WHITE PAPER

November 2000

Prepared By

Commercial Portables
Product Marketing

Compaq Computer
Corporation

CONTENTS

COMPAQ

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.

THE COMPETITIVE INFORMATION CONTAINED IN THIS PUBLICATION IS BASED ON DATA AVAILABLE FROM PUBLIC SOURCES AT THE TIME OF PUBLICATION. COMPAQ COMPUTER CORPORATION SHALL NOT BE RESPONSIBLE FOR ANY INACCURACIES, ERRORS, OR OMISSIONS IN INFORMATION CONTAINED HEREIN, INCLUDING, BUT NOT LIMITED TO, INFORMATION OBTAINED FROM THIRD PARTY SOURCES, SUCH AS PUBLICATIONS OF OTHER COMPANIES, THE PRESS, OR COMPETITIVE DATA ORGANIZATIONS.

THIS PUBLICATION IS MADE AVAILABLE ON AN "AS IS" BASIS AND COMPAQ SPECIFICALLY DISCLAIMS ALL ASSOCIATED WARRANTIES, WHETHER EXPRESS OR IMPLIED. IN NO EVENT WILL COMPAQ BE LIABLE FOR DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE USE OF OR RELIANCE ON THE MATERIAL CONTAINED IN THIS PUBLICATION, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. COMPAQ RESERVES THE RIGHT TO MAKE IMPROVEMENTS OR CHANGES TO THIS PUBLICATION AND THE PRODUCTS AND SERVICES HEREIN DESCRIBED AT ANY TIME, WITHOUT NOTICE OR OBLIGATION.

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. Compaq does not warrant products other than its own and then, only as strictly stated in Compaq product warranties.

Bluetooth Technology Overview
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, handheld's, 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

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 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.

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 developing a logo program, which will validate compliance with the published Bluetooth specification as well as interoperability with other Bluetooth devices. Bluetooth devices that successfully complete the Bluetooth testing criteria will have the right to bear the official Bluetooth logo. A self-certification program will be used as an interim solution to enable Bluetooth products to ship with the Bluetooth logo in advance of the official Bluetooth logo program at the end of 2000. Under the interim self-certification program, each Bluetooth capable device must list the other Bluetooth devices that have been tested for interoperability. The Logo program is very comprehensive in its scope. It will include 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.

When Will Bluetooth Technology Be Introduced?

Version 1.0A of the Bluetooth specification was completed and released July 28, 1999. Subsequently, the Bluetooth SIG allowed for the publication of errata to the "original" specification, and version 1.0B was published in December 1999. In November 2000, the Bluetooth SIG is expected to release version 1.1 of the Bluetooth specification. The industry is already working towards developing products to the 1.1 specification. Essentially, there are no

profile and usage model variances from the 1.0, 1.0A, 1.0B and 1.1 specifications. The 1.1 specification contains approximately 200 errata clean-ups in the RF protocol, baseband HCI (host controller interface) command set and tolerances – technical differences that the end-user will not recognize. PC Card solutions and Bluetooth dongle (or accessory) devices are expected to hit the market late 2000 and early 2001. You should expect to see Bluetooth integrated on a number of notebook computers and other mobile devices in the late first half of 2001. Proliferation into other devices such as cellular telephones is expected to follow quickly.

What Profiles are Currently Supported?

The current Bluetooth specification (Version 1.0b) calls for support the following profiles:

- **General Access** –generic procedures related to discovery / link management & security levels.
- **Service Discovery** – discover services available in other *Bluetooth* devices
- **Cordless Telephony** – ability for a cell phone to operate as a cordless phone when in proximity to its wired telephone service base station.
- **Intercom** – defines the intercom function in cell / mobile phones using *Bluetooth* as the radio link
- **Serial Port** – emulated serial port for applications that traditionally use a wired serial port interface
- **Headset** – defines both the transmitting & receiving voice data over a *Bluetooth* link
- **Dial-up Networking** – defined primarily as the link between a cell phone & a computer. The profile is defined so the computer can either initiate the data call or receive the data call depending on user setup.
- **Fax** –cell phone or modem may be used as a fax interface to a computer for both sending & receiving faxes.
- **LAN Access** –setting up a personal area network using Point-to-Point Protocol (PPP).
- **Generic Object Exchange (OBEX)** – defines procedures used by the files transfer, object push, & synchronization profiles
- **Object Push** –ability to push or pull a business card or an appointment
- **File Transfer** – browse a file system on, create or delete files / folders on, or transfer files from / to another *Bluetooth* device
- **Synchronization** – exchange of personal information such as calendar & phonebook. Also, the use of a mobile phone or computer to automatically start synchronization when in range

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

The cordless telephony, intercom, headset, & fax profiles are likely to be omitted. Over time, the fax profile will likely be implemented in computer applications.

What Can I Expect Beyond the Version 1.0 Specification? [1]

Whereas the 1.0 specification focused primarily on cable replacement scenarios, the Bluetooth 2.0 specification will strive to deliver many more advanced and valuable usage models. In support of the 2.0 specification development, the Bluetooth SIG has created new working groups to investigate a variety of new usage models that will return new profiles for the 2.0 specification.

The Bluetooth 2.0 SIG working groups include:

[1] Portions adapted from *Bluetooth Revealed*, (Bisdikian, Chatschik; Miller, Brent. New Jersey: Prentice Hall PTR, 2001.)

- **Radio 2.0** – investigating increased data rates (up to 2Mbps+), improved co-existence with other 2.4GHz radios (separate working group) and baseband function improvements
- **Personal Area Networking (PAN)** – concentrating on general IP networking (including security) in an ad hoc connection environment
- **Human Interface Device (HID)** – existing industry specification for computer peripherals such as keyboards, mice, joysticks, etc.; Bluetooth HID working group will develop a profile for the use of HID over Bluetooth
- **Audio/Video** – application working group investigating high end multimedia capabilities over Bluetooth; examples include movie/video clips, music with wireless headphones and video conferencing
- **Printer Profile** – associated with the cordless computer usage model, the Printing Work Group will work direct-to-printer scenarios using peer-to-peer Bluetooth connection (focus on Universal Plug and Play and Salutation technologies)
- **Enhanced Service Discover Protocols** – an extension of the 1.0 specification that seeks to formalize the Service Discovery Protocol with profiles for mapping selected service discovery protocols to Bluetooth environments
- **Local Positioning** – implementing Bluetooth as a system to determine "local" geographic proximity and thereby make the position information available to other "applications"
- **Still Image** – component of the Instant Post Card Usage Model, the underlying principal is that of a digital camera that transfers a photo image wirelessly to a variety of other Bluetooth-enabled devices

In the end, Bluetooth may see a future and prospect with endless possibilities producing new applications, profiles and usage models for many years to come.

FEATURES & BENEFITS

BLUETOOTH FEATURES & 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 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 high 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 & 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. Also, Spain, France and Japan currently have reserved portions of the Bluetooth frequency spectrum for other use. The Bluetooth SIG is actively lobbying for these frequency reservations to be lifted. Japan has agreed in principle to free up the reserved portion and is currently pending Government approval.

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

Surf the Internet regardless of the connection - Use your laptop to surf 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 Compaq 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 Compaq 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
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.
Cellular Technologies	Wireless Wide Area Networking (WWAN)	▪ I want access to e-mail and web resources while travelling 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 & 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 & 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

COMPAQ PRODUCT PLANS

Compaq Bluetooth product offerings are still in the planning and design stages. However, Bluetooth will first be offered as a PC Card option for notebooks, Compact Flash for handhelds and USB dongle for desktops in early 2001. Compaq plans to integrate a variety of wireless technologies (Bluetooth, 802.11 and WWAN) into Armada commercial notebook PCs as early as the first half of 2001. Compaq also plans to wirelessly enable the iPaq handheld using a variety of wireless communication technologies. The first product will be a WWAN solution for the iPaq handheld family of products.

Visit www.compaq.com/products/wireless for updates to the Compaq wireless product portfolio.

FREQUENTLY ASKED QUESTIONS[2]

Bluetooth Overview Questions

Why is it called *Bluetooth*?

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

What is the *Bluetooth* SIG?

The *Bluetooth* SIG was formed as a group of companies working together to define, develop & promote an open, royalty-free specification for seamless wireless connectivity & 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, & 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, & Toshiba. Since then over 2000 adopter companies have joined including Compaq, Lucent, Motorola, & 3Com.

When will Bluetooth specifications be released?

Please see – "When Will Bluetooth Technology Be Introduced"

What are the features of *Bluetooth*?

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

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*.

---

[2] Adapted from frequently asked questions published on the Bluetooth Special Interest Group (SIG) web site. For more information refer to 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 & 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 & 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, & Medical (ISM) band. This band provides license-free operation in the United States, Europe, Japan, & 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, 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, & 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 & data communication. *Bluetooth* can support an asynchronous data channel, up to three simultaneous synchronous voice channels, or a channel, which simultaneously supports asynchronous data & 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 & *Bluetooth* logo on a product, manufacturers have to get their product tested & 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 & 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 & in development to do this question justice. With over 1800 adopter companies, new applications are being developed everyday.

In the office & on the road, *Bluetooth* eliminates cabling & 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 & cell phone aligned to maintain a connection using the infrared port. *Bluetooth* allows users to leave the cell phone in a briefcase & 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 & unplugging.

Designed to be an extremely low cost technology, other peripherals are likely to contain Bluetooth such as fax machines, cameras alarm systems, & 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 & use it services or for it to detect your presence & 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 & 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 & 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 & 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, & 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 & 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 & 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 & connected to my laptop or handheld over another *Bluetooth* connection at the same time requires the scatternet 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

What about using *Bluetooth* in Japan, Spain, & France?

In April 2000, an European Union (EU) directive went into effect creating a harmonized approval process. This harmonized approval process eliminated the national approvals that were previously in effect. This greatly streamlined the approvals process for much of Western Europe & eliminated a barrier for new technology.

France & Spain, though under the EU directive, had special requirements for mostly military reasons. Since that time Spain has dropped its special requirements. France is dropping its special requirements effective January 2001.

Japan too had special requirements. Those requirements have also been dropped.

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).

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 transmitis 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 & a pacemaker.

Can I use *Bluetooth* on an airplane?

Like with your cell phone & pager, *Bluetooth* must be turned off in an airplane. *Bluetooth* like your cell phone & pager are radio devices & are prohibited by the airlines during flight to minimize the risk of interference with the airplane's radio frequency equipment such as radar & 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, & two secret keys. The two secret keys are a 128-bit private user authentication key & 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, & 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 & requires authentication & 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 & 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. 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* & 802.11 co-exist in one PC?

Today, *Bluetooth* & 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 a adjacent PC Card slots will not work together, because of antenna interference.

The 802.15 working group is looking into *Bluetooth* & 802.11 coexistence. Additionally, there is 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) & 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 & 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 & distances, thus increasing the potential platforms & 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 & 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 & current news on the technology:

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

http://www.palopt.com.au/*Bluetooth* – Palo Pacific Technology *Bluetooth* Resource Center provides links to different *Bluetooth* & other technology sites

http://*Bluetooth*.ericsson.se/support/online.asp – An good audio-visual introductory course on *Bluetooth*.

http://www.*Bluetooth*forum.com – Originally www.*Bluetooth*.net, 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.

Compaq & Bluetooth

What is Compaq doing with *Bluetooth*?

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

Compaq is working to bring commercially viable *Bluetooth* technology to market that can be easily installed, widely deployed & cost effectively supported by customers

When will Compaq put *Bluetooth* into all of its products?

It is difficult to say when Compaq will offer *Bluetooth* technology in all of the products. Today, the technology is not sufficiently mature to warrant making it available in all products and the cost is too high. First implementations will be limited to a few products to allow customers time to understand the technology. Overtime it is expected that *Bluetooth* will migrate into more & more products as the technology is more widely accepted.

Will Compaq publish a list of products that have been tested & known to work with Compaq products?

Yes, Compaq is working with *Bluetooth* vendors to ensure that beyond the *Bluetooth* logo certification program that products work properly in conjunction with Compaq products. This extra level of testing by Compaq is designed to help lower the overall cost of ownership with Compaq products and create a pleasant user experience. In support of this effort, Compaq will implement the *Bluetooth Compatibility Program* for Bluetooth developers to work closely with Compaq 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 & cell phone) & may be as many as eight devices. All *Bluetooth* devices are peers & have identical implementations. When establishing a connection to another device, one

unit will act as a master & the other(s) as slave(s) for the duration of the connection. Piconets can be established & 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 a Scatternet?

A scatternet is a collection of piconets joined by a *Bluetooth* device that is a master in one piconet & a slave in another piconet.

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 Scatternet?

Multiple independent and non-synchronized piconets form a scatternet.

What is a Master unit?

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 which 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.