Bluetooth: Connecting Palm Powered® Handhelds

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Connecting Palm Powered Handhelds

Introduction

Because you're reading this, chances are you already know that Bluetooth is a short-range wireless connectivity protocol named after the tenth-century Viking king who united Scandinavia after years of fighting and destructive competition. Today Bluetooth is following the same symbolic path: to establish a common platform for communicating between disparate types of computing devices. Beyond the colorful origin of its name, Bluetooth is a compelling new radio technology that opens up a new world of opportunity for uniting and empowering mobile device users.

Palm OS® is the world leader in handheld computing platforms, and Palm is a committed member of the Bluetooth Special Interest Group (SIG). We feel that Bluetooth is ideally suited for connecting Palm Powered® handhelds to a wide variety of complementary devices, and we are deeply committed to helping Bluetooth become the standard for the new style of computing known as personal area networking. The purpose of this paper is to help customers and partners who are interested in wireless mobile devices, networks, and services understand the philosophy and structure of Bluetooth and how that applies to Palm Powered handhelds.

Some Things You Can Do with Bluetooth

Bluetooth is a powerful new technology that enables many new types of mobile computing solutions. Let's start by looking at how Bluetooth can make things simpler for you today. At Palm we see Bluetooth implementations falling loosely into four general scenarios, each of which presents opportunities for new products and services. Palm has defined these usage scenarios as follows:

1. Connecting a Palm Powered handheld to the Internet wirelessly through a cell phone
2. Enabling interoperability among devices of various types
3. Facilitating multiuser applications, collaboration, and information sharing across multiple handhelds
4. Providing local area network (LAN) and Internet access through stationary access points

Scenario 1: A Mobile Wireless Bridge to the Internet

The first usage scenario is one of the easiest to implement and understand. It is also one of the most attractive setups for mobile handheld users. The phone and handheld work in concert to give you access to remote information anywhere you go. With this elegant solution, you can leave your cell phone in your purse or backpack and use it via Bluetooth from your favorite applications.

Some of the most popular examples include:

- Accessing information on the Internet through any Web browsing, Web clipping, or WAP application, using the cell phone as a wireless modem
- Sending and retrieving e-mail or SMS messages
- Selecting and dialing phone numbers using your handheld's address book and picking up the call on your wireless Bluetooth headset

Granted, you could do these things before, but Bluetooth lets you do them faster and on the fly. It is as simple and convenient to use as your handheld computer, but with the added transparent communications power of your cell phone.

You need only "introduce" the phone and handheld to one another the first time the connection is established. After that you simply "tap 'n go" to get remote information or manage the cell phone. Bluetooth-enabled cell phones were widely available inby September 2001.

Scenario 2: Pervasive Interoperability

In this scenario Bluetooth-enabled devices of various types work seamlessly with one another to facilitate routine operations. Some practical situations include:

- Using HotSync® technology to install applications and synchronize your handheld and laptop while waiting in an airport lounge
- Sharing files and applications between devices at the touch of a button
- Printing documents on the nearest printer, even if you're not logged into the corporate network

The tools you need to do this—Bluetooth-enabled PC cards, USB adapters, and printers—are all commercially available. Native Palm Powered applications and custom third-party applications can be used with them easily.

Scenario 3: Collaboration

Now moving out of the realm of the ordinary, this scenario shows multiple Bluetooth-enabled devices in proximity to one another forming an ad hoc peer-to-peer network, sometimes called a piconet or personal area network (PAN). Here up to eight devices can communicate and share information simultaneously.

In these small networks, Bluetooth facilitates tasks that have either been unfeasible before now or possible only using network cables. Anyone who has tried to schedule a meeting among a group of busy professionals, for example, will immediately appreciate the significance of an application that can handle connections around the room automatically. Examples of collaborative computing include:

- Shared calendar or free-time finder applications
- Meeting-room and workgroup software for note taking, chat, and task assignment
- Multiplayer games

To promote new applications in the field of cooperative computing, Palm has focused its attention on the Palm™ Bluetooth API, a set of more than 85 functions that developers can use to write applications of any kind.

Just as the networking of personal computers (PCs) created entire galaxies of unexpected new uses, products, and services, we expect wirelessly enabled information-sharing and collaboration capabilities to do the same for handhelds.

Scenario 4: "Hot Spot" Networks

For public and corporate Internet connections, the Bluetooth access point concept enables the customer to access remote information as simply and easily as if it were on the local device.

In this scenario an unobtrusive LAN access point positioned permanently in a room can provide wireless connectivity simultaneously to multiple devices within range (10 to 100 meters, depending on the model). An access point can connect devices to an intranet as well as to the Internet. These hot spots can be installed in meeting rooms, classrooms, malls, airport lounges, hotel lobbies, and the like, creating a "cloud" of wireless access opportunities—public, private, and semiprivate—to personal and location-specific information. Examples using Bluetooth for network access include:

- Using access points for Web browsing or e-mail download
- Connecting to your company's intranet from inside a conference room
- Downloading or uploading homework assignments in a Bluetooth-enabled classroom
- Checking the local specials at a Bluetooth hot spot in a shopping mall

Some access points even offer notification services, such as "dresses on sale on the first floor" or "you have new e-mail." As a user of Palm Bluetooth software, you will receive such notifications only if you choose to. An endless stream of random soliciting and "ethernoise" from every shop and vendor within range will not be the experience of Palm Powered handheld users.

Why We Like Bluetooth So Much

One of the reasons why Palm is so successful is that we have always treated handhelds as handhelds. We recognized that the handheld was a new form of computing with rules of its own and we never tried to squeeze into our pocket all the functionality of a full-sized PC. Size, weight, and battery life are critical to the success of mobile products. Instead of approaching the handheld from a PC-centric perspective, in which more features are always better, we worked within the design requirements dictated by the device itself: simplicity, wearability, and mobility. As connectivity technologies began to emerge, that mantra evolved over time into simplicity, wearability, and connectability.

Since the introduction of the first PalmPilot™ organizer in 1995, all decisions about whether to make a change or add a particular functionality to the Palm OS have been considered in that light. Too often the instinct is to throw the newest technology at every possible problem, and yet indiscriminate application of technology produces some awful results: When the only tool you've got is a hammer, every problem looks like a nail. The reality is, of course, that every problem is not a nail.

That's one of the main reasons why we like Bluetooth so much. As a technology it meets all the requirements for seamless integration in a very small portable device. As a platform for customer solutions, it paves the way for uses in places that make sense in mobile computing.

Beyond that, each device in the Bluetooth solution chain is expected to keep doing what it does best. This allows the solution as a whole to leverage specialized technology across devices without diminishing the performance or degrading the form factor of any of them. The integration of Bluetooth is very much in keeping with the original Palm design philosophy, which respects the integrity of a device and the wisdom of having form follow function.

To keep Palm on its path of simplicity, wearability, and connectability, all new technologies and functionalities must offer all the qualities that continue to delight our customers. Whether people will use Bluetooth will depend on whether doing so adds convenience and on how successful we, as vendors, are in making the solutions attractive. Palm's approach to Bluetooth is to make it work as a useful part of our customers' lives—and to do that so transparently that users can ignore the technology, forget about the devices, and simply get on with the business of the day.

Interoperability

Bluetooth has redefined the scope of the term interoperability. It means that devices running Bluetooth will work with one another because they respect an established industry standard. Radio transceivers recognize each other, and software applications can share information. End-to-end Bluetooth solutions usually require products from several different sources, and each component counts on specialized functions in the others. For this to happen, vendors need to interact with one another in a way that is unprecedented in the computing industry. To provide the solutions that customers care about, manufacturers have to create hardware components that are compatible at a technical level and complementary on a functional level.

Interoperability Benefits Our Shared Customers

What counts for end users is that Bluetooth interoperability makes computing solutions smoother, because they are wireless and because they provide new and exciting ways to manage the information that's important to people.

Like any computing technology, Bluetooth is appealing to end-user customers not because of architectural prowess, or because it offers a 128-bit encrypted radio communications protocol, or because it operates in the 2.4GHz radio band. Its importance lies in what it enables people to do. Wireless solutions are simply a means for end users to accomplish personal and professional tasks by connecting electronic devices without wires. People will make connection-oriented tasks a regular part of their routine if—and only if—the convenience of doing so is no longer an issue.

The solution is not the absence of wires. You don't establish a connection without a purpose. Bluetooth is relevant because it makes otherwise-incompatible technologies attractive to use in new ways. It enables you to use your cell phone as a trouble-free wireless modem for your PDA or laptop while you're traveling. You can print a document easily as you walk past a printer, check your e-mail while sitting in your favorite chair in the living room, and send and receive SMS messages. The combinations are endless, even if many of these tasks are possible by other means with the equipment we have today.

Palm believes that people will adopt new technology when it becomes so portable and easy to use that you don't have to think about it anymore. Bluetooth starts by taking the connecting cables out of the picture, removing a significant barrier to the ease of use that we deserve.

Bluetooth and 802.11

Bluetooth operates at 1Mbps (megabit per second). Although it is slower than other wireless protocols, including Ethernet 802.11b, Bluetooth has a feature set that is appropriate for mobile devices; it minimizes battery usage, makes the most of handheld processing power, and yet still manages to be faster than most home DSL services (144Kbps, or kilobits per second, to 1.5Mbps) and ISDN lines (128Kbps). The Bluetooth chipset is smaller than that of 802.11, and most people believe that it will ultimately be less expensive because of its simpler design.

Many industry analysts have predicted the demise of Bluetooth because of the advantages and high acceptance rate of wireless Ethernet 802.11. The fact is that Bluetooth and 802.11 will co-exist, both in the marketplace and in some kinds of computing devices. Today's laptop computers are being made with chipsets that support both 802.11 and Bluetooth—because each technology has its time and

place for that kind of computer. At the same time, Bluetooth is becoming prevalent in cell phones, but 802.11 will never be. Wireless Ethernet has had a significant lead in the market, and the technology is now mature enough that many enterprises are adopting it for on-campus use. In any case, Palm Powered devices support both 802.11 and Bluetooth, leaving options open for solutions in all situations.

Bluetooth may have an uphill battle to achieve corporate adoption, but that does not exclude us from promoting Bluetooth where it is applicable to mobile users. Some of the most common uses of Bluetooth are the most relevant to Palm OS customers on the move: digital cameras, cell phones, other PDAs, printers, slide show projectors, home entertainment centers, and more.

Palm has always distinguished between three separate and distinct forms of computing: servers, PCs, and handhelds. Each has its own rules and strengths and serves different purposes. Servers are optimized for storing and processing large amounts of information, either for a corporation or a Web site. PCs are ideal for heavy-duty information creation—word processing, spreadsheets, presentations, and the like. The handheld, on the other hand, is optimized for information management and access, especially on the go. Its focus is on helping people and businesses access and manage the flow of information, anywhere, anytime. Palm Powered handhelds are ideal for targeting information on the fly—you know what you want and where it is and you can make a quick connection to get it. That's one reason why we developed Web clipping, which gets mobile users the information they need more quickly than does classic Web browsing, which is also fully possible on any Palm Powered handheld.

How Palm Fits in a Networked World

What you need above all in this kind of world is flexibility—the ability to accommodate, incorporate, and interoperate with as diverse a colony of devices as possible. In short, you need a network that is as protocol-, device-, and OS-agnostic as possible—not unlike the Palm OS itself. It is for good reason that we call the Palm handheld the hHandheld of cChoice. We encourage and promote choice as a general principle, consistently choosing open standards over proprietary ones. As a result, Palm handheld users can choose from the more than 10,000 applications and 100 hardware add-on modules, created by various members of the Palm Economy (now numbering more than 155,000 developers), to customize their handhelds to suit their individual needs. All this choice has resulted in unprecedented market acceptance and penetration in a space where many others have failed. These same principles of openness and choice will work for Bluetooth, driving market acceptance and creating the same growth dynamic, as they have for Palm Powered solutions.

Bluetooth Architecture and Operation

The Bluetooth system consists of a radio unit and associated software that have been integrated into the Palm OS. The Bluetooth radio operates in the 2.4GHz ISM (Industrial, Scientific, and Medicine) band and transmits from a minimum of 1mW (0dBm) of power up to 100mW (20dBm), depending on the device class. The physical transmission range of the radio is anywhere from 10 to 100 meters (30 to 300 feet), depending on the power of the transmitter at the antenna. Bluetooth uses frequency hopping for low interference and fading, TDD (Time-Division Duplex) scheme for full-duplex transmission, and GFSK (Gaussian Frequency Shift Keying) for transmission modulation.

The Bluetooth protocol uses a combination of circuit and packet switching. Circuit switching provides a dedicated connection, whereas packet switching shares a circuit by multiplexing it with other packet-switched connections.

This combination enables Bluetooth to effectively handle voice data, which is time-sensitive; it also maximizes efficiency by allowing multiple data streams to share the same data channel. The channel is slotted, and slots can be reserved for synchronous packets. The Bluetooth protocol stack can support an asynchronous, connection-less (ACL) link for data and up to three simultaneous, synchronous, connection-oriented (SCO) links for voice. It also supports a combination of asynchronous data and synchronous voice. Each voice channel supports a 64Kbps synchronous channel in each direction. The asynchronous channel can support a maximum 723.2Kbps uplink and 57.6Kbps downlink (or vice versa) or 433.9Kbps symmetrical links.

The basic components of the stack are a physical-level protocol (Baseband) and a link-level protocol (LMP) comprising a link manager and link controller. The adaptation layer (L2CAP) enables upper-layer protocols to interact with the lower Bluetooth stack. The upper-layer interface depends on the way the two layers are implemented and used with an application.

The Palm Bluetooth stack architecture is shown here:

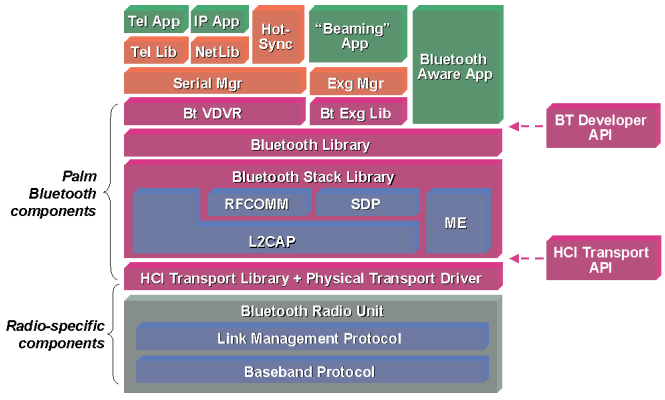

Figure 1 – Bluetooth stack and components within Palm OS

From the bottom up:

Component	Explanation
Bluetooth Radio Unit	This is the only component shown above that is not really part of the Palm Bluetooth stack. Palm OS licensees and independent third parties supply radio components, which contain Bluetooth's Baseband Protocol and Link Management Protocol. Palm Bluetooth software is designed to be hardware-agnostic, using the Host Controller Interface (HCI) as an abstraction layer.
HCI Transport Library, Physical Transport Driver	The Host Controller Interface provides abstraction between the stack and the underlying hardware implementation. The HCI supports various hardware solutions, ranging from accessories that can be plugged into a serial port, to various types of expansion cards, and even radios integrated on a device's motherboard. For each hardware implementation, a Bluetooth transport driver provides this abstraction.
HCI Transport API	The Bluetooth Transport API provides a programmer's interface to the HCI Transport Library.
Bluetooth Stack Library	The Bluetooth stack constitutes the core of the Palm Bluetooth software components: RFCOMM, Service Discovery Protocol, Logical Link Control and Adaptation Protocol, and connection Management Entity (see **Supported Profiles** below).
Bluetooth Library, Developer API	This is the programmer's interface to the Bluetooth stack itself. The API serves as an abstraction layer to shield developers from stack specifics and potentially complicated operations.
Bluetooth Virtual Driver	A new virtual driver (serial) for Bluetooth has been added to Palm OS. It emulates the behavior of a standard serial port when connecting to other Bluetooth devices. *This component implements the Serial Port Profile and is written to the Palm Bluetooth Library API.*
Exchange Library	The Palm Bluetooth stack provides integration with the Palm OS 4.0 Exchange Manager for sending data over Bluetooth using a Send menu item in applications. *This component implements the Object Push profile and is written to the Bluetooth Palm Library API.*
Applications	Applications range from those provided in the core Palm OS, to those provided by licensees and third-party developers. Applications can be written using (a) the Bluetooth API (Bluetooth-aware apps), (b) the Bluetooth virtual serial driver ("serial" applications), (c) the Exchange Manager/Bluetooth Exchange Library (for easiest data exchange mechanism), or (d) TCP/IP (which requires no modification at all). One of our goals is to create a situation wherein applications written for Palm OS work on devices from different licensees, suppliers, and hardware vendors.

Palm Bluetooth Profiles

The Palm Bluetooth stack supports most major Bluetooth profiles, providing a data-oriented feature set that is particularly relevant for handheld computing. Other Bluetooth 1.1 profiles and functionality may be added using the Palm Bluetooth API, depending on the desired profile. Palm Bluetooth software supports the following profiles:

Profile	Explanation
Generic Access	The main purpose of the Generic Access Profile (GAP) is to describe the use of the lower layers of the Bluetooth protocol stack (LC and LMP) and to describe security-related alternatives and higher layers (L2CAP, RFCOMM, and OBEX).
Service Discovery	The Service Discovery Profile (SDP) defines the protocols and procedures used by a service discovery application to locate services in other Bluetooth-enabled devices using the Bluetooth Service Discovery Profile.
Serial Port	The Serial Port Profile (SPP) defines the protocols and procedures used by devices using Bluetooth for RS-232 (or similar) serial cable emulation. The scenario covered by this profile deals with legacy applications using Bluetooth as a cable replacement through a virtual serial port abstraction.
Dialup Networking	The Dialup Networking (DUN) profile defines the protocols and procedures used by devices implementing the usage model called "Internet Bridge." The most common examples of such devices are modems and cellular phones.
LAN Access Point	The LAN Access Point (LAP or AP) profile defines LAN access using PPP over RFCOMM.
Generic Object Exchange Profile	The Generic Object Exchange Profile (GOEP) defines the protocols and procedures used by applications that provide object exchange capabilities. The usage model can be, for example, synchronization, file transfer, or Object Push.
Object Push	The Object Push profile is used for data exchange operations, namely OBEX. This profile makes use of the generic object exchange profile. Palm Bluetooth uses Object Push to send and receive business cards, calendar appointments, and other data files.

Bluetooth Security

Bluetooth provides two levels of access to services: trusted device and un-trusted device. The trusted device has unrestricted access to all services. The un-trusted device does not have a fixed relationship, and its access to services is limited. The Bluetooth Generic Access Profile, which forms the basis for all other profiles, defines three security levels:

- Level 1 (nonsecure, completely open). No security is initiated, and all devices can gain access.
- Level 2 (service-level, or application-enforced, security). The Bluetooth device initiates security procedures at the higher layers after the communications channel is established.
- Level 3 (link-level-enforced security). The Bluetooth device initiates security procedures before the channel is established, when another device attempts to establish a radio connection.

Palm Bluetooth provides Levels 1 and 2 security measures at the services-application layer.

Example of Level 2 Security

When using Level 2 security, a Bluetooth device starts the authentication process (also widely known as "pairing") after receiving a request to establish a peer-to-peer connection at either the L2CAP or the RFCOMM layer. In this

example RFCOMM will serve as the trigger point in invoking security measures instigated by the LAP as follows:

1. The LAP uses the unique address provided by the PDA when the RF connection was established.
2. The LAP gets a personal identification number (PIN)—also called a passkey—either entered manually by the user or stored in memory.
3. The LAP generates a random number and sends it to the PDA.
4. Both sides then create the unique number (link key) comprising the PIN, the PDA address, and the random number generated by the LAP.
5. The handheld sends this number back to the LAP, which then compares it to the one it generated. If they match, the PDA is authenticated.

Palm's initial implementation of Bluetooth will support security Levels 1 and 2. At Level 2 pirate devices cannot extract data from a Palm Powered device, thus providing developers with application-level security for those applications that need it.

Developer Support

To encourage adoption of the protocol and generate demand, the Palm Platform Solutions Group is working diligently to encourage the rapid proliferation of Bluetooth applications and solutions.

Through the Palm Bluetooth Seeding Program, we provided key developers with Bluetooth-enabled units, software, and direction. Now the Palm Bluetooth software is available to a much wider range of Palm developers, who will be able to acquire Bluetooth accessory hardware from a variety of supported vendors. Our purpose in doing this is not only to ensure that software development proceeds in parallel with product and stack development, but also to work with our partners and developers to get their input throughout the process.

The SIG-certified Palm Bluetooth stack offers a simple and powerful Bluetooth API (Application Protocol Interface) for the Palm OS to ensure that Bluetooth-based software applications will work seamlessly in all Palm Powered handhelds that run the Palm stack. In addition, we are working closely with licensees and key market partners to ensure that Palm OS Bluetooth solutions from different providers offer a Palm-compatible API set.

The Palm Platform Solutions Group is offering Bluetooth as an extension to the Palm OS 4.x software. This will allow licensees to easily incorporate Bluetooth into their products or release add-on Bluetooth solutions for current products. Palm has designed its Bluetooth API as a software interface that abstracts away the technical difficulties of dealing with connections and data exchange between devices, allowing developers to write Bluetooth-aware applications far more easily. Developers don't have to worry about low-level layers at all.

Product Description

General Overview of the Palm Bluetooth Software

- Certified Bluetooth™.1 compatible stack
- Add-on software for Palm OS 4.x
- May be installed in ROM or installed in RAM via HotSync operation
- Available in six languages: English, French, Italian, German, Spanish, and Japanese
- Provides serial and cell phone connections, HotSync, and Internet/network access
- Supports data exchange, collaborative applications, and games
- Handles device discovery, configuration, pairing, passkey entry, data transmission, and more

Supported Profiles

- RFCOMM, Logical Link Control Access Profile (L2CAP), and Service Discovery Profile
- Generic Access Profile (GAP)
- Serial Port Profile (SPP)
- Dialup Networking (DUN) profile
- LAN Access Point (LAP) profile
- Generic Object Exchange Profile (GEOP)
- Object Push profile

Developer Kit Tools

- The Palm Bluetooth developer API
- Host Controller Interface (HCI) hardware abstraction layer
- Bluetooth Exchange Library (to send data via Bluetooth)
- Software components, samples, test tools, and applications
- HCI drivers for serial connectors supplied as source code (can be used as models for other transport types)
- Bluetooth API Library and Transport documentation
- Programmer's Companion guide (coming soon)

The Future

We predict Bluetooth hardware's further integration, until all processor functions and radio hardware eventually reside on a single, integrated circuit. Hardware and software vendors are already moving in this direction.

With the speed of technical development now measured in "Internet time," we foresee the emergence of new Bluetooth hardware platforms with integrated software components already ported to popular operating systems. The cost reductions realized by this type of integration will enable developers to concentrate virtually all of their efforts on their product, reducing time-to-market and enhancing cost-effectiveness still further.

Palm is committed to helping Bluetooth succeed as the preferred global wireless standard for the handheld industry. To this end we are working with licensees and manufacturers of phones, laptops, printers, and Bluetooth access points to lead development of the Bluetooth standard and create Bluetooth devices of all kinds that work instantly and seamlessly with one another.

The "killer application" hasn't yet made its appearance, but we can be sure that just as LANs spurred the growth of the PC market and the Internet, wireless technologies will push handhelds in new directions—assuming wireless capability actually adds convenience and lets users do more, faster. When things move as quickly as they do in this industry, real user models sometimes get lost amid the technical terms, media, and marketing. It's easy to forget the customers and their real needs and to simply apply technology for technology's sake. That's a sure-fire recipe for failure. One of the reasons why Palm remains the handheld leader is that we keep our focus firmly on the customer and use technology intelligently to solve real problems for real people. So long as we all use that approach for Bluetooth, we are confident that our chances for success are assured.

For more information please check the following Web sites:

www.palmos.com/bluetooth

www.palmos.com/devzone

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