WHITE PAPER

April 2003

Prepared by
Smart Handheld Group

Hewlett-Packard
Company

CONTENTS

invent

Bluetooth Technology Overview

Bluetooth is a Radio Frequency (RF) specification for short-range, point-to-point and point-to-multi-point voice and data transfer. Bluetooth will enable users to connect to a wide range of computing and telecommunications devices without the need for proprietary cables that often fall short in terms of ease-of-use. The technology represents an opportunity for the industry to deliver wireless solutions that are ubiquitous across a broad range of devices. The strength and direction of the underlying Bluetooth standard will ensure that all solutions meet stringent expectations for ease-of-use and interoperability.

The purpose of this White Paper is to provide an overview of Bluetooth technology, insight into product timeframes as well as information on how Bluetooth is positioned relative to other wireless technology standards.

Notice

The information in this publication is subject to change without notice.

HEWLETT-PACKARD COMPANY SHALL NOT BE LIABLE FOR TECHNICAL OR EDITORIAL ERRORS OR OMISSIONS CONTAINED HEREIN, NOR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM THE FURNISHING, PERFORMANCE, OR USE OF THIS MATERIAL.

This publication does not constitute an endorsement of the product or products that were tested. The configuration or configurations tested or described may or may not be the only available solution. This test is not a determination of product quality or correctness, nor does it ensure compliance with any federal, state or local requirements. Hewlett-Packard Company does not warrant products other than its own strictly as stated in Hewlett-Packard product warranties.

Bluetooth Technology Overview

Fifth Edition (April 2003)
Fourth Edition (November 2000)
Third Edition (December 1999)
Second Edition (September 1999)
First Edition (June 1999)
1000/A

BLUETOOTH TECHNOLOGY OVERVIEW

A global specification for wireless connectivity

Bluetooth, named for Denmark's first Christian king and not a dire dental condition, is the name of a technology specification for small form factor, low-cost, short-range radio links between PCs, handhelds, mobile phones, and other computing and electronic devices. The Bluetooth SIG (Special Interest Group) is an industry group consisting of leaders in the telecommunications and computing industries that are driving development of the technology and bringing it to market. Over 2000 companies have executed the Bluetooth adopter's agreement and are members of the Bluetooth SIG.

technical features

Bluetooth technology provides a 10-meter personal bubble that supports simultaneous transmission of both voice and data for multiple devices. Up to 8 data devices can be connected in a piconet, and up to 10 piconets can exist within the 10-meter bubble. Each piconet supports up to 3 simultaneous full duplex voice devices (CVSD).

The gross data rate is 1Mb/s, but the actual data rates are 432Kbps for full duplex transmission, 721/56Kbps for asymmetric transmission, and 384 Kbps for TMS2000 transmission. A Time-Division Duplex scheme is used for full-duplex transmission.

Bluetooth wireless technology is designed to be as secure as a wire with up to 128-bit public/private key authentication, and streaming cipher up to 64-bit based on A5 security. The encryption strength can be very robust which is good for establishing a secure link, but there may be export problems when shipping from the US. Different hardware with smaller encryption key lengths may be required to meet US export controls.

NOTE:

A piconet is a collection of devices connected via Bluetooth technology in an ad hoc fashion. A piconet starts with two connected devices, such as a portable PC and cellular phone, and may grow to eight connected devices. All Bluetooth devices are peer units and have identical implementations. However, when establishing a piconet, one unit will act as a master and the other(s) as slave(s) for the duration of the piconet connection.

Bluetooth logo program

One of the goals of the Bluetooth SIG is to make wireless connections easy and simple to use. To ensure the best possible customer Bluetooth experience as well as interoperability with other Bluetooth devices, the Bluetooth SIG is developed a logo program, which validates compliance with the published Bluetooth specification as well as interoperability with other Bluetooth devices. Bluetooth devices that successfully complete the Bluetooth testing criteria have the right to bear the official Bluetooth logo. The Logo program is very comprehensive in its scope. It includes not only radio and protocol interoperability, but also usage profiles. Profile interoperability testing must be performed on products to obtain a Logo and the Logo will specify which usage profiles the product will support. This level of interoperability testing and qualification is unique for the industry and is being done to ensure devices can execute applications together and meet end-user expectations.

supported Bluetooth profiles

Bluetooth supports a variety of profiles. The following profiles are currently available with Bluetooth. For information about the most current profiles supported by Bluetooth, visit the Bluetooth Web site at **www.bluetooth.com**.

basic imaging

This profile defines a method for transferring images from one Bluetooth device (such as a camera) to another Bluetooth device (such as a desktop PC) for storage, editing, or printing.

basic printing

This profile enables simpler printing from a Bluetooth device to a Bluetooth printer. Using this profile does not require specific printer drivers. Instead, the printer has the capability to decipher the information sent to it so that it can produce the desired format.

cordless telephony

With this profile, a Bluetooth device that has voice capability can act as a cordless phone when it is in the vicinity of a Bluetooth access point or other Bluetooth device that has a connection to a voice network.

dial-up networking

This profile defines the link between a cell phone and a computer. The profile is defined so the computer can either initiate the data call or receive the data call depending on the user setup.

file transfer

This application allows one Bluetooth device to browse a file system on, create or delete files/folders on, or transfer files from/to another Bluetooth device.

generic access

These are generic procedures related to discovery, link establishment, and security levels between two Bluetooth devices. This profile defines the general procedures used for establishing connections to other Bluetooth devices that accept connections and service requests regardless of the devices' manufacturer.

generic object exchange (OBEX)

This profile defines procedures used by applications performing object exchanges. It defines these processes for transactions such as file transfers, object pushes and pulls, and synchronization.

handsfree

This profile enables your vehicle to communicate with a mobile Bluetooth device that comes in its vicinity.

hard copy replacement

This profile enables a Bluetooth device to communicate with a Bluetooth printer directly for advanced printing capabilities, including management of print jobs, access to specific printer drivers for greater control over formatting, and other printing features. Specific printer drivers are required to use this profile.

headset

This profile enables monaural audio to be transferred between one Bluetooth device, such as a mobile phone or a handheld device, and a headset. The most common uses for this profile include making phone calls and recording voice data using a wireless headset.

human interface device

With this profile, input devices, such as a keyboard or mouse, can be wirelessly connected to a Bluetooth device.

intercom

Two Bluetooth devices that have voice capability can communicate directly with each other without the need to connect to a voice over IP network or a cellular network. The experience is similar to using two-way radios.

LAN access

This application relates to how Bluetooth devices connect to LANs using Point-to-Point Protocol (PPP). This function allows a Bluetooth device to connect to Bluetooth devices that already participate in a LAN. After you are connected, you will have access to that LAN's resources such as network printers.

object push

This profile defines the process of pushing or pulling small objects such as a business card, calendar appointment, or a task from one device to another.

personal area networking

This personal area networking (PAN) profile concentrates on general Internet protocol (IP) networking (including security) in an ad hoc connection environment between Bluetooth devices. Basically it is the ability to set up your own personal network with other Bluetooth devices such as printers, phones, desktops, and fax machines. The size of the network is limited to eight devices (known as a piconet).

With a PAN, users can chat with each other, play games against each other, and share or exchange information between their devices.

serial port

This allows the use of an emulated serial port for applications that traditionally use a wired serial port interface, such as synchronizing information between a handheld device and a desktop PC using Microsoft™ ActiveSync, or printing to a Bluetooth printer.

service discovery

This application discovers services available in other Bluetooth devices. This establishes whether or not one device can communicate with the other and to what extent.

synchronization

This profile allows for the exchange of personal information between devices such as calendar and phonebook data. Also, it defines the ability of a mobile phone or computer to automatically start synchronization when two Bluetooth devices are in range. This synchronization can occur even if the two devices do not have compatible operating systems or applications. These profiles call for the only applications possible under the current version of the specification. Others will be added to the specification over time.

Within the handheld, desktop, and notebook computer industry, the general access, service discovery, serial port, dial-up networking, LAN access, object exchange, object push, file transfer, and synchronization profiles are likely to be implemented.

FEATURES AND BENEFITS

BLUETOOTH FEATURES AND BENEFITS SUMMARY

Feature	Benefit
Uses 2.4 GHz ISM frequency band	▪ Ensures Bluetooth devices can be used worldwide.
Piconet supports up to eight connected devices where one acts as a master and all others, slaves	▪ Multiple piconets (scatter mode) are able to connect to each other via the master devices thus increasing the total number of connected devices beyond eight.
Bluetooth will enable wireless connectivity between a notebook computer and a cellular phone	▪ Simplifies wireless connectivity to the Internet or corporate network by eliminating the hassle of proprietary cables connecting cellular telephones and notebook computers. ▪ Since Bluetooth is a worldwide standard, wireless wide area network connectivity can be delivered at a much lower cost than the alternative of integrating cellular communications into notebook computers.
Bluetooth devices are able to communicate to other devices within a ten meter range	▪ Limiting range to ten meters helps reduce power requirements making Bluetooth a practical technology for a broad range of battery operated devices like notebook computers and cellular phones. ▪ Ten meters is adequate for all wireless personal area networking applications Bluetooth has been designed to enable while minimizing other burdens on Bluetooth enabled devices such as cost and power consumption.
Public/Private key authentication and encryption are key elements of the Bluetooth standard	▪ Provides a degree of security for communications between Bluetooth devices.
The Bluetooth logo program is a key initiative within the Special Interest Group (SIG)	▪ The Bluetooth logo program will provide the industry with a mechanism to identify Bluetooth enabled devices that meet stringent compliance criteria. ▪ The Bluetooth Logo Program will ensure seamless interoperability between devices and enhance overall ease-of-use and customer experience.
Does not require line of site between devices to establish a connection	▪ Provides greater flexibility and ease-of-use over wireless technologies like IrDA, which require a line of site between devices. ▪ Allows connections to be established through barriers

Table 1 - Features and Benefits

BLUETOOTH ISSUES

frequency usage conflicts

Bluetooth radios operate in the unlicensed 2.4-GHz band. The problem that Bluetooth technology will face is that even at 2.4 GHz, the bandwidth is finite. Because this is an unlicensed band, any number of devices can use it. The 2.4 GHz frequency range used by Bluetooth is currently shared by other wireless communication standards such as 802.11b LANs, HomeRF LANs, and urban and suburban wireless telecommunications systems such as Metricom. At some point, devices start interfering with one another. As the number of open channels decrease, the devices have to wait to transmit until they have a clear channel. Because the data is packetized, these delays will be perceived as a slowdown.

Furthermore, 2.4 GHz is also the resonant frequency of water molecules and therefore the operating frequency for microwave ovens. A microwave oven is an effective jammer for low-power 2.4-GHz devices. If you're working in the vicinity of one, it can easily cut throughput by 75 percent. A leaky oven can obliterate communications with all 2.4-GHz devices in the area.

The Bluetooth radio uses a fast acknowledgement and frequency hopping transceiver that hops at 1600/sec to combat interference and fading. Bluetooth radio modules avoid interference from other signals by hopping to a new frequency after transmitting or receiving a packet. Compared with other systems operating in the same frequency band, the Bluetooth radio typically hops faster and uses shorter packets. This makes the Bluetooth radio more robust than other systems. Bluetooth also uses short packages and fast hopping to limit the impact of domestic and professional microwave ovens. Use of Forward Error Correction (FEC) limits the impact of random noise on long-distance links. The encoding is optimized for an uncoordinated environment.

compliance concerns

Other organizations, including the Federal Aviation Administration (FAA), are concerned about Bluetooth as well. However, Microwave oven usage in aircraft is accepted as normal and safe and Bluetooth emissions are comparable or lower. The operating airline has the ultimate responsibility for approving Bluetooth, and testing by the SIG members (including Intel and Boeing) is currently in progress. Bluetooth technology uses the same bandwidth frequency that several local wireless technologies use, which could mean data collisions and lost data.

BLUETOOTH TECHNOLOGY USAGE MODEL

Bluetooth technology was designed to be small and inexpensive. Bluetooth technology has no line-of-sight requirements making it a potential replacement for infrared ports. Bluetooth can operate through walls or from within your briefcase. Portable PCs can wirelessly connect to printers, transfer data to desktop PCs or PDAs, or interface with cellular phones for wireless WAN (Wide Area Networking) access to corporate networks or the Internet.

cable replacement

Bluetooth will enable users to connect a wide range of computing and telecommunications devices easily and simply, without the need to buy, carry, or connect many proprietary cables. It delivers opportunities for rapid ad hoc connections, and the possibility of automatic, unconscious, connections between devices. It will virtually eliminate the need to purchase additional or proprietary cabling to connect individual devices. Because Bluetooth can be used for a variety of purposes, it will also potentially replace multiple cable connections via a single radio link. It will allow users to think about what they are working on, rather than how to make their technology work. For instance, Bluetooth radio technology built into both the cellular telephone and the laptop would replace the cumbersome cable used today to connect a laptop to a cellular telephone.

other Bluetooth usage models and applications

Printers, PDA's, desktop computers, fax machines, keyboards, joysticks and virtually any other digital device can be part of the Bluetooth system. But beyond un-tethering devices by replacing the cables, Bluetooth radio technology provides a universal bridge to existing data networks, a peripheral interface, and a mechanism to form small private ad hoc groupings of connected devices away from fixed network infrastructures.

the Internet bridge

Access the Internet regardless of the connection. Use your laptop to access the Internet wherever your are, and regardless if you're cordlessly connected through a mobile phone (cellular) or through a wire-bound connection (PSTN, ISDN, LAN, xDSL).

the automatic synchronizer

Automatic background synchronization keeps you up-to-date - automatic synchronization of your desktop, portable PC, notebook (PC-PDA and PC-HPC) and your mobile phone is made easier with Bluetooth. For instance, as soon as you enter your office the address list and calendar in your notebook will automatically be updated to agree with the one in your desktop, or vice versa.

the interactive conference (file transfer)

Connect all participants for instant data exchange - in meetings and conferences, you can share information instantly with all participants, and without any wired connections. You can also cordlessly run and control, for instance, a projector. This is not officially supporting in the 1.0 specification, but other companies are working on this application.

the instant postcard

Send instant photos and video clips from any location - wirelessly connect your camera to a Portable PC. Add comments and send them instantly to a receiver anywhere in the world.

the cordless computer

Connect your Portable PC to peripherals or to the LAN - Bluetooth enables a cordless connection of your Portable PC to printers, scanners and to the LAN. Increase your sense of freedom in everyday work by cordless connection of your mouse and keyboard to your Portable PC.

use e-mail while your portable PC is still in the briefcase

When your portable PC receives e-mail, you'll get an alert on your mobile phone. You can also browse all incoming e-mails and read those you select in the mobile phone's display.

compose e-mails on your portable PC while you're on an airplane

As soon as you've landed and switched on your mobile phone, all messages are immediately sent

POSITIONING WIRELESS TECHNOLOGIES

With the number of wireless communication standards emerging, it is important to understand how each of the standards compare. The HP perspective on wireless technology is that there are different real world usage scenarios that demand different technologies. With respect to Bluetooth, the question, from the HP perspective, is not whether or Bluetooth is better, but rather how Bluetooth complements several of the other wireless technology choices.

To understand relative positioning of each wireless standard it is important to first understand there are three primary usage scenarios for wireless connectivity:

- Wireless Personal Area Networking (WPAN)
- Wireless Local Area Networking (WLAN)
- Wireless Wide Area Networking (WWAN)

WPAN describes an application of wireless technology that is intended to address usage scenarios that are inherently personal in nature. The emphasis is on instant connectivity between devices that manage personal data or which facilitate data sharing between small groups of individuals. An example might be synchronizing data between a PDA and a desktop computer. Or another example might be spontaneous sharing of a document between two or more individuals. The nature of these types of data sharing scenarios is that they are ad hoc and often spontaneous. Wireless communication adds value for these types of usage models by reducing complexity (i.e. eliminates the need for cables).

WLAN on the other is more focused on organizational connectivity not unlike wire based LAN connections. The intent of WLAN technologies is to provide members of workgroups access to corporate network resources be it shared data, shared applications or e-mail but do so in way that does not inhibit a user’s mobility. The emphasis is on a permanence of the wireless connection within a defined region like an office building or campus. This implies that there are wireless access points that define a finite region of coverage.

Whereas WLAN addresses connectivity within a defined region, WWAN addresses the need to stay connected while traveling outside this boundary. Today, cellular technologies enable wireless computer connectivity either via a cable to a cellular telephone or through PC Card cellular modems. The need being addressed by WWAN is the need to stay in touch with business critical communications while traveling.

The following table summarizes each wireless connectivity usage scenario by wireless technology.

WIRELESS USAGE SCENARIOS BY TECHNOLOGY

Wireless Standard	Application Category	Usage Scenario
Bluetooth	Wireless Personal Area Networking (WPAN)	▪ I want to instantly connect my notebook computer to another Bluetooth enabled notebook to transfer a file. ▪ I want to collaboratively work on a document using Microsoft NetMeeting, where meeting participants use notebooks that are wirelessly connected via Bluetooth. ▪ Using a Bluetooth enabled, wireless headset, I want to listen to a CD playing on my notebook computer while it is in my briefcase. ▪ I often travel to a remote site and want to walk up to a shared printer, connect and print a document without having to physically connect using a standard printer cable. ▪ I want to connect to the Internet via a cellular phone without having to take my telephone out of my briefcase ▪ I want to set up an ad hoc network with my handheld device
802.11b	Wireless Local Area Networking (WLAN)	▪ I want to always be connected to my corporate LAN while moving about in my office building or campus. ▪ Usage demands that I have access to corporate network data at performance levels equivalent to a wire based LAN connection. ▪ I want to access Hot Spots such as in airports and coffee shops.
Cellular Technologies	Wireless Wide Area Networking (WWAN)	▪ I want access to e-mail and web resources while traveling away from the home office.

Table 2 – Wireless Usage Scenarios by Technology

Bluetooth is emerging as the preferred wireless technology for WPAN. The only other competing technology is IrDA, which has a number of shortcomings that make it much more difficult to use than Bluetooth. Enhanced IrDA support is expected in Windows 2000 which will improve usability for file transfer and synchronization. Given the fact that IrDA will enjoy a significant edge over Bluetooth in terms of installed base, IrDA will likely continue to be integrated into notebook computers and other handheld devices. As the installed base for Bluetooth grows the need for IrDA will likely decrease; however, this is not expected for several years. For the near to medium term IrDA and Bluetooth will likely coexist.

For WLAN, 802.11 is emerging as the preferred technology in the commercial space. Higher throughput, longer range and other characteristics make it better suited for WLAN than Bluetooth.

The following tables provide a comparison of each technology.

WIRELESS TECHNOLOGIES – ADVANTAGES AND DISADVANTAGES

Technology	Advantages	Disadvantages
Bluetooth	No line of site restrictions as with IrDA Low power consumption makes integrated in battery powered devices very practical 2.4 GHz radio frequency ensures worldwide operability Qualification program ensures that products displaying the Bluetooth logo have been tested to meet stringent expectations for ease of use Tremendous momentum not only within the computer industry but other industries like cellular telephones and transportation	Early stages of development make Bluetooth an immature technology that will need to prove itself Bluetooth shares the same frequency range as 802.11b Wireless LAN products (i.e. 2.4GHz) which means that under some conditions these two technologies will not be able to operate in the same physical space
802.11b	Provides highest bandwidth of current wireless standards	Requires infrastructure investment in terms of wired access point; although can be setup in a peer-to-peer configuration
Infrared (IrDA)	IrDA is an established technology that enjoys a large installed base within notebook computers and other devices Recent trend towards use of IrDA in cellular telephones, which has the potential to expand use of IrDA as a cable replacement Will maintain a speed advantage over initial Bluetooth products (i.e. 4Mbps versus 1Mbps) IrDA will maintain a cost advantage over initial Bluetooth; however, this cost advantage is expected to quickly erode over time as the number of available Bluetooth solutions grows Windows 2000 is expected to included enhanced support for IrDA which will improve usability for file transfer and synchronization Since IrDA is based on infrared technology, it will not interfere with other radio frequency based technologies like 802.11b wireless LAN; in environments where 802.11b wireless LAN products have been deployed IrDA may be the more appropriate wireless PAN technology	Limited range relative to other wireless technologies Requires line of site, which limits flexibility and makes the technology more difficult to use Historically, poor software and operating system support has made the technology difficult to use

Table 3 - Wireless Technologies - Advantages and Disadvantages

COMPARING WIRELESS TECHNOLOGIES

	802.11b	Bluetooth	Infrared (IrDA)
Market	Wireless Local Area Network (WLAN)	Wireless Personal Area Network (WPAN)	Wireless Personal Area Network (WPAN)
Technology	Radio Frequency	Radio Frequency	Optical
	2.4 GHz FHSS, DSSS	2.4 GHz FHSS	850 nm
Power	Moderate	Low	
	20 dBm	0/20 dBm	
Data Rate	High	Moderate	Low
	2 / 11 Mbps	1 Mbps	115Kbps / 4 Mbps
Distance	30 meters / 98 feet	10 meters / 32 feet	5 meters / 16 feet
Topology	128 devices	8 devices	10 devices
	CSMA	point-to-multi point	point-to-multi point
Security	Optional WEP	Public/Private key authentication and encryption	Application Layer

Table 4 - Comparing Wireless Technologies

HP PRODUCT PLANS

HP understands the importance of staying connected and has harnessed the power of Bluetooth technology into select notebooks and handhelds to give you greater mobility while sustaining your everyday computing needs. To see the full line of HP's Bluetooth offerings and to view product compatibility, visit HP's Website **http://h18004.www1.hp.com/products/wireless/wpan/**. Also, visit **http://h18004.www1.hp.com/products/wireless/** for updates to the HP wireless product portfolio.

FREQUENTLY ASKED QUESTIONS[1]

Bluetooth Overview Questions

Why is it called Bluetooth?

In 1998, a special interest group (SIG) was formed to develop and promote the technology. The SIG took the name Bluetooth from Harald II "Bluetooth" King of Denmark who was born in the 10th century. Bluetooth peacefully unified Denmark and Norway.

What is the Bluetooth SIG?

The Bluetooth SIG was formed as a group of companies working together to define, develop and promote an open, royalty-free specification for seamless wireless connectivity and cable replacement for a wide variety of mobility-enhancing devices.

In developing the Bluetooth specification, the SIG is strictly adhering to some basic principles that can be summed up in five key words: freedom, security, simplicity, versatility, and reliability. These key words are the foundation of Bluetooth.

Who are the members of the SIG?

The founding SIG members are Ericsson, Intel, IBM, Nokia, and Toshiba. Since then over 2000 adopter companies have joined including HP, Lucent, Motorola, and 3Com.

What are the features of Bluetooth?

The features of Bluetooth are best described through the Bluetooth profiles specification. These profiles lay out the capabilities and usage models in an un-ambiguous fashion. Please see – **" Supported Bluetooth Profiles"**

Is there a Bluetooth standard?

The Bluetooth standard comes from the Bluetooth SIG. The IEEE has formed a working group called 802.15 that is looking to adopt Bluetooth.

[1] Adapted from frequently asked questions published on the Bluetooth Special Interest Group (SIG) web site. For more information refer to **http://www.bluetooth.com/**.

Will Bluetooth products work only in certain areas of the world?

Bluetooth technology will work globally. It works in the globally available spectrum. However, the number of available channels is reduced for Spain, France, and Japan. The Bluetooth SIG is actively working with the various country authorities to harmonize the spectral allocation worldwide and good progress has already been made toward this goal.

How is Bluetooth technology going to be licensed? Is this technology royalty-free? Are there any patents or licenses involved?

Yes, there are several patents on different parts of the technology. Because of this all licensees will have to sign a zero cost license agreement to cover sharing of intellectual property and naming.

How does Bluetooth work?

Bluetooth uses a frequency hopping spread spectrum technique. Spectrum spreading is accomplished by frequency hopping up to 1600 hops per second on 79 channels between 2.402 GHz and 2.480 GHz.

Bluetooth radio modules avoid interference from other signals by hopping to a new frequency after transmitting or receiving a data packet. The sophisticated mode of transmission adopted in the Bluetooth specification ensures protection from interference and seeks to insure the security of the data.

In what frequency range do Bluetooth devices operate?

Bluetooth operates in the 2.4 GHz range referred to as the Instrumentation, Scientific, and Medical (ISM) band. This band provides license-free operation in the United States, Europe, Japan, and most industrialized nations worldwide.

How much power does Bluetooth transmit?

In the Bluetooth specification there are three classes of radios, which are characterized by their output power. Class 1 is specified to have a maximum transmit power of +20 dBm (100 milliwatts). Class 2 has a maximum transit power of +4 dBm (2.5 milliwatts). Class 3 has a maximum transmit power of 0 dBm (1 milliwatt).

The Bluetooth specification limits the radio output power exactly to that actually required. For instance, if the receiving radio indicates that it is only a few meters away, the transmitter immediately modifies its signal strength to suit the exact range.

This feature dramatically reduces the radio's power consumption as well as its radio interference. Furthermore, the radio chip automatically shifts to a low-power mode as soon as traffic volumes becomes low or stops. The low-power mode is only interrupted by very short signals with the purpose of verifying the established connection.

The radio with Bluetooth wireless technology consumes less than a few percent of the power consumed with a modern mobile phone. The transmission mode is only used as necessary, and always for the shortest possible period of time.

Does Bluetooth support voice communication?

The Bluetooth specification calls for up to three synchronous voice channels of 64 Kbps. The current specification supports 3 voice profiles: intercom, cordless telephony, and headsets.

What is the range of Bluetooth?

The link range is up to 10 meters using a 0 dBm radio. The range is extended up to 100 meters using a +20 dBm radio. First products will use 0 dBm radios.

What is the transfer speed?

The gross data rate of Bluetooth is 1 Mbps. The protocol splits that bandwidth to support both voice and data communication. Bluetooth can support an asynchronous data channel, up to three simultaneous synchronous voice channels, or a channel, which simultaneously supports asynchronous data and synchronous voice. Each voice channel supports a 64 Kbps synchronous (voice) link. The asynchronous data channel can support an asymmetric link of up to 721 Kbps in either direction, while permitting 57.6 Kbps in the return direction or a symmetric link up to 432.6 Kbps.

Will Bluetooth devices from different manufacturers interoperate?

To be able to carry the Bluetooth name and Bluetooth logo on a product, manufacturers have to get their product tested and certified. This testing will help insure that products interoperate.

How do Bluetooth devices communicate with each other?

The Bluetooth specification calls for devices to connect in an ad-hoc fashion into small Bluetooth networks called piconets. These piconets provide a bubble of connectivity around the user and are the basis for creating a personal area network.

Bluetooth Usage and Applications

What are the expected applications?

There are too many applications in the conceptual stage and in development to do this question justice. With over 1800 adopter companies, new applications are being developed everyday.

In the office and on the road, Bluetooth eliminates cabling and provides added mobility. Users no longer have to cable a cell phone to a handheld or notebook computer. Users no longer have to keep the computer and cell phone aligned to maintain a connection using the infrared port. Bluetooth allows users to leave the cell phone in a briefcase and still make that connection back to the office to update their calendar or to the Internet for the latest stock quote. Bluetooth allows the mobile computer to synchronize with our desktop computer when the mobile computer is dropped off on the desk. No more plugging and unplugging.

Designed to be an extremely low cost technology, other peripherals are likely to contain Bluetooth such as fax machines, cameras alarm systems, and virtually any other electronic device. Unlike other technologies available today, Bluetooth is designed to be a bubble of connectivity that moves with you. Incorporating Bluetooth into these other peripherals allows you to just walk-up to the machine and use it services or for it to detect your presence and initiate a pre-determined program or routine.

Will Bluetooth change the way we work?

The way we work could change as well thanks to Bluetooth technology. The Bluetooth specification includes the concept of synchronization. It is potentially one example of how Bluetooth could change the way we work. The synchronization profile is likely better described as unconscious synchronization. The ability to automatically synchronization applications such as phonebooks and calendars between two devices either when you come within range of that device or at pre-subscribed times using your cell phone. Thus, you can create an appointment on your handheld computer and have it synchronize with your desktop just by walking past your office on your way to your next appointment. No longer will you have to take the time to plug into your computer and check for updates.

Other examples that have been suggested include the way we interact with automobiles. So that when we are within range of the automobile, it would automatically adjust mirrors, move the seats to a preset position that is correct for us, unlock the car, and turn on interior lighting. No more locking or unlocking the car door. No more fussing to adjust the mirrors or seats to your preferences.

These are just a couple of examples of how Bluetooth might change the way we work and possibly make our lives just a little easier.

Can I use Bluetooth to form a network?

The Bluetooth specification today allows for a piconet. This piconet consists of a master and up to 7 slaves. Devices in the piconet form an ad-hoc network.

To form a network where I can be attached to a LAN for my corporate data and connected to my laptop or handheld over another Bluetooth connection at the same time requires the scatter mode feature of Bluetooth.

Will I be able to use Bluetooth in my car?

Blue tooth will likely take a number of forms in your car in the future. First, you will likely be able to use Bluetooth as an adjunct to your cell phone allowing hands free operation while driving.

There is also some interest on the part of automobile manufacturers to use Bluetooth in a remote diagnostic equipment interface in your car. There are plans for using Bluetooth to keep track of vehicles from factory to dealer. Though the hands free cell phone kits are likely to appear first.

Why not simply build phones into mobile PCs rather than develop Bluetooth Technology?

The cost is too high. There are many different phone standards to choose from. There is no standard that is universally available around the world. The usage models for mobile PCs do not match that of phones.

Compliance and Frequency Usage Conflicts

Will France have special Bluetooth products before January 2001?

Yes, Bluetooth products shipping into France before January 2001 will support only 23 of the 79 channels available throughout the rest of the world. Bluetooth products complying with the 23-channel requirement will not interoperate with products using 79 channels. After January 2001, older products will need to be upgraded to interoperate with 79 channel products.

Will microwave ovens interfere with Bluetooth?

With its frequency hopping spread spectrum radio scheme, microwave ovens will only have an impact on Bluetooth in a limited range of its total frequency spectrum according to a study done by Ericsson
http://infotooth.tripod.com/documents/Microwave_Oven_Interference_on_Wireless_LANs_Operating_in_the_2.4_GHz_ISM_Band.pdf).

Will cordless phones interfere with Bluetooth?

Yes (depending on the frequency). 2.4 GHz cordless phones will interfere with Bluetooth communications, but cordless phones on other frequencies will not.

What is the medical impact of Bluetooth wireless technology?

There has not been an empirical study done of Bluetooth. There is not enough of an installed base to do a study. Of note, Bluetooth devices transmit approximately 3% the power of a typical cell phone. Even at 20 dBm or 100 milliwatts, Bluetooth is no more than 1/10 the power of a typical cell phone.

What impact does Bluetooth have on pacemakers?

Currently, the only recommendation available is for cell phones. The Health Industry Manufacturers Association recommends that a minimum separation of 2.5 cm be maintained between a cell phone and a pacemaker.

Can I use Bluetooth on an airplane?

Like with your cell phone and pager, Bluetooth must be turned off in an airplane. Bluetooth like your cell phone and pager are radio devices and are prohibited by the airlines during flight to minimize the risk of interference with the airplane's radio frequency equipment such as radar and radios.

Bluetooth Security

Does Bluetooth offer any security for my data?

The Bluetooth specification is designed to be unambiguous and comprehensive. It includes up to 128-bit security to help insure acceptance in the corporate environment. The specification also includes a logo certification program to ensure compatibility among all the various devices incorporating Bluetooth.

How does security work with Bluetooth?

Bluetooth uses 4 basic keys in its security mechanism. A 48 bit fixed public address that is unique for each device, a 128-bit random number generated for each transaction, and two secret keys. The two secret keys are a 128-bit private user authentication key and a private user encryption key that can vary from 8 bits to 128 bits. The encryption key can vary in length to allow for export restrictions. From these basic keys, other keys are generated for each link to ensure that other Bluetooth devices that are not part of the piconet cannot either inadvertently or intentionally eavesdrop on a Bluetooth connection.

What are the different security levels available for Bluetooth?

The Bluetooth specification calls for three levels or modes of security. Those modes are as follows:

- **Non-Secure** – a device will not initiate any security procedure. This mode would allow anyone walking up to the device to take advantage of its services. This mode was envisioned for use with public devices such as printers where people would walk up, establish an ad-hoc connection, download the job to the printer, and walk away.
- **Service Level Enforced Security** – In this mode permission to access a device is dependent on the service requested. For example, creating the ability to download files to a PC but not allowing access to calendar or phonebook applications.
- **Link Level Enforced Security** – this is the most secure mode and requires authentication and authorization before being granted access to any service available on the device. This mode is for devices such as cell phone that are only to be used by an individual or a limited number of individuals.

Are transmissions secure in a business and home environment?

Yes. Bluetooth has built in encryption and authentication and is thus very secure in any environment. In addition a frequency-hopping scheme with 1600 hops/sec is employed. All of this together with an automatic output power adaptation to reduce the range exactly to requirement makes the system difficult to eavesdrop.

Bluetooth Comparisons to Infrared

How does Bluetooth compare to Infrared technology we see in cell phones and computers?

Like infrared, Bluetooth is designed to be a low cost widely implemented technology. Some of the software layers used in infrared are part of the Bluetooth specification. Unlike infrared, which requires a line of sight to operate, Bluetooth can penetrate walls since it uses radio technology as its medium.

Does IrDA have any advantages over Bluetooth?

Yes. Depending on the version of IrDA, IrDA has a faster data transfer rate. Bluetooth can transfer data at 1Mb/s while IrDA can transfer up to 4 Mb/s. IrDA may be a more appropriate technology for applications where bandwidth is more important than some of the limitations of IrDA such as the line of sight requirement.

How will IrDA and Bluetooth application and operating system support compare?

Microsoft Windows 98 and Windows 2000 and to a lesser extent, Windows 95 currently include native support for IrDA. With Windows 2000 and Windows 98 this support includes application level support that enables file transfer and direct connect network connections. While it is too early compare with application support for Bluetooth, the expectation is that Bluetooth will address many of the usability issues with IrDA in part by addressing the software stack in the specification. The Bluetooth 1.0 specification addresses usability by defining what are called Profiles. Profiles define specific usage scenarios, such as file transfer for example, that include definition of the software stack. By taking the specification to this level, there is greater assurance that compliant Bluetooth products will interoperate.

Are communications with IrDA more secure than Bluetooth?

Since communication with IrDA requires line of sight between devices, it can be more difficult to eavesdrop on an IrDA connection than one using Bluetooth. That said, the Bluetooth SIG is addressing security by including provisions for secure device authentication and data encryption based public/private key cryptographic technology. Evaluating security for each technology must first start with an evaluation of the user's specific threat model and the value of the information being transmitted. Based on this evaluation IrDA may be a more appropriate technology for some applications.

Bluetooth Comparisons to 802.11

Can Bluetooth and 802.11 co-exist in one PC?

Today, Bluetooth and 802.11 use different radios products such as two PC Cards. The distance between the antennas will determine the level of interference or coexistence of the two products within the same PC. A Bluetooth PC card and an 802.11 PC card plugged into an adjacent PC Card slots will not work together, because of antenna interference.

The 802.15 working group is looking into Bluetooth and 802.11 coexistence. Additionally, there are some industry efforts to combine the two technologies into a single product. It is too early to gage the results of any of the efforts either in scope or timeframe.

Why is Bluetooth so much slower than 802.11?

Bluetooth was conceived to go into a broad range of devices including those operated with batteries such as handheld computers. To maximize battery life in those environments, the output power (range) and speed were kept purposefully low.

Will 802.11 interfere with Bluetooth?

A theoretical study by Ericsson was done to understand the impact on a Bluetooth radio in the presence of an 802.11 network. It was determined the maximum degradation of throughput under the worst-case scenario was 22%.
http://infotooth.tripod.com/documents/Bluetooth_voice_and_data_performance_in_802.11DS_WLAN_environment.pdf)

Does Bluetooth support roaming similar to 802.11?

Though there are a number of proposals under consideration for future revisions of the Bluetooth specification, Bluetooth does not support roaming today. The genesis of Bluetooth was cable replacement / elimination and there is no concept of roaming in that environment.

Bluetooth in the Future

What is the future direction of the Bluetooth standard?

At this time, we anticipate the Bluetooth SIG to evolve the Bluetooth technology to provide greater bandwidth and distances, thus increasing the potential platforms and applications used in the emerging personal area networking marketplace.

What is the future of Bluetooth?

Bluetooth is a continually expanding technology. There are plans to add many new application profiles. With over 1800 companies working on Bluetooth, the future could not be brighter. With a strong special interest group behind Bluetooth, the standardization of the application profiles is almost assured.

According to market researchers, Cahners In-Stat Group, it is anticipated that as many as 670 million products will have Bluetooth built-in by the year 2005.

Will the speed of Bluetooth increase?

Some members of the Bluetooth SIG such as Sony and Eastman Kodak are interested in seeing the speed of Bluetooth increasing for applications such as streaming video. Proposals are under consideration but it is not clear when products based on any of the proposals would be available.

Where can I go for additional information about Bluetooth Wireless Technology?

The amount of information about Bluetooth seems to grow exponentially every month. Here are some good sources of background information and current news on the technology:

http://**http://www.bluetooth.com/** – This is the official website for the Bluetooth SIG.

http://www.palowireless.com/bluetooth/ – Palo Pacific Technology Bluetooth Resource Center provides links to different Bluetooth and other technology sites

https://www.bluetooth.org/ – This site provides a good Bluetooth technical overview

Because the technology is new, new information today is old or obsolete tomorrow. Check these links often to keep up with the current news on Bluetooth technology.

HP and Bluetooth

What is HP doing with Bluetooth?

HP has been quietly working on developing Bluetooth products. We are active in the Bluetooth SIG and you will likely see HP people at all the Bluetooth conferences.

HP is working to bring commercially viable Bluetooth technology to market that can be easily installed, widely deployed and cost effectively supported by customers.

To see the full line of HP's Bluetooth offerings and to view product compatibility, visit HP's Website **http://h18004.www1.hp.com/products/wireless/wpan/**. Also, visit **http://h18004.www1.hp.com/products/wireless/** for updates to the HP wireless product portfolio.

Will HP publish a list of products that have been tested and known to work with HP products?

Yes, HP is working with Bluetooth vendors to ensure that beyond the Bluetooth logo certification program that products work properly in conjunction with HP products. This extra level of testing by HP is designed to help lower the overall cost of ownership with HP products and create a pleasant user experience. In support of this effort, HP will implement the Bluetooth *Compatibility Program* for Bluetooth developers to work closely with HP on compatibility scenarios.

Bluetooth Terminology

What is a Piconet?

A collection of devices connected via Bluetooth wireless technology. A piconet can be as few as two devices (portable PC and cell phone) and may be as many as eight devices. All Bluetooth devices are peers and have identical implementations. When establishing a connection to another device, one unit will act as a master and the other(s) as slave(s) for the duration of the connection. Piconets can be established and linked together ad hoc. Each piconet is identified by a different frequency hopping sequence to keep them separate from other Bluetooth piconets. All users participating on the same piconet are synchronized to this hopping sequence.

What is Multipoint?

Multipoint is better described as point to multipoint. Multipoint is the ability for a Bluetooth device to broadcast information to the other devices in the piconet. For this to occur, the broadcasting device must be the master with all other devices being slaves.

The current Bluetooth specification does not support Multipoint implementation. A number of companies are including a multipoint implementation they each believe to be close to the final agreed specification. At this time, there is no guarantee of interoperability between vendors until the final specification is ratified.

What is a Scatter mode?

Scatter mode is a collection of piconets joined by a Bluetooth device that is a master in one piconet and a slave in another piconet.

What is a Master unit?

This is the device in a piconet whose clock and hopping sequence are used to synchronize all other devices in the piconet.

What is a Slave unit?

All devices in a piconet that are not the master.

What is a Mac address?

3-bit address to distinguish between units participating in the piconet.

What are Parked units?

Devices in a piconet that are synchronized, but do not have a MAC addresses.

What is Sniff and hold mode?

Devices synchronized to a piconet can enter power-saving modes in which device activity is lowered.