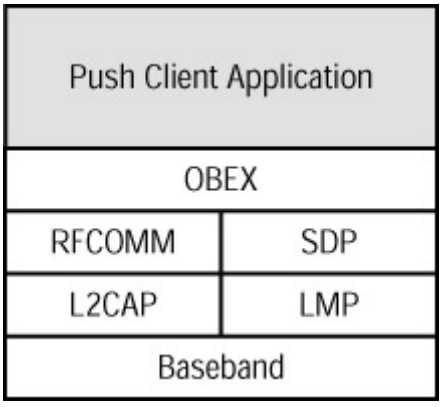

Figure 8.28: Protocol stack for the Object Push Profile

Chapter 9: Competitive and Complementary Technologies

Bluetooth isn't the only wireless connectivity solution available today. There are several other technologies that are being pushed for wireless connections and networking. Some of these technologies are direct competitors with Bluetooth; some are sufficiently different (and serve sufficiently different applications) as to coexist with Bluetooth, and even to complement Bluetooth's applications.

This chapter examines the major competing and complementary wireless technologies, and shows how each compares to Bluetooth.

Infrared

The most directly competitive technology to Bluetooth is *infrared* (IR). The Infrared Data Association (IrDA) has established a standard for infrared connections (called the IrDA standard) that has been adopted by more than 160 different companies and is widely used today. If you have a PalmPilot or other PDA, chances are you've used its IR port to connect

and synch to your PC, or to beam business card data to and from another PDA. In fact, IR capability can be found on more than 150 million computing devices, with sales of such devices growing at a 40% annual rate.

However, as widely accepted as it is, IrDA has several significant drawbacks—not the least of which is its narrow-angle line-of-sight limitation. Because of this, many consider Bluetooth to be the natural replacement for IrDA technology.

How IrDA Works

IrDA uses infrared light—*not* radio waves—to transmit data signals from one device to another. Since light cannot pass through solid objects, devices connecting via IrDA have to be in direct sight of one another. A further limitation is that the range is limited and the angle of contact is relatively narrow; any signals beyond 3 feet (1 meter) and outside of a 30-degree cone won't be received.

These technical constraints pretty much limit IrDA to direct one-to-one connections, as shown in Figure 9.1. (You can't use IrDA to connect multiple devices in any kind of network.) Typical uses of IrDA are to connect two PDAs together, to connect a PDA to a PC, or to connect other fixed peripherals to a PC. Remember, the two devices have to be relatively close together—with nothing between them—and essentially locked into place. Moving a device is likely to interrupt the infrared connection.

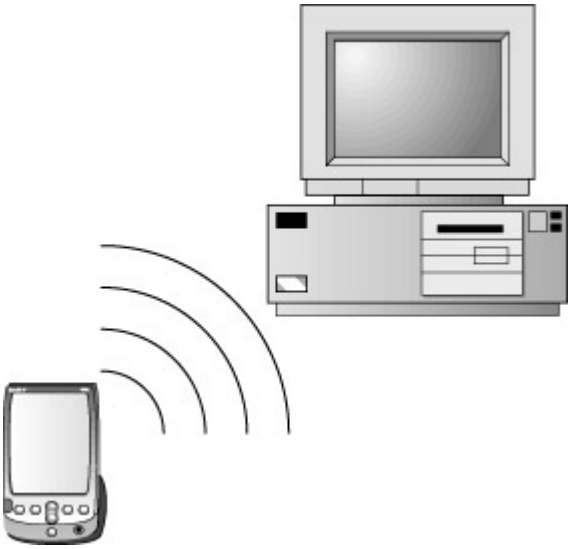

Figure 9.1: A typical IrDA connection

Despite these limitations, IrDA has several things going for it. First, it's fast. Standard IrDA transmits data at a maximum throughput of 4Mbps, while the new *Fast Infrared* (FIR) standard defines a 16Mbps transmittal rate. Bluetooth's 1Mbps maximum throughput pales in comparison.

Note A slower IR standard, designed to transmit data via serial connections, is called SIR (Serial Infrared). Its maximum data rate is 115Kbps.

Second, the very limitations of the technology (line-of-sight, range, and angle) make IrDA a very secure way to transmit data. Unless you're close and in the cone, you can't pick up the

infrared signals at all. And, because the signals are light-based rather than radio wave–based, interference from other devices is a moot point. (In addition, IrDA requires no FCC regulation.)

What kinds of devices utilize an IrDA connection? The list is long and growing:

- Personal digital assistants (PDAs)
- Handheld, notebook, and desktop computers
- Printers
- Modems
- Digital still cameras
- Scanners
- Copiers
- Fax machines
- Watches
- Hands-free car kits
- Medical and industrial equipment

IrDA backers claim that future iterations of the technology—utilizing up to a 60-degree connection angle—will make it suitable for cordless telephones, joysticks, mice, and the like. One would have to question whether even a 60-degree angle is wide enough for some of these applications. That said, utilizing IrDA for ATM/credit card transactions seems feasible, as does connecting PCs and data projectors via infrared.

Although it's not widely used, a component of the Infrared Mobile Communications (IrMC) specification defines a manner for transmitting full-duplex voice data over an IrDA link. Bandwidth for voice communications is set at 115.2Kbps, but transmitting voice and data simultaneously is not possible. A typical use of this voice capability is a mobile phone's hands-free kit in a car.

If a device does not have an IrDA port built in, adding an IR adapter is relatively easy and inexpensive. In fact, the manufacturing cost per device (less than $2) is the lowest of all the wireless technologies we'll examine in this chapter.

Note You can learn more about IrDA at the Infrared Data Association's Web site, at www.irda.org.

Advantages of IrDA

IrDA is an ideal wireless replacement technology—as long as the two devices are positioned close together. It's also the best technology to transmit secure data.

Here then, are the chief advantages of IrDA:

- Fast (4Mbps)
- Inexpensive ($2 or less per device)
- Low power consumption
- Secure
- Not susceptible to RF interference
- Widely used

Disadvantages of IrDA

IrDA is *not* a good technology for local area networking. The speed isn't nearly as fast as Ethernet or 802.11 wireless, and the connection limitations are too great. It also isn't good for public ad hoc connections—the kind of connections that Bluetooth excels at. It's pretty much limited to short-range point-to-point connections, such as replacing the cables between a PC and its peripherals.

The chief drawbacks of IrDA, then, are:

- Limited range (3 feet)
- Limited connection angle (30 degrees)

How IrDA Compares with Bluetooth

Both IrDA and Bluetooth can be used to replace cables between computing and communications devices. IrDA does it faster, but Bluetooth does it with more flexibility and range. Given that Bluetooth's 1Mbps transmission rate is fast enough for printers, scanners, keyboards, mice, and the like (pretty much everything except video—you'll still need the cable between your PC and your monitor), IrDA's added speed doesn't offset its placement drawbacks. In the cable-replacement market, Bluetooth is the likely winner.

In terms of connecting a computing device to a wired LAN, IrDA's 4Mbps (soon to be 16Mbps) speed gives it a marked advantage over Bluetooth's 1Mbps connection. While Bluetooth is adequate for printing files and other occasional applications, full LAN connection at 1Mbps is just too slow. Score one for IrDA.

When it comes to creating ad hoc public connections—such as sending and receiving e-mail while walking through an airport—Bluetooth is the clear winner. You simply can't do this with today's infrared technology; the range and angle limitations are prohibitive.

Ad hoc *private* connections, however, are a different thing. If you're using a "smart" credit card or other device to beam payment information to a high-tech cash register at your local retail store, both IrDA and Bluetooth will do the job adequately. In fact, IrDA's more secure technology might give it a slight advantage over Bluetooth's RF broadcasting.

Another scenario where IrDA outshines Bluetooth is the exchange of business card data. This typically happens in a crowded room, in a hotel lobby, on the show floor of a convention or trade show, or some other location where dozens or hundreds of other users are in close proximity. Using Bluetooth to exchange data with one other person—out of hundreds, all carrying PDAs and many trying to do the same thing—is dicey; even with the built-in security constraints, it's tough to pick that one guy out of the crowd and make sure that he's the only one that gets your data. With IrDA, it's a simple matter of pointing and clicking; because of the narrow transmission angle and short transmission range, it's easy to limit your exchange to a single device.

All that said, it is likely that—despite the best efforts of the Infrared Data Association—Bluetooth will replace IR for the majority of relevant applications, especially those involving cable replacement.

HomeRF

HomeRF is a wireless networking technology designed expressly for use in home and small business networks. Like Bluetooth, HomeRF uses the 2.4GHz RF band—hence its name (RF in the home).

HomeRF was developed by the HomeRF Working Group, a group of businesses led by Proxim, which is partly owned by Intel, which is also a promoter member of the Bluetooth SIG. (This is just one example of the multiple bets being placed by some of the leading hardware manufacturers.) Other members of the Working Group include Cayman Systems, Compaq, Motorola, and Intel proper—all of whom currently have HomeRF networking products on the market.

How HomeRF Works

The HomeRF Working Group based the HomeRF technology on the Shared Wireless Access Protocol (SWAP). HomeRF/SWAP provides for the following transmission channels:

- Six voice channels based on the Digital Enhanced Cordless Telephone (DECT) standard
- One data channel, based on the IEEE 802.11 wireless Ethernet specification

The initial HomeRF/SWAP devices could transmit at a theoretical maximum of 2Mbps—although 1Mbps rates were more common. The latest version of HomeRF, however, based on SWAP version 2.0, boasts significantly faster transmission rates—up to 10Mbps, which is comparable to Ethernet or 802.11 wireless.

Like Bluetooth, HomeRF uses frequency hopping spread spectrum (FHSS) technology to reduce interference and improve security. For both 1.0 and 2.0 devices, frequency hopping takes place at 50 hops per second, at 1MHz intervals.

HomeRF is a low-priced alternative to more expensive 802.11 wireless networks (discussed next). HomeRF networks do not require dedicated access point hardware; point-to-point connections are made between devices on the network. Figure 9.2 shows the topography of a typical HomeRF network.

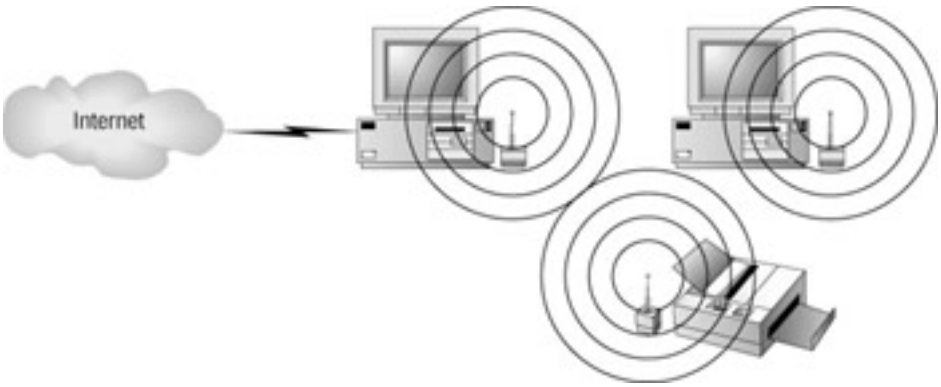

Figure 9.2: A typical HomeRF home network

The trade-off for this cost savings, however, is distance and reliability. Compared to 802.11, HomeRF connections are limited to about 50 feet, and they're really not as robust as the

connections possible under an 802.11 or Ethernet network. While these trade-offs are probably acceptable in a home or even small office environment, corporate users will no doubt prefer the more robust performance of an 802.11 wireless network.

Note You can learn more about HomeRF at the HomeRF Working Group's Web site, at www.homerf.org.

Advantages of HomeRF

HomeRF was purpose built for wireless home networks, and that's where the technology shines. For the typical home PC user, HomeRF is easy to install and configure, it works well within the home environment, and it's relatively inexpensive (when compared to 802.11).

Here, then, are the chief advantages of HomeRF:

- Fast (10Mbps with SWAP 2.0; just 1–2Mbps with SWAP 1.0)
- Less expensive than other wireless networking alternatives ($70–$200 per device)
- Easy to install
- Requires no dedicated access point
- Allows up to 127 devices per network
- Allows multiple networks in the same physical location
- Frequency hopping reduces interference with home and portable electronics

Note The more corporate-oriented 802.11 wireless technology, discussed next, is particularly susceptible to interference from just the sort of electronic devices typically found in the home environment—microwave ovens, garage door openers, cordless phones, and so on. By utilizing frequency hopping technology, both HomeRF and Bluetooth are relatively immune to signals from these types of devices. 802.11, on the other hand, uses a non–frequency hopping technology that is prone to interference from all sorts of devices. Put an 802.11 network in the home, and you'll find that its effective range is cut at least in half by all this interference; the same devices have little or no effect on HomeRF or Bluetooth connections.

Disadvantages of HomeRF

While HomeRF shines in the home, it's not quite up to par when used in a larger office or corporate environment. It also is not well-suited to simple cable-replacement applications, or to the types of ad hoc point-to-point connections that Bluetooth excels in.

That said, here are the chief disadvantages to HomeRF:

- Limited range (75–125 feet) when compared to 802.11
- Difficult to integrate into existing wired networks
- Less stable than 802.11 or Ethernet-based network connections
- High power consumption (not suitable for portable use)

How HomeRF Compares with Bluetooth

HomeRF is a good technology for small and low-load networks. It is not a good technology for larger networks or networks spread out over larger spaces, nor is it designed for portable devices or ad hoc connections.

What this translates to is a type of peaceful coexistence between the HomeRF and Bluetooth technologies. You can use Bluetooth to replace the cables between your peripherals and your PC, then use HomeRF to connect your PCs to each other in a small home network. Because both technologies use frequency hopping, they shouldn't interfere with each other in any way. This type of interrelationship, shown in Figure 9.3, gives you the best of both worlds.

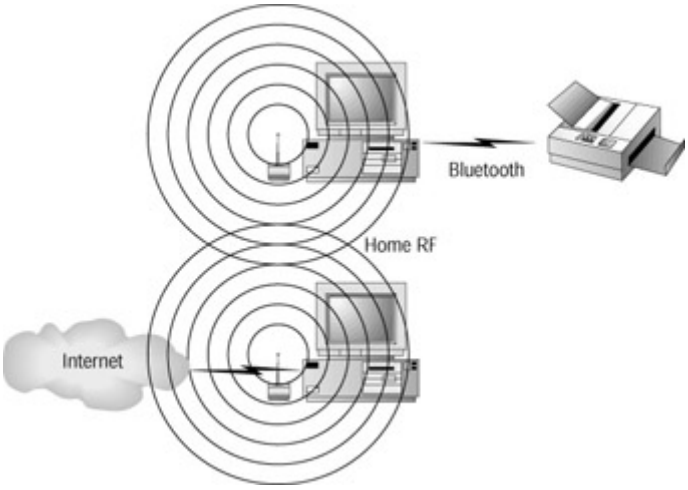

Figure 9.3: Using Bluetooth and HomeRF together

Naturally, HomeRF doesn't factor into any of Bluetooth's portable or ad hoc applications. As it's strictly a "set it up and leave it" technology, it doesn't compete with Bluetooth in any other environments.

IEEE 802.11b/Wi-Fi

The Wireless Ethernet Compatibility Alliance (WECA) has embraced a robust wireless networking technology based on a specification developed by the Institute of Electronic and Electrical Engineers (IEEE). The IEEE 802.11b specification is at the core of a technology that has been dubbed *Wi-Fi*, for *Wireless Fidelity*. Wi-Fi is targeted at corporate networks, as it is a more costly—and higher performance—technology than either Bluetooth or the somewhat competing HomeRF.

WECA is supported by a variety of hardware manufacturers—including 3Com, Apple, Cabletron, Compaq, Lucent, and Nokia—many of which are also members of the Bluetooth SIG.

How 802.11 Works

Like Bluetooth and HomeRF, 802.11 utilizes RF signals broadcast in the 2.4GHz RF band. Unlike Bluetooth and HomeRF, both of which use frequency hopping technology (officially called frequency hopping spread spectrum, or FHSS), 802.11 uses direct sequence spread spectrum (DSSS) technology. The difference between FHSS and DSSS is that where FHSS

signals hop over 79 different frequencies spaced at 1MHz intervals, DSSS signals are fixed within a 17MHz channel (three of which are available in the 2.4GHz band), but covered with a lot of engineered "noise" to reduce interference and improve security. Additional security is provided by the Wireless Equivalent Privacy (WEP) encryption standard, which uses 128-bit encryption technology.

One upshot of using DSSS instead of FHSS is that 802.11 is fast, with up to 11Mbps data transmission rates. In this respect, 802.11 is an acceptable substitute for Ethernet, which has similar transmission speeds. The downside of using DSSS is that 802.11 is more susceptible to interference from other devices using the 2.4GHz band, especially the types of devices typically found in a home environment—cordless phones, garage door openers, microwave ovens, and the like.

As you can see in Figure 9.4, an 802.11 network requires the use of access point (base station) hardware, which can add to the cost of the network. (Base stations cost anywhere from $250 to more than $1200.) An access point is the receiver/transmitter unit that remote devices access to connect to the network. Most of these access point base stations include an integrated Ethernet controller, for connection to existing Ethernet networks.

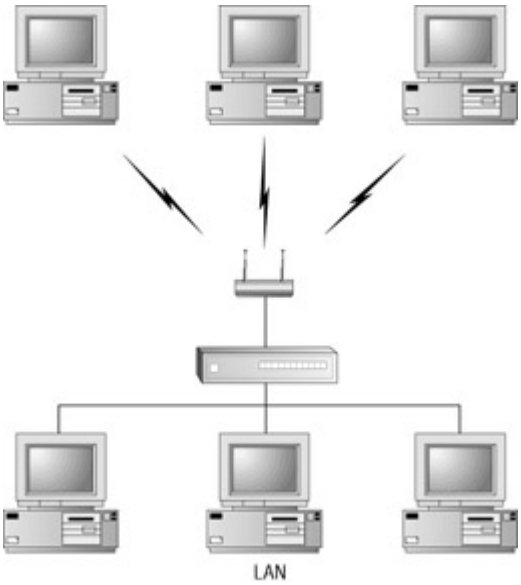

Figure 9.4: A typical 802.11 network

With the added complexity of access points and LAN configuration, an 802.11 network is not a "plug and play" type of solution. In fact, 802.11 can be a difficult technology to set up and use—with many of the same operational challenges also found in Ethernet-based networks. The trade-off for this cost and complexity is speed, reliability, and increased range—up to 300 feet, or even further in open areas.

In fact, the best way to think of 802.11 is as Ethernet without the wires. 802.11 networks share the same benefits (speed and reliability) and liabilities (cost and management) as do wired Ethernet networks.

To that end, 802.11 is a standard strictly for data transmissions. 802.11 does not handle voice signals or offer any form of telephony support. While it can be used for ad hoc connections, its real strength is in replicating dedicated Ethernet networks, but without wires.

Note It *is* possible to transmit voice signals over a data line, utilizing voice-over-IP processes. This is the same technology that enables voice communication over the Internet, but the results are of lesser quality than traditional voice calls.

Ongoing technological developments promise to increase the speed and ease-of-use of networks based on this IEEE standard. Engineers are said to be working on a new wireless standard based on the upcoming IEEE 802.11a (not b) specification, which is said to use the 5GHz RF band to deliver speeds up to an incredible 54Mbps.

Note You can learn more about 802.11/Wi-Fi at WECA's official Web site, at www.wi-fi.net.

Advantages of 802.11

802.11/Wi-Fi shines as a wireless network for corporate and campus environments. It's fast and robust, and completely compatible with existing Ethernet networks.

The chief advantages, then, of 802.11/Wi-Fi include:

- Fast (11Mbps)
- Robust and reliable connections
- Long range (300 feet or more)
- Easily integrated into existing Ethernet networks

Disadvantages of 802.11

As good as 802.11 is at the office, it isn't quite as suitable in a home environment. Its cost is a little too high, it's a bit too complex, and it's a tad too susceptible to interference from other devices around the house. These drawbacks don't rule out 802.11 for home use—in fact, some companies are actively pushing Wi-Fi for the home—but, at least currently, they place 802.11 at a competitive disadvantage to purpose-designed HomeRF products.

Another major issue affecting the adoption of 802.11 is that this technology has been plagued, in the past, by compatibility issues. It seems that different manufacturers read the specifications in different ways, so that an 802.11 network card by one manufacturer might not work on a 802.11 network built by another manufacturer. In fact, this compatibility issue was behind the formation of WECA and the establishment of the Wi-Fi standard. Just as the Bluetooth SIG tests Bluetooth devices for compliance with the Bluetooth Specification, WECA now tests 802.11 devices for interoperability; devices passing WECA testing can display the Wi-Fi label.

This said, the primary disadvantages of 802.11/Wi-Fi are:

- High cost
- Requires physical access points
- Difficult to configure and maintain
- No voice or telephony support
- Possible compatibility issues between devices from different manufacturers

How 802.11 Compares with Bluetooth

802.11 is a good technology for large, high-speed networks. Because of its cost and operational complexity, it is less suitable for smaller home networks and the type of ad hoc networks that Bluetooth addresses.

The relationship between Bluetooth and 802.11 is similar to the relationship between Bluetooth and HomeRF. It's conceivable that you would use Bluetooth to connect your peripherals to your PC, and use 802.11 technology to connect your PC to the office or campus LAN. The two technologies coexist relatively well, although there are some possible interference issues between Bluetooth and 802.11 signals. (This interference affects the 802.11 connection only, slowing it down slightly while Bluetooth transmissions are active).

While WECA is pushing 802.11 as a public networking technology (putting 802.11 access points in coffeehouses, for example), it's less well suited to these applications than is Bluetooth. 802.11 doesn't function well on an ad hoc basis (it still requires a relatively complex setup routine), however; establishing ad hoc connections (both public and private) is one of Bluetooth's inherent strengths.

It's possible to conclude that 802.11 and Bluetooth are both complementary and competitive. It will be interesting to see if and how these technologies learn to live with each other over the next few years.

Where Bluetooth Fits

As discussed throughout this chapter, Bluetooth both competes with and complements existing RF and IR technologies. Table 9.1 shows how they stack up, head-to-head, in terms of key features and specifications.

Table 9.1: Comparison of Wireless Technologies

	Bluetooth	**HomeRF**	**IEEE802.11b/ Wi-Fi**	**IrDA**
Technology	RF	RF	RF	Infrared
Primary Use	Cable replacement and ad hoc device-to-device connections	Home or small office LANs	Corporate or campus LANs	Cable replacement and ad hoc device-to-device connections (narrow angle)
Maximum speed	1Mbps	10Mbps	11Mbps	4Mbps
Range	30 feet	150 feet	300 feet	3 feet
Connects through walls	Yes	Yes	Yes	No
Connection angle	360 degrees	360 degrees	360 degrees	30 degrees
Data support?	Yes	Yes	Yes	Yes
Native voice/telephony support?	Yes	Yes	No	Yes

Table 9.1: Comparison of Wireless Technologies

	Bluetooth	**HomeRF**	**IEEE802.11b/ Wi-Fi**	**IrDA**
Frequency sharing	FHSS	FHSS	DSSS	
Requires separate access points (base stations)?	No	No	Yes	No
Susceptibility to RF interference	Medium	Medium	High	None
Power requirements	Low	High	High	Low
Manufacturing cost per device	$15 now; dropping to $5	$70–$120	$100–$300	$2

Who Does What Best

After absorbing all the specs and debating all the pros and cons, here's the best way to position Bluetooth and the other technologies:

- Bluetooth is best used as a cable-replacement technology, and to establish both private and public ad hoc communications between two or more devices (within a 30-foot range). It does not have the range or bandwidth required for wireless LAN applications.
- IrDA is best used as a cable replacement technology where close line-of-sight proximity between devices exists. It does not have the range or bandwidth required for wireless LAN applications, the wide-angle capability required for ad hoc public connections, or the voice capability required for home applications.
- HomeRF is best used in home networking applications, where it has been designed to carry voice and data signals with minimal interference. It does not have the range or robustness necessary for corporate LAN applications.
- 802.11 is best used in corporate and campus LAN applications. It does not currently have adequate interference protection or voice capability for home applications.

Picking a Winner

Is there overlap between these four technologies?

Yes.

Is it possible that one or more of these technologies will eventually be deemed irrelevant by the marketplace?

Also yes.

So which of these technologies will be the winners—and which will be the losers?

It's impossible to predict, of course, but one can get a sense of the trends.

For starters, if things continue on their current course, it's likely that Bluetooth will supplant IrDA for both cable replacement and ad hoc connections. Bluetooth's strengths (and massive

industry support) are, frankly, overwhelming, especially when faced with infrared's inherent line-of-sight limitations.

In addition, if 802.11/Wi-Fi can be made easier to use (and slightly lower priced), it's more than possible that Wi-Fi will become the de facto standard for all wireless networking—even in the home. Looking at it another way, it is highly unlikely that HomeRF will ever make inroads in the corporate environment. If a single standard is to emerge, that standard is likely to be Wi-Fi.

That leaves Bluetooth (for short-range and point-to-point connections) and 802.11/Wi-Fi (for wireless networks) as the likely survivors of any wireless technology wars. With many of the same companies backing both standards, expect to see future Bluetooth and Wi-Fi devices modified and marketed for better coexistence, each focused on different types of consumer applications.

Chapter 10: Challenges to Success

Bluetooth is a great technology, and seemingly delivers everything the marketplace wants—a global standard for quick and easy ad hoc connections at a low price, small size, light weight, and with low power consumption. With all this going for it, Bluetooth is a shoe-in for success—right?

In all probability, yes. But Bluetooth's success is not a given, and there are many challenges ahead before the technology reaches mass marketplace acceptance.

This chapter details some of the key challenges facing the Bluetooth wireless technology in the months and years ahead. Some of these challenges are minor and easily overcome, while others are more ominous and could present significant obstacles to success.

Performance

When looking at the performance of Bluetooth in real-world settings, two questions must be raised:

First, do actual Bluetooth products deliver on promised performance?

And, second, are Bluetooth's specs still viable in today's marketplace—especially when compared to competitive alternatives?

To answer these questions, we must examine some of Bluetooth's most controversial performance issues.

Limited Range

Class 3 Bluetooth radios (the most common class) can transmit and receive signals over a 10-meter range—about 30 feet. While this appears to be an adequate range for cable-replacement applications (and far surpasses the range of competing infrared connections), it may prove inadequate for other, more robust applications.

In particular, one must question the viability of public ad hoc connections, such as those envisioned by the Forbidden Message usage model. If you recall, one implementation of this usage model envisions users composing e-mail messages on their laptops while they're traveling on airplanes, and then having those messages send themselves automatically when the users deplane and walk by a Bluetooth access point installed in the airport terminal. The problem with this model is Bluetooth's limited range; for the usage model to work in the real world, the airport would have to install Bluetooth access points every 60 feet or so, which could prove impractical.

There are two potential solutions for this particular range-related issue. The first is to enhance the Bluetooth standard to allow for higher-power, longer-range devices. (In fact, Class 1 devices in the current standard are defined for a 100-meter range—but with a hundredfold increase in transmitting power required!—and further discussion is ongoing about increasing Bluetooth's range to 200 meters.) The second solution is to install Bluetooth kiosks in public places, where users could gather round to gain access to backend Bluetooth services. The first solution, if the power consumption issue can be worked out, might be the best; the second solution removes some of the convenience and ad hoc connection promises that many find so appealing about the Bluetooth technology.

Another range-related limitation concerns using Bluetooth to connect to wireless LANs. Of course, Bluetooth wasn't intended to be a wireless LAN technology; 802.11/Wi-Fi and HomeRF are purpose-built standards that can do the job better than Bluetooth ever can. Still, comparing Bluetooth's 30-foot range to the 150-foot range of HomeRF or the 300-foot range of 802.11, one senses a distinct competitive disadvantage inherent to Bluetooth.

In fact, 802.11's 300-foot range might give it a leg up in the public connection market. Imagine a busy city intersection, with businesses on every corner. As you can see in Figure 10.1, a single Wi-Fi access point placed inside one of those businesses could receive signals from compatible devices in the stores, bars, and coffeehouses on all four corners of the intersection. If Bluetooth technology were used for the same purpose, separate Bluetooth access points would have to be installed on every corner.

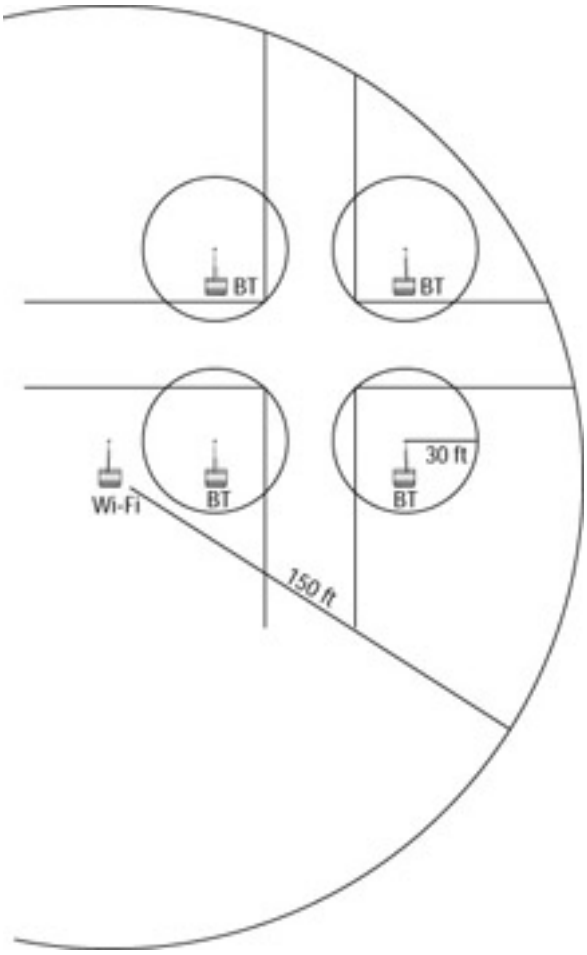

Figure 10.1: Bluetooth vs. 802.11—Bluetooth's limited range requires more access points to reach the same number of users.

In this instance, at least, Bluetooth's 30-foot range could be a serious limitation.

Limited Speed

Perhaps even more detrimental than Bluetooth's range limitation is its slow data transfer rate. As described back in Chapter 6, "A Quick Guide to the Bluetooth Technology," Bluetooth has a theoretical maximum transmission rate of 1Mbps. More practically, asymmetric data transmission is accomplished at 721Kbps, with symmetric data transmission at just 432.6Kbps. Compare these rates with the 4, 10, and 11Mbps rates of IrDA, HomeRF, and 802.11/Wi-Fi, respectively (as shown in Figure 10.2), and you see the serious handicap Bluetooth faces as a data transmission technology.

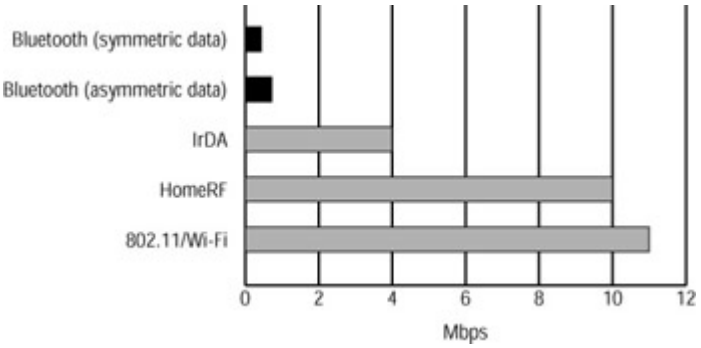

Figure 10.2: Data transmission rates compared

In practical terms, Bluetooth's data transmission rates are fast enough for many applications. Voice transmission, for example, works just fine at these rates—and is, in fact, defined in the Bluetooth Specification at just 64Kbps, which is as fast as it needs to be. 400-700Kbps is also fast enough for sending data to your printer, for receiving data from a wireless keyboard or mouse, and for beaming vCards and small files back and forth between devices. It is not, however, fast enough for sending video signals to your computer monitor, or for transferring really large files from one device to another.

More importantly, Bluetooth is decidedly not fast enough to function as the gateway to a local area network. If all you need to do is print out a file from your laptop PC, fine—but if you want to work all day as a node on your corporate network, Bluetooth won't pass muster.

To be fair, Bluetooth wasn't designed as a wireless networking technology. It was designed to replace cables (which it does well) and to create other types of ad hoc point-to-point connections (which it also does well, within its 30-foot range). 802.11/Wi-Fi and HomeRF were purpose built to handle the large data loads inherent in a local area network, and if you want a wireless LAN, those are the technologies to use—*not* Bluetooth.

The question remains, however, as to whether a sub-1Mbps technology can adequately perform all the functions detailed in the Bluetooth Specification—especially the LAN Access and Internet Bridge usage models. While a 432Kbps Bluetooth-based Internet connection sounds fast when compared to a standard 56.6Kbps modem, it's already slower than today's current home broadband technologies; both DSL and cable modems are capable of providing 1Mbps-plus connections.

In addition, Bluetooth's 1Mbps limitation could be *extremely* limiting as new technologies and applications develop in the years to come. In fact, if 802.11's ad hoc connection capabilities can be improved, it can conceivably do everything Bluetooth currently does—but 10 times faster.

Will this speed difference be a killer for Bluetooth—or will future versions of the Specification define faster transmission rates? In this matter, only time (and speed!) will tell.

Interference

One of the major problems with Bluetooth's 2.4GHz technology is that lots of other devices use this same unlicensed RF band. The list is long and disturbing, and includes everything from garage door openers and microwave ovens to competing wireless technologies such as HomeRF and 802.11/Wi-Fi.

In general, interference with normal household devices appears to be more of a theoretical problem than a real one. By utilizing relatively fast frequency hopping, most interference with other devices in the 2.4GHz band is minimized or completely eliminated. The only potential problems appear to be with microwave ovens and with devices connected to a 802.11 wireless network.

In the case of microwaves, the problem occurs because microwaves are generated at the 2.4GHz frequency, and can actually jam transmissions from any Bluetooth device operating within a few feet of an operating microwave oven. The good news is that frequency hopping minimizes this signal jamming to a substantial degree; if serious problems continue to occur, the best advice is to back away from the oven another foot or so.

In the case of 802.11 networks, a very real problem does exist—although it's the 802.11 technology that's the problem, not Bluetooth. Remember that 802.11 doesn't incorporate frequency hopping, which makes it much more vulnerable to interference than are Bluetooth or HomeRF. 802.11 devices are more likely to experience interference from household devices using the 2.4GHz band, and could be affected by nearby Bluetooth devices.

Clashing with 802.11

Concerns about interference between 802.11 networks and Bluetooth devices were first raised in a September 2000 report from the Radiocommunications Agency (U.K.). This report contained the following warning:

Interference from indoor DSSS RLANs (radio LANs) at a distance of 10 metres from [a] Bluetooth device will reduce the range of [the] Bluetooth device to 2 metres. On this basis it is possible that Bluetooth would experience difficulties operating within the vicinity of a high density DSSS RLAN system.

Further testing seems to indicate that these interference concerns were misplaced; when used in the same general vicinity, it's not the Bluetooth devices that have problems, it's the 802.11 network.

Both Symbol Technologies, Inc. (a maker of bar-code readers) and Toshiba (a Bluetooth SIG founder) have reported that, in some instances, Bluetooth devices can significantly degrade the performance of nearby 802.11 networks. This interference, however, was not as substantial as anticipated, and is not expected to seriously impact the acceptance of either technology.

Symbol's tests placed two notebook PCs equipped with Digianswer Bluetooth cards one foot apart, and set them to continuously transmit. Engineers then activated a handheld computer equipped with an 802.11 card; the 802.11 handheld was set to continuously transmit to a LAN access point positioned at a 40-foot distance.

Engineers discovered that when the 802.11 device was within 1 to 3 feet of the Bluetooth notebooks, the 802.11 network slowed down from its normal 11Mbps to about 1Mbps. Importantly, the 802.11 network didn't shut down; data still got through, albeit at much slower rates. The Bluetooth connections were not impacted to any great degree.

Continuing the test, moving the 802.11 device 3 to 6 feet away from the Bluetooth devices dramatically improved performance of the 802.11 network. At this distance the 802.11 connection experienced some degradation, but nothing as severe as before. Beyond 6 feet, there was no noticeable interference.

In the words of Barry Issberner, vice president of business development at Symbol, "It's not a big issue."

Toshiba's tests were similar, and with similar results. Toshiba engineers reported "some degradation," but noted that the two types of wireless links can run acceptably in the same area.

The Two-in-One Solution

Perhaps the most important statement about the coexistence of these two technologies comes from those companies that are supporting both standards. Any company—such as IBM—that invests in both Bluetooth and 802.11/Wi-Fi has a vested interest in making the two technologies work well together.

Some companies are even working on PC accessories that incorporate both Bluetooth and 802.11 on a single card. Surely any device that is purpose built to support both technologies will be designed to do so in a way that minimizes or eliminates any interference issues.

Two companies working on such a device are Intersil, a manufacturer of 802.11 chips, and Silicon Wave, a manufacturer of Bluetooth radio chips. Intersil and Silicon Wave are working together on a dual-mode platform that supports both technologies and eliminates any potential interference problems. Their jointly developed card will use dynamic switching so that both the Bluetooth and the 802.11 components can share the same antenna and, eventually, many of the same radio components.

The advantages of such a two-in-one approach are threefold. One, interference issues become moot, because they're simply engineered out. Two, the cost of a two-in-one card will be significantly less than purchasing two separate cards. Three, and perhaps most important, by supporting both standards, consumers will benefit by not having to choose one technology over the other—they get the best of both worlds, and can use either Bluetooth or 802.11 in whatever applications are most appropriate.

Security

As discussed back in Chapter 7, "Inside the Bluetooth Specification," two Lucent Technologies researchers have raised concerns about the security of Bluetooth devices and connections. They claim that the PIN keys, device addresses, and encryption keys central to Bluetooth's security scheme can be easily hacked or stolen by electronic bugging devices and other common methods, thus opening up Bluetooth connections to electronic eavesdropping and other potential attacks.

These claims have been downplayed by the Bluetooth SIG, who point out that the Lucent study was a Bluetooth-sponsored attempt to expose security holes so that they can be plugged in future versions of the Bluetooth Specification. In fact, the Lucent researchers suggested several solutions to these potential problems, including requiring longer and more frequently

changed PINs, adopting certificate-based security methods, incorporating better physical shielding for Bluetooth devices, and utilizing randomly generated pseudonyms in place of fixed device addresses.

In addition to these security issues, computer viruses could be as big a problem in the Bluetooth world as they are elsewhere in the world of computing. As with all security-related issues, the easier the device is to operate (and Bluetooth devices are designed for maximum ease of use), the easier it is to infect with a software virus.

In fact, the eventual introduction of viruses into Bluetooth devices is something that many take for granted. Says Terry Nozick, an analyst with Mobile Insights, "Any new way that somebody can introduce viruses into something, they will."

Will there be potential security problems with the Bluetooth technology? Yes—as there have been and will continue to be with any new technology. Will these security concerns impact the adoption of Bluetooth? That remains to be seen, but it's unlikely; Bluetooth's security as it exists today is adequately robust for most applications, and the benefits offered by Bluetooth look as if they will dramatically outweigh the minimal security risks that might be associated with the technology.

Complexity

We all know that Bluetooth was developed as a technology to reduce complexity. But what happens if the Bluetooth technology actually *increases* the complexity of our daily lives?

This scenario could happen, especially if increased security measures are implemented in Bluetooth hardware and software. Right now, most Bluetooth devices enable you to enter your PIN into the device's memory, and then recall it automatically or with the press of a button. If security concerns force manufacturers to eliminate this convenience feature, you'll have to manually enter your PIN every time you use your Bluetooth device. Too much of this could cause some users to abandon their devices entirely.

Even worse is the security scheme recommended by the two Lucent engineers who first discovered the potential security holes in the Bluetooth Specification. Under this scheme, your PIN would have to be longer than 4 digits (they like 6 or 8), and you would be forced to change it on a frequent basis. With all the PINs and passwords that consumers have to juggle already, imagine having a new one for your Bluetooth device thrown at you every day or so. *That* would be too much complexity, for most consumers!

Power Usage

Some early adopters of the Bluetooth technology have voiced complaints that Bluetooth devices are power pigs. Adding Bluetooth technology to a portable device, they claim, drains the device's batteries more rapidly than is normal.

Some of these power problems might be caused by first-generation Bluetooth chipsets, which use two chips (one for the radio and one for the controller) instead of the single integrated chip envisioned by many manufacturers. IT Week Labs found that many devices based on the initial chips had power consumption problems, and several manufacturers admitted that these early products are more for evaluation than for general consumer use.

Annette Jess Hansen of GN Netcom, a Bluetooth adopter, commented on the power usage problem faced by first-generation Bluetooth products. "We expect lower power consumption when a single or dual-chip Bluetooth chipset becomes available," she said in an interview with the publication *IT Week*.

In the same article, Nick Hunn, director of research and development at TDK Systems, concurred. He stated his belief that "battery life will improve over time, although we may have to wait for the next generation of silicon, in about twelve months' time, before we see any significant improvements."

In other words, whatever power consumption problems may exist today, they'll be solved as the technology continues to develop.

Compatibility

Even though the Bluetooth SIG has a rigorous qualification program for Bluetooth-enabled devices, there are still some who fear compatibility issues among the huge number of different Bluetooth chip sets from a variety of different manufacturers. If a Bluetooth device from Company A can't connect to a device manufactured by Company B, how will consumers react?

This fear of incompatibility may be premature and misplaced. The Bluetooth SIG's testing and qualification program is designed to ensure interoperability, and there is no evidence to date of connection problems between different types of devices. In fact, there have been numerous Unplugfests held in locations around the world, where hundreds of developers bring their Bluetooth devices for the very purpose of seeing if they connect to all the other devices present. To date, the only notable problem uncovered at these Unplugfests is that when you get hundreds of Bluetooth devices all transmitting at the same time, the available bandwidth can very quickly get overloaded!

That said, an attempt to connect some 130 Bluetooth base stations at the CeBIT 2001 trade show turned into a disaster (or at least a major embarrassment) when one of the participants failed to provide the proper software for its Bluetooth equipment, causing the entire network to crash and burn. (The fact that the Bluetooth network got up and running the following day and stayed live through the balance of the show didn't make the press, unfortunately.) The CeBIT setback illustrated a problem that many early adopters have noted—that the 1.0 version of Bluetooth doesn't work that well when you try to create a network that includes more than two devices. So while the initial version of Bluetooth works well with just a PC and PDA or a headset and a mobile phone, there may be potential problems with more complex configurations. Bluetooth officials stress that devices that conform to version 1.1 of the Bluetooth Specification shouldn't be plagued by these issues.

Of course, incompatibility *could* become an issue if Bluetooth manufacturers introduce their own proprietary extensions to the Bluetooth Specification. When proprietary applications exist, interoperability is compromised. For example, a Bluetooth mobile handset that incorporates non-standard technological extensions (no doubt added by the manufacturer to incorporate features not provided by their competitors) might not interface perfectly with similar Bluetooth devices produced by other manufacturers. This type of proprietary technological one-upmanship is standard operating procedure at many high-tech companies; Microsoft alone can provide dozens of examples of proprietary extensions that crippled

interoperability with competitors' products. If this type of uncooperative behavior bleeds over into the Bluetooth world, serious problems could ensue.

Overall Performance

Other comments from users of first-generation Bluetooth devices suggest that the technology, at least in its first iteration, may not quite be ready for prime time. There have been numerous reports in the technology press that the first Bluetooth devices are slow, insecure, and somewhat finicky—often not recognizing other devices within the 30-foot bubble, or connecting to the wrong devices when a choice is present.

Given that these are the very first Bluetooth devices to make it out of the lab and into the real world, one shouldn't be surprised that some performance problems exist. In fact, one would almost expect the initial products of any emerging technology to have an above-normal rate of operational, performance, and reliability problems. It will take a little time for all the manufacturers to get all the kinks worked out of their new products; it would be unfair to damn the technology based on the "teething" problems inherent in new high-tech devices.

In short, judge Bluetooth's performance by the *next* products to hit the street, not the first ones. After all—just how reliable were the very first VCRs when they were released in the late 1970s, or the very first microwave ovens, or the very first CD players? In all these instances, later models all performed better and lasted longer than their first-born siblings. The same will be true of Bluetooth. Think of the first Bluetooth products almost as test models or prototypes—great for early adopters, but probably not ready for prime time just yet. Wait six months to a year, and the next generation of products is likely to perform at specified levels, and with the promised results.

Cost

Perhaps the biggest potential inhibitor to the global acceptance of the Bluetooth wireless technology is the cost of Bluetooth radio chips. While the goal is to produce a single $5 radio/controller chip, today's chipsets contain separate ICs for the radio and controller, and cost—depending on who you talk to—anywhere from $15 to $25. If we assume actual costs somewhere in the middle of this range, $20 is just too high for manufacturers to economically incorporate Bluetooth into their existing products.

Consider the average cellular telephone, selling at retail well below $100. This translates into a manufacturing cost of $25 or so. Adding Bluetooth capability to this phone would increase manufacturing cost by roughly 80%—much more than the manufacturer can profitably absorb. If this percentage cost increase is passed on to the consumer, that $100 phone will soon be selling for close to $200—an almost-doubling of the price that today's market will bear.

Looking at these economics, you can see why the $5/chip target is necessary for Bluetooth to hit a wide market. "You can't put a $20 Bluetooth chip in these products," confirms Jan Edbrooke of Logitech, who is holding off on releasing Bluetooth-equipped mice and keyboards until chip prices get more affordable.

But what will have to happen to drive chip prices down to that level?

The answer to that question is simple: Volume. Higher manufacturing volume results in lower prices. So the more Bluetooth chips built, the lower their price. Of course, manufacturing higher volumes is a direct result of increased sales—and sales typically come from lower prices. So to get lower prices, you have to sell more—but to sell more, you have to have lower prices. It's a chicken-and-egg story—which comes first, lower prices or increased sales?

However it transpires, for Bluetooth to gain mass-market acceptance, chip prices will have to come down. If not, Bluetooth will be a technology relegated to a few high-end (and high-priced) products—which is not to anyone's benefit.

Regional Conflicts

While Bluetooth purports to be a global standard for wireless connections, there are three countries that present obstacles to this desired universality. In Japan, in France, and in Spain, portions of the necessary 2.4GHz band have been previously reserved for other uses (primarily military), thus prohibiting Bluetooth's use of the full band. (For more details on these regional problems, see Chapter 6.)

If only part of the 2.4HGz band is available in a particular region, Bluetooth devices manufactured in other countries will simply not work—and may be legally prohibited from being sold in that region. The solution is to manufacture special variations of Bluetooth products in each of these three countries; these variant products would have to be tweaked to operate only in the approved subset of the total Bluetooth range.

What follows are descriptions of how this situation breaks down in each of the three countries in question.

Japan

Japan promises to be one of the largest single markets for Bluetooth products, so frequency restrictions here could have major repercussions throughout the entire Bluetooth industry. At the time this is written, Bluetooth products manufactured for the Japanese market can only transmit and receive on those frequencies between 2.471GHz and 2.497GHz. This translates into just 23 1MHz frequencies, compared to the 79 1MHz frequencies available for use elsewhere.

The Bluetooth Specification allows for 23-frequency use, so building country-specific Bluetooth radios to work in Japan will not be a problem. Bluetooth devices manufactured in other countries, however, cannot be imported into Japan, nor can Japanese Bluetooth devices be exported to other countries.

France

France has frequency restrictions similar to those in Japan, as the France military and civil service have been allocated specific frequencies in the ISM band. At the time this is written, Bluetooth products manufactured for the French market can only transmit and receive on 23 1MHz frequencies between 2.4465GHz and 2.4835GHz. As with the Japanese situation, France-specific devices can and will be manufactured, but not sold outside of France; Bluetooth devices manufactured in other countries cannot be used inside French borders.

Spain

The final problem country is Spain, and a similar situation exists there. Due to previous frequency allocations, Bluetooth products manufactured for the Spanish market can only transmit and receive on 23 1MHz frequencies located between 2.445GHz and 2.475GHz. Bluetooth manufacturers will have to produce Spain-specific Bluetooth devices, and sell these devices only within Spain. Devices manufactured elsewhere will not function within Spanish borders.

Competitive Technologies

Any competitive technology can be an impediment to Bluetooth's potential success. As you learned back in Chapter 9, "Competitive and Complementary Technologies," the three closest competitors to Bluetooth are IrDA (infrared), HomeRF, and 802.11 (Wi-Fi).

To compete successfully against IrDA in the cable-replacement market, Bluetooth must demonstrate a substantial competitive advantage. Since IrDA is faster than Bluetooth, Bluetooth's primary competitive advantages are range and angle of connection. If Bluetooth adherents can prove IrDA substantially more difficult to use (because of precise placement requirements), Bluetooth may be able to gain inroads and eventually surpass the sales of the more established infrared technology.

As discussed in Chapter 9, Bluetooth and HomeRF are being positioned as complementary technologies, not as competitors. That said, there is nothing stopping home users from connecting computer peripherals directly to their wireless networks via HomeRF, instead of using Bluetooth to forge a wireless link from peripheral to PC—nothing except cost, that is. It currently costs anywhere from $70 to $120 to enable a device for HomeRF, compared to the $20 (and hoped-for $5) cost of Bluetooth. Because of this cost differential, it seems unlikely that home users will add HomeRF capability to all their peripherals; Bluetooth's greater affordability could lead to a peaceful coexistence between these two technologies in the home.

Bluetooth's most serious competitor will probably turn out to be 802.11. WECA, the industry group pushing 802.11/Wi-Fi, has ambitious goals for the technology, including non-LAN applications that overlap similar applications from Bluetooth. This will be a most interesting competition, with Bluetooth's lower price and lower power consumption up against the faster speed, increased range, and potential ubiquity of 802.11 networks. If any technology can knock Bluetooth out of the game, 802.11 is the one.

Slow Adoption

Bluetooth has been big news since the release of the 1.0 Specification in July of 1999. Industry analysts expected the first Bluetooth-compatible devices to hit the market in the fall of 2000, and for Christmas of 2000 to be the first big splash for the technology.

That didn't happen.

Christmas 2000 came and went, with no working Bluetooth products available for sale. The first Bluetooth products didn't arrive on store shelves until the first quarter of 2001, and then they were few and far between—more a curiosity than a serious factor in the marketplace. This late launch led many observers to question the viability of the technology, and to wonder exactly when Bluetooth would begin to have a noticeable impact on the computer and communications markets.

Expectations vs. Reality

In answer to Bluetooth's disappointingly slow launch, some analysts simply pushed back their schedules. Joyce Putscher of Cahners In-Stat Group commented that "Bluetooth will really begin to sink its teeth into the market in 2001." Frost & Sullivan gleefully anticipates that Bluetooth-embedded systems will "explode" onto the market in 2001 and trigger a "wireless mania."

This bullishness on the part of analysts (who make money by selling expensive reports to companies interested in the technology's potential—and who typically don't sell reports that contain a lot of bad news) is balanced by the actual plans of Bluetooth manufacturers. While some initial products are being released in 2001 to test the market, many manufacturers don't expect to release significant numbers of serious Bluetooth-enabled products until 2002.

Indeed, some analysts share the manufacturers' caution.

"2001 won't be the year of Bluetooth," cautions Tim Bajarin, veteran industry analyst with his own firm, Creative Strategies. That doesn't mean Bajarin is down on Bluetooth; he just questions the timing. "This is exciting, revolutionary stuff," he added—whenever it actually hits the market.

Waiting for 1.1b

Some of this product delay has been due to the adoption of version 1.1b of the Bluetooth Specifications, several months into 2001. While the changes from 1.0 to 1.1b represented relatively minor clarifications and corrections, the changes were significant enough to impact the design of Bluetooth chips from several manufacturers. Toshiba, for one, claimed that shifting to a 1.1b-compatible chip would require an extra six months of work, and would delay the shipping of its chip sets until the third quarter of 2001.

Waiting for 1.1b may actually be a good strategy, as the revised Specification fixes some of the holes and bugs that have come to light in the initial Specification. Given the choice of waiting a few months for more stable and robust products, or rushing potentially problematic products out sooner, most of those in the Bluetooth industry will vote for the slight delay.

It's likely most consumers would concur.

Waiting for Microsoft

Another speed bump on the road to adoption is the fact that for Bluetooth to work in the computer world, it needs to work well with Windows. Unfortunately, a version of Bluetooth that will work with Windows 2000 won't be available until sometime later in 2001—and Microsoft recently announced that their next version of Windows, christened Windows XP,

will not include built-in Bluetooth support. (Mike Fole, Microsoft's appointed wireless architect, blamed the removal of Bluetooth support on the lack of commercially available Bluetooth hardware; "There's no stable hardware to test it on," he told the press.)

At least some part of this delay has been Microsoft's fault. The operating systems behemoth deliberately dragged its feet on the whole issue of Bluetooth, many claim. This may have been due to a natural caution on Microsoft's part, or it may have been a result of the glacial pace that Microsoft typically adopts when integrating new technologies into its operating systems. It may even, some suspect, have been due to a deliberate internal strategy; since the Bluetooth SIG requires a pooling of patents, Microsoft management may have balked at this un-Microsoft-like cooperation.

Windows XP aside, Microsoft appears to have gotten off its soggy tail and revved up its support for Bluetooth in recent months. The company is an active participant in several workgroups that are developing new profiles for version 2.0 of the Bluetooth Specification, and has become quite visible in its support of the technology overall. (See www.microsoft.com/HWDEV/bluetooth/ for more information on Microsoft's current Bluetooth efforts.) One can only hope that Microsoft steps up its development efforts and adds Bluetooth support to Windows XP and its other operating systems in short order.

Waiting for Critical Mass

IBM is one of those companies dragging its heels on releasing Bluetooth-enabled products, in their case notebook computers. In IBM's case, it's not a technology issue, it's a simple matter of math—they want to wait until there are more Bluetooth-compatible devices out there to connect with.

While IBM has released a Bluetooth PC card that can be used in their (and others') notebooks, the company won't be building Bluetooth into their line of ThinkPads until sometime in 2002. According to Leo Suarez, director of product marketing for IBM Mobile Systems, "We want to wait until there are Bluetooth-enabled phones" to connect to.

This illustrates a perennial problem. If you're the first on the market with a new product, you don't have any other products to work with. So you wait to produce your product until other compatible products are also available. But if you wait too long, you lose first-mover advantage. Even worse, if *everybody* waits, a critical mass never develops—and the technology is stillborn.

The timing of product releases is always an issue with any new technology. In Bluetooth's case, however, it's likely that once a few key companies take the pioneering first steps, the floodgates will open for all the companies-in-waiting. With 2000-plus members of the Bluetooth SIG, the impetus to get products on the market should eventually outweigh any hesitation concerning critical mass.

In other words, once it gets started, be concerned about *too many* Bluetooth products, not too few!

Hype

At the end of the day, perhaps the biggest obstacle to Bluetooth's success might be the Bluetooth technology itself. The longer the market has to wait for Bluetooth, the more oversized the expectations of those who are kept waiting. In fact, some of the claims being made about Bluetooth's capabilities are already somewhat on the far side of wild-eyed; if consumers buy into the hype, they may find themselves greatly disappointed by what the technology can really do.

As an example, there have been some claims that Bluetooth will become the dominant player in the wireless LAN market, particularly in the home. Given Bluetooth's 1Mbps transfer rate (and this is a theoretical maximum—real-world data transfer will probably be in the 400Kbps range), there is no way it can compete with technologies, such as HomeRF, that offer 10Mbps and higher transfer rates. Anyone expecting Bluetooth to actually work as a LAN-replacement technology will be sorely disappointed.

Consultant Craig Mathias of the Farpoint Group admits that he's skeptical about the technology. "Bluetooth already has one black eye for overpromising, now they may get another one for under-delivering. All it will take is one widely respected reviewer to say this stuff doesn't work, and that could be the end of it in the consumer market."

Already we're starting to see news headlines along the lines of "Early Bluetooth Lacks Bite" and "Bluetooth Getting Long in the Tooth." (Just how many lame dental similes can these journalists come up with, anyway?) Will consumers become disenchanted with Bluetooth before a critical mass of products ever hits the shelves?

To some degree, this is a natural stage in the introduction of any new technology; the hype always precedes the reality. One can only hope that consumers (and, importantly, reviewers) will be patient and give Bluetooth a chance. Once they see the technology strut its stuff they can judge Bluetooth on its own merits—where it should perform admirably.

Will Bluetooth Succeed?

Given all these potential problems, the question remains: Will Bluetooth succeed?

Most observers are betting in the affirmative. They claim that support for the technology across multiple industries is too strong to be sidetracked by what amount to relatively small obstacles. There are too many companies investing too much money, these observers say, for Bluetooth not to be successful.

As one example of this cross-industry interest, Barry Issberner of Symbol Technologies relates the huge support for Bluetooth he's already seeing from the automobile industry. He claims that Avis wants to install Bluetooth chips in all their rental cars, so that Avis clerks can use a portable Bluetooth device to read a car's mileage, fuel level, and other vital information "more quickly and accurately" than before. A few adoptions of this magnitude and Bluetooth's triumph is a virtual certainty.

When you see the incredible support for Bluetooth across so many different industries, combined with the pent-up demand for Bluetooth solutions at the consumer level, it's hard to imagine Bluetooth being anything less than an unqualified success. If real-world Bluetooth

devices and applications deliver what they promise, we'll all have a Bluetooth in our pocket sometime soon—and won't be able to remember how we ever did without it!

Chapter 11: Bluetooth in the Future

It might seem a little odd to talk about Bluetooth in the future, when the technology hasn't even hit wide release yet. However, for Bluetooth to keep pace with both technological changes and changes in the marketplace, engineers must constantly be working to advance the Specification—to make Bluetooth better over time. This chapter discusses some of the efforts in regard to the next generation of Bluetooth technology, and ventures to guess just what will happen to Bluetooth in the future.

Beyond the 1.0 Specification: Bluetooth 2.0

The next generation of Bluetooth is already in the planning stages. Version 1.0 of the Bluetooth Specification was released in July of 1999, a very minor modification (version 1.0b) in December 1999, and a further revision (version 1.1) in early 2001. The first major addition to the Specification, however, will be version 2.0—and this version is already in development, for release late in 2001 or sometime in the year 2002.

Bluetooth 2.0 will be an enhancement to Bluetooth 1.0, not a modification. This means that version 1.0 of the Specification will stand as written, and the new components of version 2.0 will sit on top of the previous spec. This dictates that version 2.0 include new usage models and profiles—not modifications of existing profiles—as well as extensions to the basic performance specifications.

The known work in progress for version 2.0 is discussed in the following sections. Know, however, that some of these projects may not make it into the final Specification, and that other projects may be added before the final release date.

Radio 2.0

Recognizing the speed limitations of version 1.0 Bluetooth radios, the Bluetooth SIG has formed a new working group to evaluate enhanced performance specifications. The Radio 2.0 Working Group, co-chaired by Ericsson and Nokia, is charged with improving the transmission speed of Bluetooth devices, to be more competitive with the competing IrDA, HomeRF, and 802.11 technologies.

In particular, the Radio 2.0 Working Group is developing a new "high-rate mode" that can be adopted by next-generation Bluetooth devices. Proposed specifications for this mode include:

- 10Mbps transmission rate at the current 10-meter (30-foot) range
- Concurrent support for both low-rate and high-rate slaves within a single piconet
- Low cost ($10 target)
- Legacy compliance with the 1.0 Specification

It's important to note that any new specifications dictated by this working group will not replace version 1.0 specs, but rather define optional extensions to the previous Specification.

This will ensure backward compatibility for any Bluetooth 2.0 devices, which is important to maintain the interoperability of the Bluetooth standard.

Interestingly, the Radio 2.0 Working Group is *not* currently charged with increasing the transmission range of Bluetooth devices. This may change if longer-range competitors gain market acceptance.

New Usage Models

As described in Chapter 3, "The Bluetooth Industry," several new working groups have been established to develop usage models and profiles for an increased number of Bluetooth applications. These potential new usage models, arranged by industry and topic area, are described next.

Audio/Video

The new Audio/Video Working Group is charged with developing usage models and profiles that integrate Bluetooth technology into the home consumer electronics environment—focusing primarily on use with audio/video devices. As defined in the working group's charter, potential new usage models include:

CD-Quality Headphones, Speakers, and Microphones This usage model envisions several related applications of the Bluetooth wireless technology. One application would be listening to music or television sound via wireless headphones; a second application would be establishing wireless connections between full-range speakers and A/V receivers; a third would be providing connections for wireless microphones. All these applications share the common need to transmit and receive CD-quality sound (which is *not* provided for in the 1.0 Bluetooth Specification).

Wireless Video Displays This usage model envisions sending VGA-quality signals between A/V devices (such as DVD players) and video displays. (Standard definition television broadcasts have an effective resolution of 640 x 480 pixels—identical to that of the computer industry's VGA standard.) Since video signals eat up large quantities of bandwidth, implementation of this application will likely utilize some sort of MPEG video compression.

Note Unfortunately, a new profile based on this usage model would not have applicability in personal computer systems, as the VGA is an older, lower-resolution computer display standard. Higher resolution transmittal is necessary before computer displays can take advantage of Bluetooth's cable-free connections.

Wireless Video Cameras This usage model describes a wireless connection between a digital video camera/camcorder and a television set or A/V receiver. As with the preceding usage model, this profile will dictate VGA-quality video (sufficient for standard TV-quality broadcasts and recordings) and will likely utilize an MPEG video compression scheme.

Video Conferencing This usage model incorporates bits and pieces from other applications to enable a completely wireless video conference. This includes wireless audio (the microphone and speaker usage models) and video (the wireless video display model), which would then feed directly to a standard telephone line (utilizing existing 1.0 usage models).

In short, the guiding principle behind the Audio/Video Working Group is to eliminate all the cables traditionally used in the hookup of a home audio/video system.

Automotive

The Car Profile Working Group, chaired by Nokia and Motorola, is developing usage models and profiles for both portable and car-embedded Bluetooth devices within the automotive environment. Not wanting to reinvent the wheel (so to speak), this working group intends to reuse existing 1.0 specifications whenever possible.

The use of Bluetooth in the car will have far-reaching impact, with many exciting applications already in the planning stages. Potential new usage models envisioned by this working group include:

In-Car Phones This usage model envisions operating a mobile phone via an in-car device—in essence, creating a Bluetooth wireless version of a traditional hands-free car kit. If you have your Bluetooth phone in your pocket when you ease behind the wheel, the car kit will sense the presence of the phone and use it to establish an on-the-go cellular connection, utilizing a speaker and microphone built into the car interior.

The PDA-to-Car Bridge This usage model is a little tricky; in essence, it describes how a portable device (such as a PDA) would export its user interface to your car. This may involve the synchronization of data between the PDA and your car's built-in computer, or it may stretch to use an in-dash video display as the interface and display for your PDA or notebook computer. It may even grow to define an e-mail retrieval system that incorporates the larger cellular network, your mobile phone, a wireless hands-free car kit, your PDA or notebook PC, and some sort of new interface for reading messages—perhaps incorporating voice synthesis over your car's speakers.

Personalizing the Car and its Devices This usage model will enable you to carry your personal in-car environment with you from vehicle to vehicle. Imagine storing your own preferences for seat adjustment, temperature control, and even radio station presets in your Bluetooth-enabled phone or PDA; whenever you enter a new vehicle (even a rental car!), the car will sense your preferences and adjust itself to your liking.

Remote Car Access This usage model is the "key replacement" application. Instead of opening your car with a physical key, you'd use your Bluetooth-enabled mobile phone or PDA to beam a coded signal to lock or unlock the doors (and start up the engine and adjust the radio to your favorite station).

Remote Access to Car Position If you've ever had trouble finding your car in a crowded parking lot, you'll like this usage model. This model envisions using your Bluetooth phone or PDA to track down your vehicle, providing either a map or step-by-step instructions to get from where you are to wherever you parked your vehicle.

Car-to-Environment Communication This usage model envisions all manner of communications between your car and the external environment. This might entail your car running low on gas and then informing you of a gas station coming up two blocks on the right. Perhaps you'll receive the latest local weather reports, or an interactive map of your coming route—including up-to-the-minute information on traffic conditions, accidents, and

road work. Even more likely is the use of Bluetooth to electronically pay tolls, parking fees, and the like, all automatically. Some have even theorized that this usage model could enable local businesses along your route to beam you coupons and advertisements to entice you to pull over and spend your money. ("Thirsty? Get fifty cents off any coffee drink at Starbucks, coming up at the next corner.")

Diagnostics and Programming Cars are more computerized today than ever before. When you pull into your local service shop, chances are the mechanic hooks your car up to some sort of computerized diagnostic machine. With Bluetooth, no physical connection will be necessary; you'll pull into the bay and your car will transmit all its diagnostic information, wirelessly and automatically. This usage model has interesting potential for the car rental industry, where just pulling into the car return lot will cause the rental car to beam your mileage and fuel level information to the agency's computer—which will then beam your bill to your PDA or mobile phone, which will then authorize payment, all automatically.

Human Interface Devices

The Human Interface Device (HID) Working Group is being driven by Microsoft, and focuses on all the things you use to interact with your personal computer system, home entertainment system, and other consumer devices and appliances. These devices include but are not limited to mice, keyboards, trackballs, front panel controls (knobs, buttons, sliders, switches, and the like), keypads, and gaming devices (including joysticks, throttles, steering wheels, and pedals). The HID Working Group is also responsible for defining Bluetooth usage for devices that may not require direct human interaction but provide data in a similar format, such as bar code readers, thermometers, voltmeters, and other measuring devices.

This working group is responsible for integrating all manner of wireless HIDs into the Bluetooth Specification—and making sure that they're compatible with other Bluetooth devices, easy to use, and affordable. They're initially working with four general usage models:

Desktop Computer This usage model will build on the existing Cordless Desktop usage model to include scenarios where a single HID is connected to several computers and where one computer is connected to several HIDs.

Conference Room This usage model expands upon a specific application of the existing Interactive Conference model. This new usage model defines how a small wireless pointing device can be used by a presenter to control a computer-driven presentation. A device built for this purpose would be exclusively handheld and not need a surface to sit or roll on.

Living Room This usage model describes how various wireless devices can be used in a typical living room to control remote computers, WebTV-type devices, and video games. These devices could include wireless keyboards (for WebTV access) and various video game controllers. Another possible device for this scenario would be a wireless remote control with built-in video screen.

Remote Monitoring This usage model will define all manner of remote monitoring applications—both for the home and for industrial uses. Applicable devices would include everything from remote security cameras to battery-powered temperature, wind, and pressure

sensors. Once a standard wireless interface is defined, these devices could become modular and essentially interchangeable.

Local Positioning

Nokia and Microsoft are working together in the Local Positioning (LP) Working Group to provide more granular positioning options than are currently available in satellite-based global positioning systems (GPSs). Using Bluetooth access points as place identifiers, the new usage models under discussion are meant to enable a user to accurately determine his or position indoors and in other built-up environments, typically invisible to satellite positioning systems. This local (down to the specific floor and cubicle inside a given building) positioning can then be integrated with traditional GPS information to provide highly accurate, remarkably fine-tuned positioning information.

Personal Area Networking

Version 1.0 of the Bluetooth Specification addressed only LAN-based and dial-up networking solutions; it didn't address true IP-based personal area networking. The purpose of the new Personal Area Networking (PAN) Working Group is to define standards for ad hoc personal networks for data, voice, video, and other forms of workgroup communications. Microsoft and Intel are working together on this part of the 2.0 Specification.

Printing

The Printer Working Group, chaired by Hewlett-Packard and Ericsson, is charged with developing specifications for Bluetooth-enabled printers. Specification details will include connection establishment, security, pairing, capability negotiation, and so on. Whenever possible, printer-related profiles will reuse existing 1.0 specifications.

Envisioned usage models include printing directly from a notebook or desktop PC, PDA, digital still camera, or mobile phone.

Still Imaging

The Imaging Working Group, headed by Nokia, is responsible for integrating digital still cameras and related devices into the Bluetooth Specification. The goal is to facilitate the exchange of digital still images (and any related data) between the image generator (camera) and another device. The second device will be used to display, store, print, or further transmit the digital images.

While all this might appear to be a special case of the File Transfer Profile, the Imaging Working Group will focus on the unique requirements of high-quality digital images, as defined in the existing Instant Postcard usage model.

Bluetooth and Cellular Telephony

Since Bluetooth was a product of the research and development department of one of the world's largest mobile telephone companies (Ericsson), it should come as no surprise that

Bluetooth development is closely entwined with developing global cellular telephony standards—in particular, third-generation (3G) wireless.

A Generational Issue

There is a hodgepodge of cellular radio standards embraced in the various countries in the worldwide market. The U.S. market is particularly fragmented—unlike Europe, which embraces a single standard across the majority of the continent.

Current cellular standards and technologies, however, are limited—especially when it comes to transmitting non-voice data at speeds acceptable to Internet-savvy consumers. The next generation of cellular systems is designed to address this shortcoming—and Bluetooth is intended to be compatible with these new 3G systems.

The first generation of mobile communications systems was strictly analog. There were many different analog cellular systems employed in various regions of the world, including the U.S.'s Advanced Mobile Phone System (AMPS), the U.K.'s Total Access Communication System (TACS), and Scandinavia's Nordic Mobile Telephone (NMT) system. Analog cellular systems were fine for transmitting voice signals, but were unable to carry any data signals, as data is always transmitted in digital format.

Thus evolved the second generation (2G) systems, which utilized digital technology. Unfortunately, there were just as many digital systems as there were analog systems—including Europe's Global System for Mobile communications (GSM), the U.S.'s Digital AMPS (DAMPS) system, and Japanese Digital Cellular (JDC) in Japan. To confuse things further, the DAMPS system can actually incorporate several different competing technologies. These technologies—including Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA)—enable cellular networks to cram more users into the available frequency range, and are totally incompatible with each other.

Note GSM is also used in the U.S., for PCS 1900 service. In Europe, GSM operates at 900MHz and 1800MHz; the PCS 1900 GSM service operates at 1900MHz, and is not compatible with European GSM phones and systems.

All of these 2G systems, being digital in nature, can transmit both voice and data signals, although data transmission is at extremely low rates (as low as 14.4Kbps for some U.S. systems, although 64Kbps rates are possible). In essence, 2G wireless was still designed with voice in mind, not data.

Developing the Third Generation

Which brings us to the third generation. The new 3G wireless platform was designed from the start to incorporate both voice and high-speed data, and to create a global standard that would eliminate the competing and incompatible systems that fragmented the first- and second-generation cellular industry.

Developed by the International Telecommunications Union (ITU), the International Mobile Telecommunications 2000 (IMT-2000) standard is actually a modular platform that evolves and extends the current GSM standard. A 3G cellular network will provide digital voice transmission and broadband digital data transmission, as well as videoconferencing and other

data-related applications—and all with global roaming capabilities, through either terrestrial or satellite-based networks.

Phones designed to work on 3G networks can have capabilities far beyond the mobile phones we know today. As an example, Figure 11.1 shows a prototype 3G mobile terminal from Nokia. It has a color video screen for Web browsing, video conferencing, and GPS-type positioning applications.

Figure 11.1: Nokia's prototype 3G mobile terminal (Photo courtesy Nokia)

As this book is written, IMT-2000 is still under development. The first IMT-2000-compliant 3G cellular networks are expected to become available in Europe, Japan, and the United States sometime in 2001.

Bluetooth and 3G Wireless

As 3G wireless systems are designed to transmit high-speed data, the implementation of 3G worldwide will enable the successful implementation of Bluetooth's Internet Bridge usage model. Current cellular systems simply don't transmit data fast enough to be practical; 3G systems, interfacing with Bluetooth technology, will provide the high-speed data transfer rates necessary for full-featured Internet access.

Bluetooth, which was built to handle simultaneous voice and high-speed data transmissions (up to 1Mbps), was essentially ready for 3G wireless from day one. Imagine a new 3G mobile phone with built-in Bluetooth capability: the 3G network handles the global part of the connection, while the Bluetooth radio handles the local part of the connection, and provides a gateway to the global network.

What Does the Future Hold?

Throughout this book you've been presented with plentiful background information about the Bluetooth wireless technology, as well as many different visions of how Bluetooth might become part of your high-tech future. You now know as much as you need to know to be comfortable with the Bluetooth technology and with future Bluetooth products.

Will Bluetooth be part of your future? A lot of companies are betting a lot of money in the affirmative. Of course, all the money in the world will not ensure the success of a new product or technology; if the products don't work, or if the technology is a solution in search of a problem, then failure is possible. Consumers vote with their pocketbooks, and if they ascribe little or no value to Bluetooth-enabled products, they simply won't buy them. If they see the value—and agree with the cost-benefit trade-off—then the products will fly off the shelves.

The success of Bluetooth, then, depends on the answers to a few simple questions:

- Does it work as promised?
- Does it offer a demonstrable value to consumers (including industrial consumers)?
- Is the value offered worth the price?

If, when more Bluetooth products hit the market, the answers to all these questions are yes, then expect Bluetooth to be a big part of your future. If, on the other hand, the answer to one or more of these questions is no, then Bluetooth will go down as one of the biggest high-tech failures on record.

Given the resources dedicated to Bluetooth, and the companies behind the technology, it's hard to imagine that Bluetooth will not deliver on its promise. Ericsson, Intel, IBM, Lucent, Microsoft, Motorola, Nokia, Toshiba, 3Com, and 2000 more companies are committed to Bluetooth's success, and these companies seldom fail—especially when working in tandem.

Is there a Bluetooth device in your future? The probability is yes—and it's likely that that Bluetooth device will change the way you connect and communicate, soon and for the rest of your life.

Part IV: Appendices

In This Part

Appendix A: Acronyms
Appendix B: Technical Specifications
Appendix C: Bluetooth Resources
Glossary

Appendix A: Acronyms

2G	second generation (wireless)
3G	third generation (wireless)
ACL	Asynchronous Connection-less
ACO	Authenticated Ciphering Offset
AMPS	Advanced Mobile Phone System
API	Application Programming Interface
AT	audio/telephony
ATM	Asynchronous Transfer Mode; Automatic Teller Machine
A/V	audio/video
BB	Baseband
CDMA	Code Division Multiple Access
CID	Channel Identifier
CL	Connection-less
CODEC	COder/DECoder
CTP	Cordless Telephony Profile
CVSD	Continuous Variable Slope Delta
DAC	Device Access Code
DAMPS	Digital Advanced Mobile Phone System
DECT	Digital Enhanced Cordless Telephone
DSL	Digital Subscriber Line
DSP	digital signal processor
DSSS	direct sequence spread spectrum
DTMF	Dual Tone Multiple Frequency
DUNP	Dial-Up Networking Profile
EIA	Electronic Industries Alliance
ETSI	European Telecommunications Standards Institute
FaxP	Fax Profile
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
FH	frequency hopping
FHSS	frequency hopping spread spectrum
FIR	Fast Infrared
FP	File Transfer Profile
FSK	Frequency Shift Keying
FTP	File Transfer Protocol
GAP	Generic Access Profile
Gbps	gigabits per second
GFSK	Gaussian Frequency Shift Keying
GHz	gigahertz (millions of cycles per second)

GOEP	Generic Object Exchange Profile
GPS	global positioning system
GSM	Global System for Mobile communications
HC	Host Controller
HCI	Host Controller Interface
HID	Human Interface Device
HSP	Headset Profile
Hz	Hertz (cycles per second)
I/O	input/output
IC	integrated circuit
IEC	International Electrotechnical Commission
IEEE	Institute of Electronic and Electrical Engineers
IMT-2000	International Mobile Telecommunications 2000
IntP	Intercom Profile
IP	Internet Protocol; intellectual property
IR	Infrared
IrDA	Infrared Data Association
IrMC	Infrared Mobile Communications
IrOBEX	Infrared Object Exchange
ISDN	Integrated Services Digital Network
ISM	industrial, scientific, medical
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-T	International Telecommunication Union—Telecommunications
JDC	Japanese Digital Cellular
Kbps	Kilobits per second
KHz	Kilohertz (thousands of cycles per second)
L2CAP	Logical Link and Control Adaptation Protocol
LAN	local area network
LAP	LAN Access Profile; LAN Access Point
LC	Link Controller
LCP	Link Control Protocol
LLC	Logical Link Control
LM	Link Manager
LMP	Link Management Protocol
LP	Local Positioning
Mbps	megabytes per second
ms	millisecond
mW	milliwatt
NMT	Nordic Mobile Telephone
OBEX	Object Exchange; Object Exchange protocol

OEM	Original Equipment Manufacturer
OPP	Object Push Profile
OSI	Open Systems Interconnection
PAN	personal area network
PCM	Pulse Code Modulation
PCMCIA	Personal Computer Memory Card International Association
PCS	Personal Communications Service
PDA	Personal Digital Assistant
PDN	Packet Data Network
PDU	Protocol Data Unit
PIM	Personal Information Manager
PIN	Personal Identification Number
PnP	Plug and Play
POTS	plain old telephone service
PPP	Point-to-Point Protocol
PSTN	Public Switched Telephony Network
QoS	Quality of Service
RF	radio frequency
RFCOMM	Radio Frequency Communication Protocol
RSVP	Resource Reservation Protocol
RX	Receiver
SCO	Synchronous Connection Oriented
SD	Service Discovery
SDAP	Service Discovery Application Profile
SDP	Service Discovery Protocol
SIG	Special Interest Group
SIR	Serial Infrared
SLP	Service Location Protocol
SMS	Short Messaging Service
SP	Synchronization Profile
SPP	Serial Port Profile
SSL	Secure Sockets Layer; Service Security Level
SWAP	Shared Wireless Access Protocol
TACS	Total Access Communication System
TCP	Transport Control Protocol
TCS	Telephony Control Specification
TCS-BIN	Telephony Control Specification—Binary
TDD	Time Division Duplex
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TIA	Telecommunications Industry Association

TMN	Telecommunications Management Network
TTP	Tiny Transport Protocol
UART	Universal Asynchronous Receiver-Transmitter
UDI	Unrestricted Digital Information
UDP	User Datagram Protocol
UMTC	Universal Mobile Telecommunications System
UpnP	Universal Plug and Play
USB	Universal Serial Bus
UWB	Ultra-Wideband Radio
UWCC	Universal Wireless Communications Consortium
WAE	Wireless Application Environment
WAN	Wide Area Network
WAP	Wireless Application Protocol
WDP	Wireless Datagram Protocol
WEP	Wired Equivalent Privacy
WID	Wireless Information Device
Wi-Fi	Wireless Fidelity (802.11)
WLAN	wireless LAN
WLL	Wireless Local Loop
WML	WAP Markup Language
WRC	World Radio Conference
WSP	Wireless Session Protocol
WTLS	Wireless Transport Layer Security
WTP	Wireless Transaction Protocol

Appendix B: Technical Specifications

The following table details the key technical aspects of the Bluetooth 1.0 specification.

Bluetooth 1.0 Specification

Definition	**Specification**
Type of operation	Radio frequency (RF)
Operating band	Unlicensed ISM band, between 2.402GHz and 2.480 GHz
Modulation	Gaussian Frequency Shift Keying (GFSK)
Peak data transfer rate	1Mbps
Sensitivity	-70dBm
Range	10 meters (100 meters optional)
Duplexing	Full-duplex, Time Division Duplex (TDD)
Signal type	Spread spectrum

Definition	Specification
Frequency hopping rate	Up to 1600 hops/second (3200 hops/second for inquiries and pages)
RF carriers	79
Carrier spacing	1MHz
RF output	Class 3 (10-meter range): 0dBm (1mW);
	Class 2: +4dBm (2.5mW);
	Class 1 (100-meter range): +20dBm (100mW)
Voice channels	Up to 3 simultaneous synchronous channels, or a single channel that simultaneously supports asynchronous data and synchronous voice; each channel should support 64Kbps in each direction
Data channels	Single asynchronous channel that can support 721Kbps asymmetric (with up to 57.6Kbps in the return direction) or 432.6Kbps symmetric
Piconet connections	Each master unit can share an asynchronous channel with up to 7 simultaneously active slave units
Scatternet connections	Each scatternet can contain up to 10 piconets with a minimum of collisions

Appendix C: Bluetooth Resources

The Bluetooth SIG

The Bluetooth Special Interest Group (SIG) is the official industry group for the Bluetooth wireless technology. Key information about the Bluetooth SIG can be found on the Internet, at the following URLS:

The Bluetooth SIG
www.bluetooth.com

Membership Application
www.bluetooth.com/sig/membership/membership.asp

Qualification Process
qualweb.opengroup.org

Qualified Products
qualweb.opengroup.org/Template.cfm?LinkQualified=QualifiedProducts

SIGnal Newsletter
www.bluetooth.com/news/signal/signal.asp

Bluetooth Information Resources

The following Web sites, mailing lists, and newsletters offer valuable information about the Bluetooth technology and Bluetooth-enabled products.

Web Sites

AnywhereYouGo.com Bluetooth Center
www.anywhereyougo.com/bluetooth/

Bluetooth Weblog
bluetooth.weblogs.com

Howstuffworks.com's "How Bluetooth Short Range Radio Systems Work"
www.howstuffworks.com/bluetooth.htm

MobilInfo's Bluetooth Technology Page
www.mobileinfo.com/Bluetooth/index.htm

PaloWireless Bluetooth Resource Center
www.palowireless.com/bluetooth/

The BlueLink
www.thebluelink.com

Wuzap.org
www.wuzap.org/bluetooth/

Mailing Lists

Bluetooth and PAN General Discussion Mailing List
www.topica.com/lists/bluetooth/

Bluetooth-Dev (Developer's) Mailing List
mail.anywhereyougo.com/mailman/listinfo/bluetooth-dev/

Bluetooth News and Discussion Mailing List
bluetooth.listbot.com

Bluetooth-Related News and Discussion Mailing List
groups.yahoo.com/group/blueinfo/

Newsletters

Incisor Newsletter
www.click.co.uk/incisor.htm

PaloWireless Bluetooth Newsletter
www.palowireless.com/bluetooth/subscribe.asp

SIGnal Newsletter
www.bluetooth.com/news/signal/signal.asp

Books

An IEEE Guide: How To Find What You Need in the Bluetooth Spec
Tom Siep, IEEE Press.

Bluetooth: Connect Without Cables
Jennifer Bray and Charles F. Sturman, Prentice Hall PTR.

Bluetooth Demystified
Nathan J. Muller, McGraw-Hill.

Bluetooth Revealed
Brent A. Miller and Chatschik Bisdikian, Prentice Hall PTR.

Bluetooth Companies

Here is a list of Bluetooth-related companies, most of which are mentioned in this book, that have Bluetooth-enabled products either planned, in development, or available for sale.

3Com Corporation
www.3com.com

Adamya
www.adamya.com

ALPS Electric Co. Ltd.
www.alpsusa.com

AmbiCom
www.ambicom.com

Anoto
www.anoto.com

Arca Technologies
www.arcatech.com

Axis Communications
www.us.axis.com

BlueLinx, Inc.
www.bluelinx.com

Bluesocket
www.bluesocket.com

BlueTags
www.bluetags.com

Brain Boxes
www.brainboxes.com

BrightCom
www.brightcom.com

BT Syncordia
www.bt.com/syncordia/

Cambridge Silicon Radio
www.csr.com

Centre for Telecommunications Information Networking
www.ctin.adelaide.edu.au

Classwave
www.classwave.com

Commil
www.commil.com

Compaq Computer Corporation
www.compaq.com

Computer Access Technology Corporation
www.catc.com

DCM Technologies
www.dcmtech.com

Digianswer A/S
www.digianswer.com

ELSA
www.elsa.com

Ensure Technologies
www.ensuretech.com

Ericsson Mobile Communications AB
www.ericsson.com/bluetooth/

Extended Systems, Inc.
www.extendedsystems.com

GigaAnt
www.gigaant.com

GN Netcom
www.gnnetcom.com

HCV Enterprises
www.hcv.com.au

Hewlett-Packard
www.hp.com

IBM Corporation
www.ibm.com

i-data
www.i-data.com

Idmicro
www.idmicro.com

Impulse Software
www.impulsesoftware.com

Infineon Technologies AG
www.infineon.com

Intel Corporation
www.intel.com/mobile/technology/wireless.htm

Intersil
www.intersil.com

Johnson Controls
www.johnsoncontrols.com

Lesswire
www.lesswire.com

Logitech
www.logitech.com

Lucent Technologies, Inc.
www.lucent.com/micro/bluetooth/

MicroMedical Industries
www.micromed.com.au

Microsoft Corporation
www.microsoft.com/hwdev/bluetooth/

Motorola, Inc.
www.motorola.com/bluetooth/

NEC Corporation
www.necus.com

Nokia Corporation
www.nokia.com/bluetooth/

Panasonic
www.panasonic.com

Philips Semiconductors
www-us.semiconductors.philips.com

Plantronics
www.plantronics.com/bluetooth/

Red-M
www.red-m.com

RTX
www.rtx.dk

Samsung
www.samsung.com

Siemens AG
www.ic.siemens.com/networks/gg/isa/bts/index.htm

Signia Technologies
www.signiatech.com

Silicon Magic
www.simagic.com

Silicon Wave
www.siliconwave.com/bluetooth.html

Socket Communications
www.socketcom.com

Sony
www.sel.sony.com

Stonestreet One
www.stonestreetone.com

Symbol Technologies
www.symbol.com

Tadlys
www.tadlys.com

Taiyo Yuden International
www.t-yuden.com

TDK Systems Europe
www.tdksys.com/bluetooth/

Texas Instruments
www.ti.com

Toshiba Corporation
www.toshiba.com

Troy XCD
www.troyxcd.com

VoiceFlash Networks (a subsidiary of Registry Magic)
www.registrymagic.com

Widcomm
www.widcomm.com

Xircom
www.xircom.com