Bluetooth Technology

by

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ABSTRACT

Bluetooth is the codename adopted by a consortium of wireless equipment manufacturers that is working toward a low-cost, global standard for wireless communication of data and voice. It will operate in the unlicensed ISM band (industrial, scientific, and medical) with gross transfer rate up to 1Mbps and it will connect devices within a range of 10 or up to 100m.

The benefits of Bluetooth technology are twofold. First, it enables a user to replace the various cables between devices with a universal short-range radio link. For example, a cellular telephone and a portable computer equipped with the Bluetooth technology can interface without the need for cables. Further, they could interoperate with similarly equipped devices such as printers, fax machines, desktop computers and peripherals, and a host of other digital devices. The second major benefit of the Bluetooth technology is its ability to provide a connection between the ad hoc network and existing data networks.

Bluetooth technology is designed for wireless personal area networks (WPANs), which are networks of personal electronic devices in close proximity to each other. Expectations for Bluetooth technology are that it will become a major player in the wireless data communications market, due primarily to its simplicity and its support from large companies, many of whom are integrating the technology into their products. Further, Bluetooth members are encouraging vendors to incorporate the technology into their products by waiving intellectual property royalty fees.

That being said, this paper will explore the technical aspects of Bluetooth as well as the strategic rationale behind the founding companies. Since e-commerce might be heavily affected by this technology, especially business-to-consumer and consumer-to-consumer, this paper also explores the impact and possible changes in consumer and merchant behaviors.

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I would like to thank all my professors and friends from Sloan, whom either have directly or indirectly helped me and contributed to this thesis effort.

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PSTN –	Public Switch Telephone Network
LAN –	Local Area Network
WLAN –	Wireless Local Area Network
PAN –	Personal Area Network
WPAN –	Wireless Personal Area Network
WAN –	Wide Area Network
DSL –	Digital Subscriber Line
ISDN –	Integrated Service Digital Network
ISM band -	Industrial, scientific, and medical band
Piconet -	Connections that can support up to 8 devices sharing 1Mbps of bandwidth
PDA –	Personal Digital Assistants
B2B –	Business-to-Business
B2C –	Business-to-Consumer
CDMA -	Code Divison Multiple Access
TDMA -	Time Divison Multiple Access

Bluetooth - Connections Made Easy

Technically Bluetooth is cable replacement. Its slogan is "connections made easy". When you start understanding the technology you find a whole new universe of opportunities.

Chapter 1

Bluetooth Technology

1.0 Introduction

In early 1998 a group of computer and telecommunications industry leaders, Ericsson, IBM, Intel, Nokia and Toshiba, together began developing a way for users to connect a wide range of mobile devices quickly and easily, without cables. To ensure that this technology is seamlessly implemented in a diverse range of devices, these leaders formed a special interest group, formally announced on May 20, 1998, to design a royalty-free, open specification technology, code named "Bluetooth."

- Date: Formally announced on May 20, 1998
- Founding Members: Ericsson, IBM, Intel, Nokia and Toshiba - known as SIG (Special Interest Group) - as of December 1999
- Adopters list: companies who have joined the consortium (1300+)

As of December 1999 over 1300 companies have joined the consortium (adopters list). The Bluetooth SIG continues to gain momentum, adding such industry notables as HP, Qualcomm, Philips, TDK Systems, FedEx, Dell, Compaq, Sony, BMW, Volvo, Boeing, Bosch, Casio, Canon, Epson, NEC and many others. Each member company receives a royalty-free patent license from other member companies to implement the Bluetooth 1.0 specification in its

products. In addition, member companies receive access to Bluetooth technical specifications and intensive training seminars such as the Bluetooth Developers Conferences.

1.1 The vision

Bluetooth is the code name for the rapidly emerging global specification for wireless connectivity for mobile PCs, handheld computing devices, wireless phones, headsets, other wearable devices and computer peripherals including printers, projectors and others. Led by Ericsson, IBM, Intel, Nokia and Toshiba, the Bluetooth Special Interest Group (SIG) was established to create a global specification for a wireless communications interface and control software, in order to ensure device interoperability.

The Bluetooth Program:

- Bluetooth promise - wireless connections made easy
- Bluetooth values - freedom, simplicity, reliability, versatility and security
- Usage models - what the technology can do
- Specification profiles - how to implement the usage models
- Certification, testing and interoperability - product test to ensure interoperability

1.2 History of the name Bluetooth [1]

Harald Bluetooth was born in the year 910. He was the son of Gorm, the king of Denmark. Harald Bluetooth later became the first Christian king of Denmark and introduced

[1] Source: www.bluetooth.com

Christianity to the Danes. Harald Bluetooth also united Denmark and Norway as a single kingdom. He died on November 1, year 986.

The Bluetooth Special Interest Group, has chosen to give this new uniting technology the name Bluetooth, to show that this is a new revolutionary technology that will unite people across borders and across different systems.

1.3 Overview

Imagine having your docked mobile PC and PDA automatically synchronize your address list and calendar as soon as you walk through your office door. Imagine never again having to wrestle with cables to connect electronic devices. With Bluetooth technology, these feats, and many more, will soon become routine functions of mobile computing.

Bluetooth is an open application for short-range wireless connectivity, which will allow wireless communication between a variety of communication devices. It operates within a globally available frequency band to ensure that communication between devices will be possible all over the world. The range of possible applications is unlimited and Bluetooth will make cables redundant between almost all devices that need to communicate together. Bluetooth will enable instant connectivity and will maintain the connection even when devices are not in line of sight.

In theory, it is pretty simple. Every notebook, PDA, cell/PCS phone, pager, etc - EVERY device that is capable of communicating should have a Bluetooth chipset embedded in it. This is most likely a single integrated circuit (IC) that includes a very low power (perhaps a milliwatt or two) data radio transceiver with a hardcoded unit ID number (like all LAN cards have) and/or a

flashport so an IP address can be uploaded and assigned to it at any time. The target cost is under $5 to the end-user (added to the price of the device; not an upgrade feature) and less to the device manufacturer.

One example of an application that would use Bluetooth is the instant postcard. Use a digital camera or video recorder to capture the scene, add written or spoken comments with your phone, notebook or laptop and send the multimedia message anywhere in the world. All the devices used to create the message will communicate with each other without cables allowing you to put together a composite message with ease.

For additional information regarding user models please see *Making mobile devices more useful* section of this paper - page 22.

1.4 Bluetooth Development Requirements

Before the air interface for Bluetooth could be designed, however, certain requirements had to be settled. Focusing on a worldwide utilization and envisioning the technology inside all electronic devices the SIG established three technological prerequisites:

- The system must operate worldwide
- The connection must support voice and data - multimedia applications
- The radio transceiver must be small and operate at low power. That is, the radio must fit into small, portable devices, such as mobile phones, headsets and personal digital assistants (PDA)

The focus of user scenarios envisioned for first-generation products is typically on traveling business people. Portable devices that contain Bluetooth radios would enable them to leave cables and connectors at home.

1.5 Challenges to make Bluetooth happen

Bluetooth has to reach the mass market, in order to make it happen. The SIG has been actively engaged in working out regulatory issues around the world. To encourage the widest possible deployment of the technology, Bluetooth is an open industry specification that will be made available to Bluetooth SIG members on a royalty-free basis. The growing momentum behind Bluetooth is indicated by the fact that the SIG recently enrolled its 1300th member company (December 1999). The Bluetooth Developers Conference is another factor that proves the success of growing market acceptance:

- 1st Bluetooth Developers Conference – October 1998 - 350 attendees
- 2nd Bluetooth Developers Conference – June 1999 - 900 attendees
- 3rd Bluetooth Developers Conference – December 1999 - 1800 attendees

It is easier to be born as a standard than to become one. Technologies on the market that predominantly use proprietary or closed standards suffer from lack of interoperability between different manufacturer's equipment. As a result, it slows market growth. Bluetooth is setting standards for compatibility and as a consequence it will expand the market for all the companies

involved. The SIG members are committed to making frequent technology upgrades and improvements when necessary to keep the momentum going.

That said, Bluetooth enjoys momentum in the computing and telecommunications sector that suggest it will emerge as the major platform for three reasons:

- The technical specifications are released to all application and hardware developers to make it an open standard
- The tremendous size of the adopter list of companies discourages individual efforts to create a competing, proprietary platform
- The momentum generated by early application successes will cement its position as the industry standard

The main idea behind Bluetooth is connection made easy. Being an open standard that will operate worldwide and with all the major high tech companies involved, this new technology will revolutionize the way people behave, interact and do business.

The technology is already here and developed. From now it will continue to evolve facilitating communication between several devices. Even though the new user models seem simple, they will have great impact on the way people interact. The cellular phone proposal seemed to be very simple too – to have a mobile phone, anywhere and anytime. Bluetooth follows the same idea but better. It is a common standard and will operate worldwide. There are no different standards as cellular phones (CDMA, TDMA, GSM, etc). On the top of that the market potential is huge.

The first-generation products will focus on travelling business people and the market will soon expand to non-business people. Due to the nature of the founding companies, early products will include mobile computers, mobile phones, headsets and handheld devices.

- 1st level of products: mobile computers, mobile phones, handheld devices and headsets.
- 2nd level of products: desktop PCs and peripherals such as printers, projectors, digital cameras and others
- 3rd level of products: other (automobile industry for example - Volvo, BMW and others)

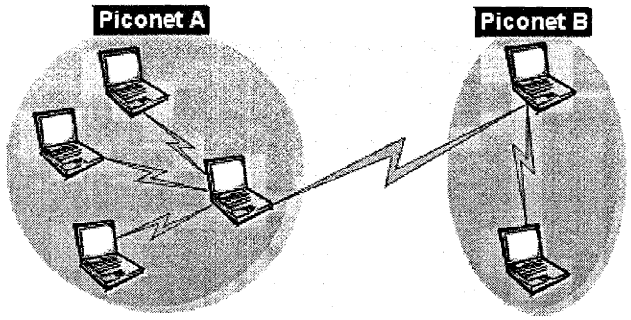
Making a brief mental calculation it is easy to understand that several million units are expected to be sold in the coming years.

For additional information please see, the *Impact of Bluetooth* section of this paper – page 70

1.6 Technology Description[2]

Bluetooth is a universal radio interface that enables portable electronic devices to connect and communicate wirelessly via short-range, ad hoc networks. Each unit can simultaneously communicate with up to seven other units per piconet. Moreover, each unit can simultaneously belong to several piconets. [3]

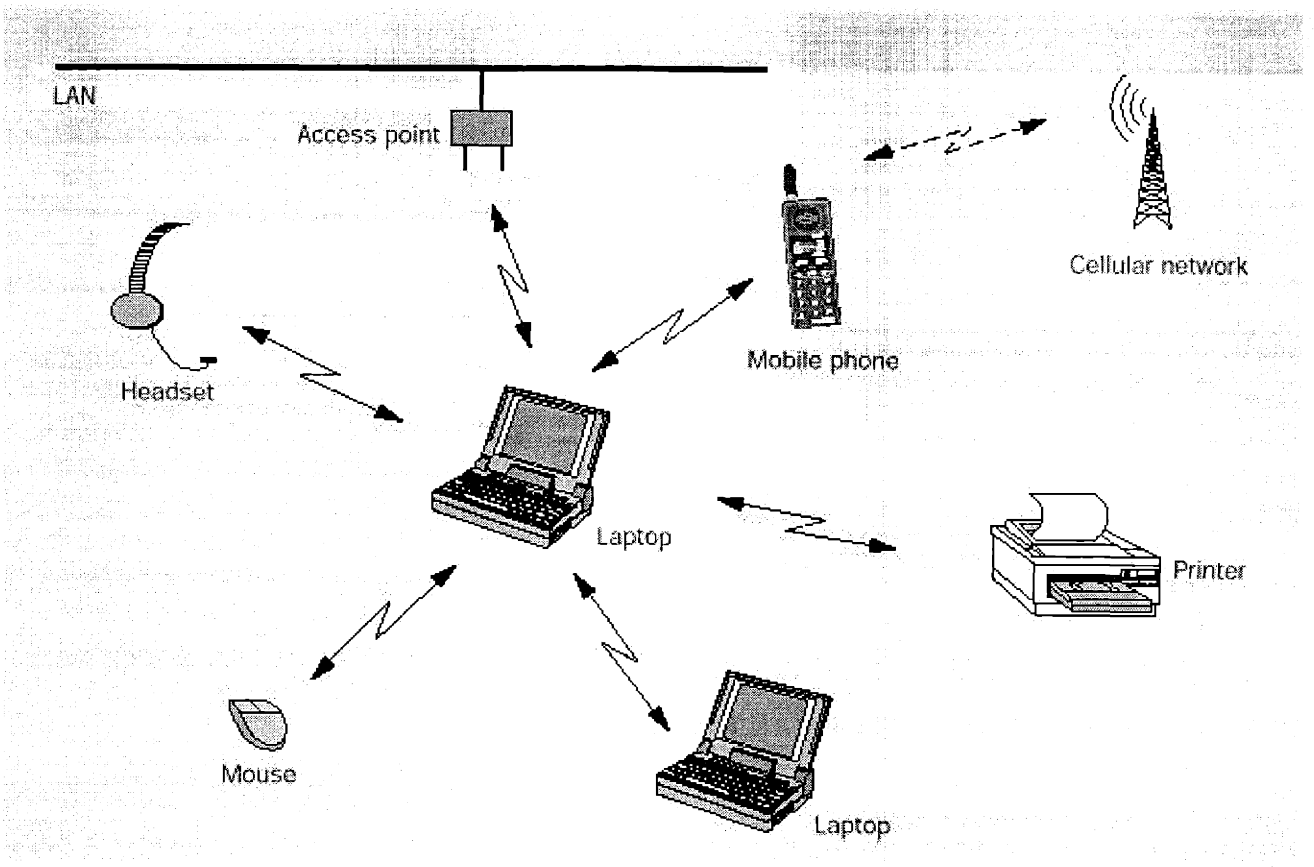
[2] Compiled from: www.bluetooth.com
[3] Connections that can support up to 8 devices sharing 1Mbps of bandwidth



Source: Technology Brief – www.dell.com – August 1999

Exhibit 1 – Bluetooth piconets

Bluetooth technology eliminates the need for wires, cables and connectors for and between cordless or mobile phones, modems, headsets, PDAs, computers, printers, projectors, local area networks, and so on, and paves the way for new and completely different devices and applications.



Source: www.bluetooth.com
Exhibit 2 - Applications envisioned for the near future

1.6.1 Technical Summary of Bluetooth

Bluetooth radios operate at 2.4 GHz. A frequency hop transceiver is applied to combat interference and fading. A shaped, binary FM modulation is applied to minimize transceiver complexity. The gross data rate is 1Mbps. A Time-Division Duplex scheme is used for full-duplex transmission. The Bluetooth baseband protocol is a combination of circuit and packet switching. Slots can be reserved for synchronous packets. Each packet is transmitted in a different hop frequency. A packet nominally covers a single slot, but can be extended to cover up to five slots. 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 64 Kbps synchronous (voice) link. The asynchronous channel can support an asymmetric link of maximally 721 Kbps in either direction while permitting 57.6 Kbps in the return direction, or a 432.6 Kbps symmetric link.

1.6.2 Radio

The Bluetooth air interface is based on a nominal antenna power of 0dBm. The air interface complies with the FCC rules for the ISM band at power levels up to 0dBm. Spectrum spreading has been added to facilitate optional operation at power levels up to 100 mW worldwide. Spectrum spreading is accomplished by frequency hopping in 79 hops displaced by 1 MHz, starting at 2.402 GHz and stopping at 2.480 GHz. This is handled by an internal software switch. The maximum frequency hopping rate is 1600 hops/s. The nominal link range is 10 centimeters to 10 meters, but can be extended to more than 100 meters by increasing the transmit power.

1.6.3 Technical features

- Designed to switch among 79 channels in the ISM 2.4-GHz band at 1,600 hops per second
- Bluetooth uses 0-bit, 40-bit or 64-bit encryption - secure enough for nonsensitive information (extra encryption will be needed for e-cash and financial transactions)
- With a range of 10 m (10m personal bubble), Bluetooth supports ad-hoc networking of up to 10 piconets, each handling eight devices (more piconets reduce throughput). Optional amplifiers can increase range to 100 m

- The power of Bluetooth (0.1 milliwatts) is below the leakage limits allowed for nontransmitting electrical devices, eliminating possible interference and health risks
- With a throughput of 1 Mbps and three voice channels (64 Kbps each), the remaining bandwidth is configurable as 432 Kbps symmetric, 721/56 Kbps asymmetric and duplex 384 Kbps 3G cellular compatibility mode.
- 3 simultaneous full duplex voice per piconet (CVSD@64 Kbps)
- Simultaneous voice/data capable
- Works in globally free spectrum (2.4 GHz, ISM band) - globally available frequency, 79 MHz of spectrum available
- Open industry standard - mobile computers, mobile phones, handhelds, data access points and others

1.6.4 Sources of Interference

Since the ISM (Industrial-Scientific-Medical) band is open to anyone, radio systems operating in this band must cope with several unpredictable sources of interference, such as:

- Baby monitors
- Garage door openers
- Cordless phones
- Microwave ovens (the strongest source of interference)

Interference can be avoided using an adaptive scheme that finds an unused part of the spectrum, or it can be suppressed by means of spectrum spreading. Bluetooth devices use a technique called "frequency hopping spread spectrum" that allows Bluetooth transceivers to resist signal interference and fading.

1.6.5 Frequency hopping spread spectrum

Frequency hopping chops the data signal up into small data packages that hop from frequency to frequency within the ISM band as a function of time. Bluetooth enabled devices have a hop rate of 1,600 hops per second over 79 channels. This technique minimizes interference because other signals in the same band can only affect the spread spectrum resulting from frequency hopping if both signals are being transmitted simultaneously at the same frequency. Therefore the interference over time is low, with consequent insignificant or zero bit errors. (frequency hopping over 100 channels is considered military secure in the USA)

Although the hopping frequency may seem to be random, an algorithm has to be applied so that a receiver, hopping between frequencies in synchronization with the transmitter, can receive the message correctly. In turn, different algorithms can be used to fine-tune the avoidance of interference by virtually ensuring that no two transmitters will hop to the same frequency at the same time.

1.7 Bluetooth Specification 1.0

The final Bluetooth specification version 1.0 was released to the public on July 26, 1999 and the first products are expected to be announced in early 2000.

With the completion of the Bluetooth 1.0 specification, developers from around the world can complete the design of products equipped with Bluetooth technology and prepare for product qualification and interoperability testing.

The Bluetooth 1.0 specification consists of two documents:

- Foundation Core, which provides design specifications
- Foundation Profile, which provides interoperability guidelines

Over the past year, more than 200 engineers and technical experts from the Bluetooth SIG have contributed to the development of the specification. Products based on Bluetooth technology, such as mobile computers, mobile phones, handheld devices, and peripherals such as headsets and network access points, are expected to come to market in mid-2000.

According to Simon Ellis[4], marketing manager at Intel:

"It has been a fruitful co-operation despite the fact that we are rivals and all have different aims and directions. Everyone realizes the importance of creating new technology and is tempted by the giant profits at stake if Bluetooth is a success."

[4] Mobile & Handheld Products Group – Intel's intranet – summer 99

1.8 Making mobile devices more useful [5]

Bluetooth technology has been termed the "personal area network" because it will allow users of phones and mobile computing devices to use the Internet and other networking applications any time and anywhere they happen to be.

In order to understand how it is possible to make mobile devices more useful, let us go through ten general user models:

- ***User model 1***

The three in one phone: on the move, at home and in the office

"When you are at the office, your phone functions as an intercom (no telephone charge). At home, it functions as a portable phone (fixed line charge). And when you're on the move, the phone functions as a mobile phone (cellular charge)."

Cooperative technologies: Cellular system, PSTN, Corporate LAN

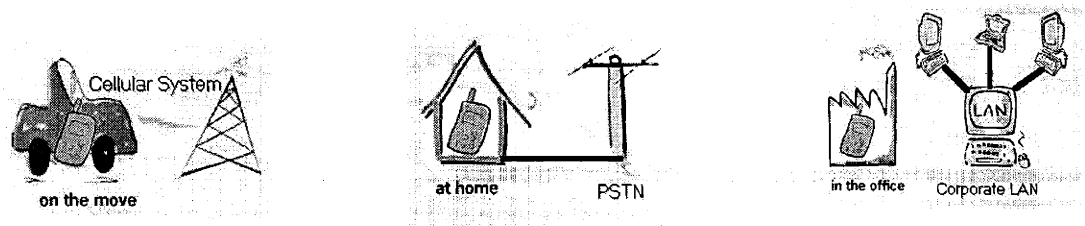


Exhibit 3 – The three in one phone

[5] All user models compiled from www.bluetooth.com

- ***User Model 2***

Surf the Internet regardless of the connection

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

Cooperative technologies: Cellular system, PSTN, Corporate LAN

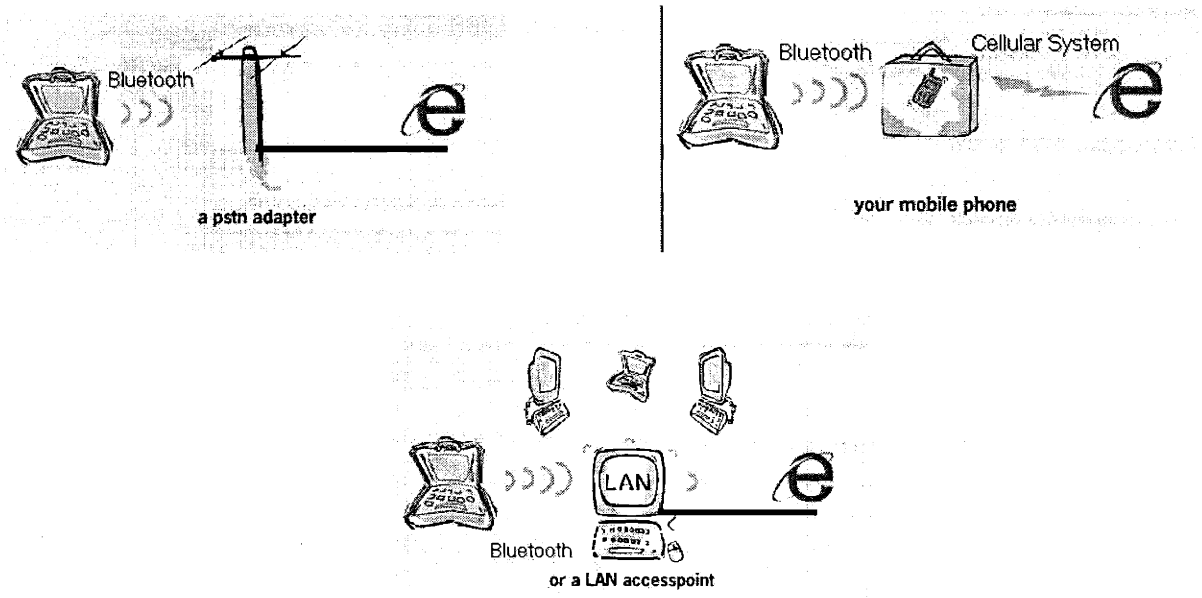


Exhibit 4 - Surf the Internet regardless of the connection

- ***User Model 3***

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. Transfer files, show presentations without connecting any wires."

Cooperative technologies: only Bluetooth

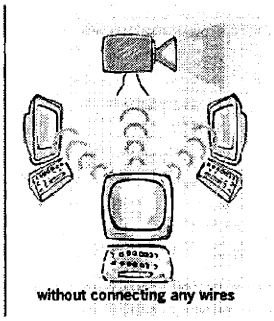


Exhibit 5 - Connect all participants for instant data exchange

- ***User Model 4***

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

"When your portable PC receives an 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."

Cooperative technologies: Cellular System

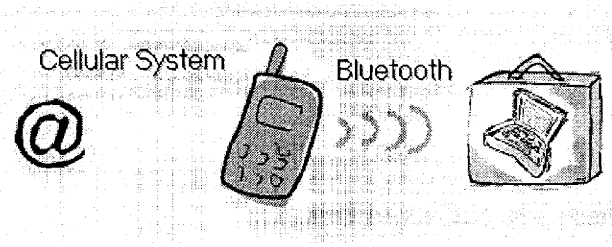


Exhibit 6 - Use e-mail while your portable PC is still in the briefcase

- ***User Model 5***

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."

Cooperative technologies: Cellular System

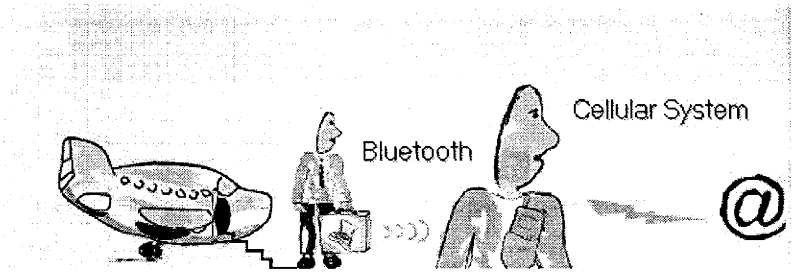
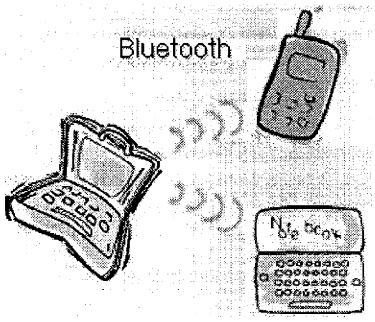


Exhibit 7 - Compose e-mails on your portable PC while you're on an airplane

- ***User Model 6***

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. 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."



Cooperative technologies: only Bluetooth

Exhibit 8 - Automatic background synchronization keeps you up-to-date

- ***User Model 7***

Send instant photos and video clips from any location

"Cordlessly connect your camera to your mobile phone or any wire-bound connection. Add comments with your mobile phone, a notebook or your portable PC and send them instantly to a receiver anywhere in the world. Suitable for professional as well as personal use."

Cooperative technologies: Cellular system and PSTN.

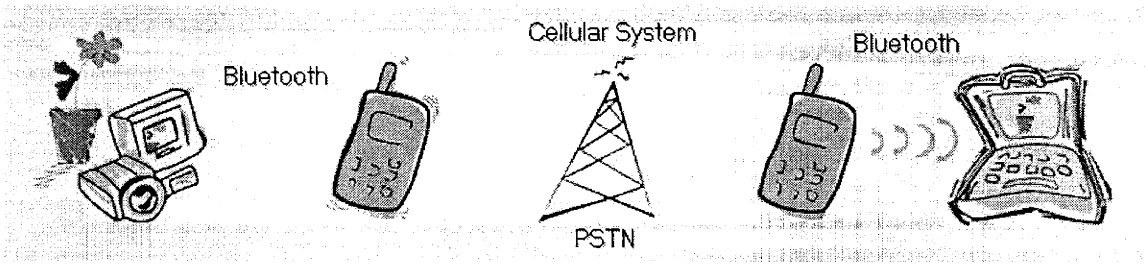


Exhibit 9 - Send instant photos and video clips from any location

- ***User Model 8***

Transfer files between computers - floppy and network replacement

Cooperative technologies: only Bluetooth

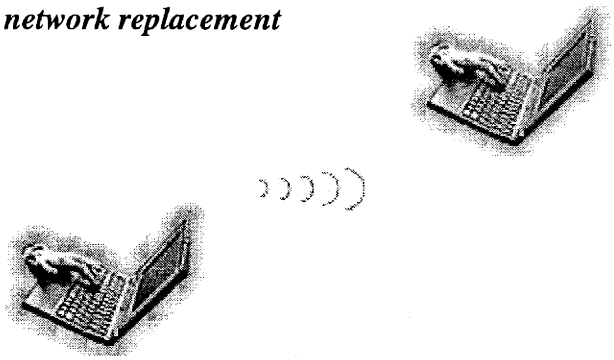


Exhibit 10 - Transfer files between computers - floppy and network replacement

- ***User Model 9***

Internet Bridge

"Use Bluetooth access points as a bridge between your computer and the LAN, WAN, PSTN, ISDN and xDSL.

How convenient would it be when you are at a hotel with Bluetooth access point? No need of cables to connect on Internet and no computer and modem configuration. The access will be automatic and seamlessly!"

Cooperative technologies: LAN, WAN, PSTN, ISDN, xDSL

Exhibit 11 - Internet Bridge

- ***User Model 10***

Ultimate Headset

"Talk on your mobile phone using your Bluetooth headset. Your phone can be inside your pocket while you are driving and you will be able to answer calls."

Cooperative technologies: only Bluetooth

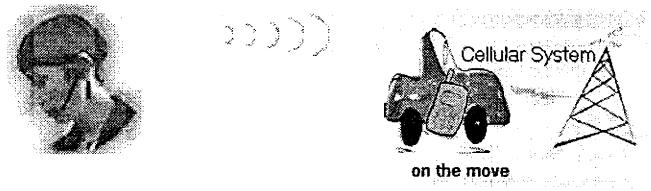


Exhibit 12 - Ultimate Headset

In conclusion, it is important to understand that the cellular system and other wireless and wired technologies are not direct competitors for Bluetooth technology - they work together in a cooperative way.

It is also important to understand that after purchasing the necessary hardware and software, there are no fees for using the Bluetooth devices. As it was mentioned before, the target cost is under $5 to the end-user (added to the price of the device) and less to the device manufacturer. Therefore, once you have Bluetooth inside your device, you pay nothing to use it. There are no subscription fees!

Note about the Cellular System

Currently, data transfers of up to 1Mbps (gross rate) are possible over Bluetooth technology. On the other hand, data transfers of up to 14.4 Kbps over a single cellular channel are possible with CDMA, whereas systems using TDMA are limited to 9.6Kbps. 3G wireless technologies will become available over a period of several years, beginning in 2000 in some countries and as late as 2002 in others. Additional capacity and higher data transfer rates are the

major thrusts of the 3G initiative. Data transfer rates of up to 2Mbps will be possible in fixed mode using wideband CDMA (W-CDMA), which is called CDMA2000 in North America.

1.9 Bluetooth Inhibitors

Inhibitors include security issues, health concerns, interference, confusion and hype. Bluetooth's low power presents no health risk; it is below the power permitted by nontransmitting devices, but vendors will have to get this message across. With the growing use of the ISM band, interference will occur; Bluetooth's high-speed frequency-hopping mitigates the impact of this. But it is unresolved if it will work in close proximity to an 802.11 WLAN device. There is currently (January 2000) a proposed law change in the US that affects how 2.4 GHz ISM band frequency hopping radio systems can be built for the US market. The proposal allows a high power frequency hopping radio, which uses a much wider frequency band than previously allowed. If the law is changed such radio systems will provide additional interference to other ISM band radio systems like Bluetooth.

Security[6] goes beyond encryption to risks of information being "stolen" by another device. Bluetooth supports various modes that permit users to select the degree of promiscuity of their devices. While the current transfer rare of 1 Mbps is low for certain applications (e.g., real-time video) this is not a barrier to adoption.

[6] For additional information on security please see, the *Bluetooth E-commerce/Bluetooth Communication Security* section of this paper – page 54.

1.10 Bluetooth Qualification Program

The mission of the Bluetooth Qualification Program is to protect the value of the Bluetooth technology and brand by ensuring:

- good performance of products
- interoperability of products
- clearly stated product capabilities

This will be achieved through a combination of manufacturer declarations, product performance testing, and interoperability testing.

But before a manufacturer can release Bluetooth-enabled devices on the global market, two parallel compliance procedures will have to be carried out:

1) The **Bluetooth Qualification Program** to ensure that the product complies with the Bluetooth specification. After the product has been approved, an adopter company can take advantage of a Bluetooth license covering patent rights and will be allowed to use the Bluetooth brand on products and in marketing activities.

2) **Regulatory type approval** to verify that a device conforms to a set of rules defined in diverse national or international regulations. The type approval is a mandatory requirement and is the

manufacturer's sole responsibility in order to gain a license to sell the device on a national or regional market.

The structure of the Qualification Program is now being worked out. The qualification process was launched in late 1999, with the full Qualification Program targeted for mid-2000. The strategies being followed are:

- to create a stable framework and process for product qualification
- to establish institutions needed to execute the program
- to publicize the qualification requirements
- to initialize the qualification test facilities

Although the full Qualification Program is targeted for mid-2000, provision is made to manage the introduction of "early products" to promote the development and spread of Bluetooth-enabled devices. For example, small deviations from the specification will be allowed if the product is not expected to cause any significant interoperability problems in the market.

Chapter 2

Bluetooth Strategy

2.0 Strategy Introduction

In today's high tech environment of rapid changes, the company that can bring the latest technology to the market faster can possibly be handsomely rewarded with a huge market share. One of the potential financial rewards from capturing market dominance is heightened when a strong network effect exists. The lure of a monopoly rent from establishing an industry standard and the presence of tipping effect can lead a company to innovate with fervor. Fueling this innovation is not only the potentially huge upside but also an equally significant downside. Should a company fail to set its product as the industry standard, it can very well be shut out of the market by the one that did establish the standard and has subsequently dominated the market.

The competition can therefore be fierce among companies to have their technologies become the standard, and they closely guard or strategically license the technology to maximize profit. In light of this environment, Bluetooth, this wireless technology developed by a group of leading "high-tech" firms, does not make explicit economic sense. It is infrequent for a group of firms to voluntarily join forces to develop a technology and subsequently attempt to establish it as a standard. More curious is that an integral part of Bluetooth initiative is to open up the technology platform to their competitors to increase those firms that adopt the technology. Save a truly altruistic goal of promoting technological advancement for the betterment of society, it is

not readily clear why the founding group initiated the development and how they or any subsequent firms adopting the technology will realize profit from the venture.

In an attempt to answer the above question under strategic lens, let us focus our attention on some key issues such as "Bluetooth competitive landscape, diffusion and life cycle", "Why did SIG initiate Bluetooth?" and "How can a firm capture value from Bluetooth technology?" In answering these questions, it will be clear that cooperation and collective effort can be a powerful tool in initiating a new technology to drive a new standard.

2.1 Strategic Bluetooth

2.1.1 The Bluetooth Special Interest Group (SIG)

The Bluetooth consortium includes Ericsson, IBM, Intel, Nokia and Toshiba. An ironic aspect of this consortium is that, as each company implements Bluetooth into its products, the quasi-cooperative companies within the consortium will become competitive against one another. Each of them will launch its own products competing against the other companies in the adopters' list. Compared to the companies in SIG, the companies in the adopters' list may have the disadvantage of getting the specification later. This would leave the SIG companies in a favorable position to be the first movers in the new market.

2.1.2 Competitive Landscape Look for Bluetooth

There is no clear direct competition for Bluetooth technology. Bluetooth represents a disruptive technology to the existing way of transmitting data/voice for person to person and device to device domains. Currently, data transference between person to person is limited to

physicality (i.e. trading of business cards) or to traditional electronic medium (i.e. e-mail and infrared beams between handheld devices). Therefore, Bluetooth, at first, can be seen as a cable replacement. It can also be seen as an improvement to infrared technology since it eliminates infrared's "line of sight" constraint. Bluetooth also focuses on the personal area network, allowing electronic devices to communicate seamlessly in a 10 meters range (or up to 100 m, depending on the power of the transmitter). Different technologies such as HomeRF and WLAN (Wireless LAN) are partial competitors since they overlap with Bluetooth in the home space and office space respectively.

Relationship between Bluetooth and other technologies

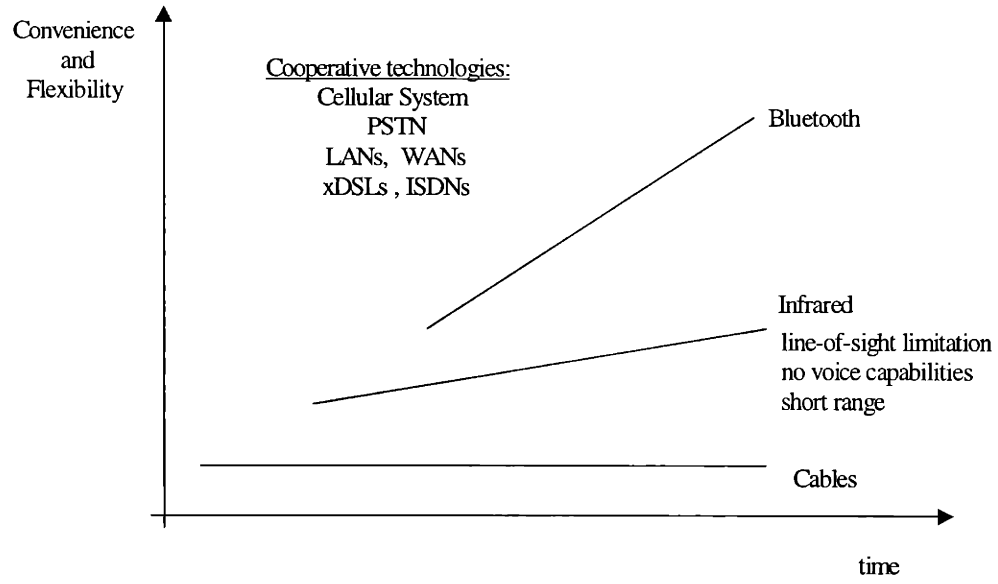


Exhibit 13 – Relationship between Bluetooth and other technologies

It is important to understand that Bluetooth cooperates with and expands the limits of existing technologies such as the Cellular System, the PSTN, LANs, WANs, xDSL and ISDNs allowing more freedom and convenience for the end user. When analyzing this functionality of Bluetooth, it can be shown that Bluetooth would push the existing technologies mentioned above higher up their s-curve.

2.1.2.1 Bluetooth Vs Infrared - One of the differences between Bluetooth and Infrared is that Bluetooth does not require "line of sight" in order to transfer data. Bluetooth technology is also capable of transmitting voice and data (opposed to data only), and it allows the user to have a "personal area network", which is defined as a 10m radius around the user. Within this range, Bluetooth devices can communicate with each other.

	Infrared	Bluetooth
Transmission rate (data)	4Mbps	1Mbps (going to 10Mbps)
Require line of sight?	Yes	No
Connect more than 2 devices?	No	Yes (up to 8 devices)
Worldwide	Yes	Yes
Voice capabilities	No	Yes
Cost	$2	$20 (going down to $5)

Table 1 – Comparison table: Infrared and Bluetooth

2.1.2.2 Bluetooth Vs HomeRF and WLAN- Within the boundaries of personal homes, HomeRF is a possible competing technology to Bluetooth. It is yet to be decided whether Bluetooth will replace HomeRF at home or if both technologies will coexist. However, it is clear that HomeRF can not substitute for Bluetooth outside of home. A similar situation occurs when

a Bluetooth device enters an office running WLAN (Wireless LAN). Since Bluetooth, HomeRF and WLAN operate on the same frequency, the transfer rate for these devices might drop significantly. However, coexistence is possible due to a technique called Frequency Hopping Spread Spectrum, which minimizes interference from other devices working on the same frequency.

HomeRF, WLAN and Bluetooth will not be used in the same environment. HomeRF is home-centric, WLAN is enterprise-centric, and Bluetooth is user-centric. Mostly envisioned for ad-hoc connection anywhere, anytime, Bluetooth will follow the user wherever he goes. This is the PAN (personal area network) concept. Bluetooth has no competitor for ad-hoc connections, but one might argue that Bluetooth has competitors in the home and enterprise environments. It is still to be defined if WLAN will be widely adopted because of its high cost ($2,000 per seat).

	HomeRF	Bluetooth
Focus/environment	Home	User – wherever he/she is
Announcement	March 98	May 98
Adopters	90+ companies	1300+ companies
Founding companies (as of Dec/99)	Intel, Ericsson, IBM and Compaq	Intel, Ericsson, IBM, Toshiba and Nokia
Range	50m	10 to 100m
Frequency hopping	50 hops/sec	1600 hops/sec
Open standard	Yes	Yes
Frequency	2.4Ghz (ISM band)	2.4Ghz (ISM band)
Data and voice	Data + 6 voice	Data + 3 voice Please see technology description
Transmission rate	1Mbps (going to 10Mbps)	1Mbps (going to 10Mbps)

Table 2 - Comparison table: Home RF and Bluetooth

	WLAN	Bluetooth
Transmission rate	Up to 11Mbps	1Mbps (going to 10Mbps)
Range	30 to 1000 meters	10 to 100 meters
Frequency	2.4Ghz (ISM band)	2.4Ghz (ISM band)
Cost per solution	>$2,000	$20 (going down to $5)

Table 3 - Comparison table: WLAN and Bluetooth

In order to improve our judgement on where these technologies are going, let's see some quotes from the industry.

Note about HomeRF [7]

"The HomeRF Working Group (HRFWG) was formed to provide the foundation for a broad range of interoperable consumer devices by establishing an open industry specification for wireless digital communication between PCs and consumer electronic devices anywhere in and around the home. The HRFWG, which includes the leading companies from the personal computer, consumer electronics, peripherals, communications, software, and semiconductor industries, has developed a specification for wireless communications in the home called the Shared Wireless Access Protocol (SWAP).

To date, the high cost and impracticality of adding new wires have inhibited the wide spread adoption of home networking technologies. Wired technologies also do not allow users to roam about with portable devices. In addition, multiple, incompatible communication standards

[7] source: www.homerf.org

have limited acceptance of wireless networks in the home. The HRFWG believes that the open SWAP specification will break through these barriers by (1) enabling interoperability between many different consumer electronic devices available from a large number of manufacturers, and (2) provide the flexibility and mobility of a wireless solution. This flexibility is important to the success of creating a compelling and complete home network solution.

Since the formation of the group was announced in March 1998, the total number of member companies now exceeds 90, and continues to expand quickly. The inclusion of nearly all the leading consumer electronics companies in the working group ensures that consumers will benefit from a wide variety of innovative, interoperable devices for use in and around the home."

Note about WLAN [8]

"A wireless LAN (WLAN) is a flexible data communication system implemented as an extension to, or as an alternative for, a wired LAN within a building or campus. Using electromagnetic waves, WLANs transmit and receive data over the air, minimizing the need for wired connections. Thus, WLANs combine data connectivity with user mobility, and, through simplified configuration, enable movable LANs.

Over the last seven years, WLANs have gained strong popularity in a number of vertical markets, including the health-care, retail, manufacturing, warehousing, and academic arenas. These industries have profited from the productivity gains of using hand-held terminals and notebook computers to transmit real-time information to centralized hosts for processing. Today

[8] source: www.wlana.com

WLANs are becoming more widely recognized as a general-purpose connectivity alternative for a broad range of business customers."

Observation: Wireless LAN's are not a seamless technology where every device communicates with every other device. Wireless LAN's still have to go through a network, just as with a wired LAN.

2.1.2.3 Quotes from the industry

Dell white paper [9]: Although HomeRF's data rate brings it close to Bluetooth performance, Bluetooth currently has more industry backing.

Dell white paper: The Bluetooth SIG and the IEEE 802.11 working group (WLAN) are cooperating to ensure that there will be no unfavorable interaction between the two technologies. Working has been done to ensure that users can use both technologies in their networks with no interference problems between the two technologies.

Wireless standards, May 13, 1999: Several proposed wireless standards promote the growth of wireless connectivity. The IEEE 802.11 standard targets professional and wireless-LAN applications. Two other standards, Bluetooth and HomeRF's, are more relaxed specs targeting cost-conscious consumer markets. The 802.11, Bluetooth, and HomeRF standards share

[9] source: White Paper – www.dell.com – Home Networking – April 1999

the same two fundamental subsystems that comprise a wireless design: the RF, or radio, side and the baseband side.

2.1.3 Expected Diffusion of Bluetooth

Despite its young age, Bluetooth has experienced much success in capturing mindshare of the major technology firms in the world. Note that the diffusion model that we speak of here is currently limited to the commercial firms and not yet applicable for the retail consumers. The specification for Bluetooth technology was released in July 1999. Companies now are developing products to be announced in early 2000 and released in mid-2000. At the current rate of adoption, one can expect the diffusion of this technology to follow the following pattern:

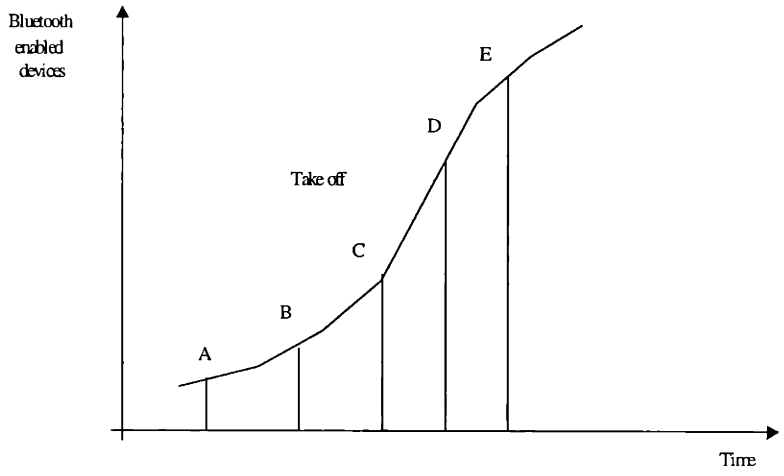


Exhibit 14 – Expected diffusion of Bluetooth

- Point A: late 1999 - ferment phase
- Point B: mid 2000 - First products (SIG companies). E.g. computers, cellular phones, PDAs, headsets and others
- Point C: late 2000 - Products from part of the companies in the adopters list, mainly companies that compete directly with SIG companies (such as Dell, Compaq and others)
- Point D: mid 2001 - Other companies in the adopters' list. Products example might be printers, projectors, digital cameras and others.
- Point E: late 2001 - More products from the companies in the adopters list.

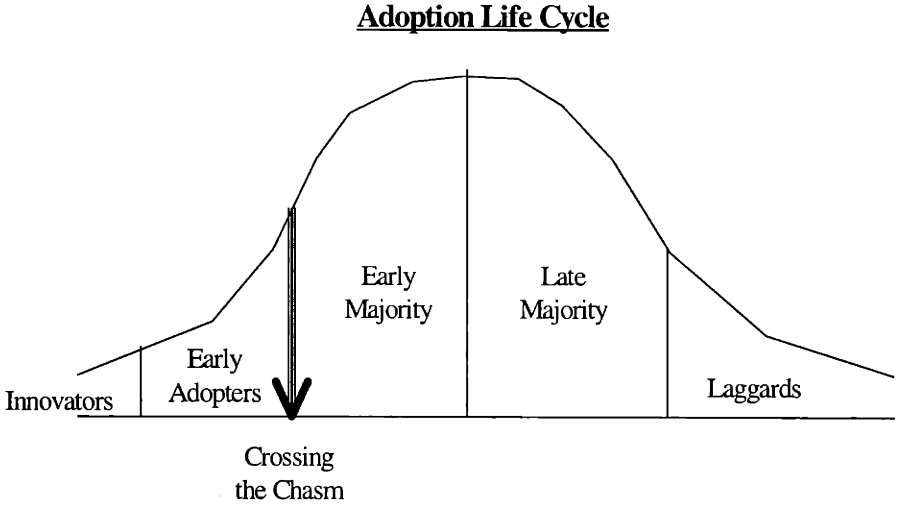
During the time it takes to reach point E, other industries such as the automobile industry should be in their developing phase. Also, companies that are not currently in the adopters' list will be "forced" to enter in order to remain competitive in its markets. A wide range of products will be launched with Bluetooth inside such as Coke machines, Gas Station pumps, and others. That will be the start of a new layer of E-commerce, enabled by Bluetooth inside products.

2.1.4 Bluetooth's Adoption Life Cycle

Bluetooth has received and benefited from much attention and participation both within and outside of technology-related industries. With more than 1300 companies on the adopters list, Bluetooth has successfully attracted the "Innovators" and most of the "Early Adopters." In reality, most of the companies on the adopters' list have not integrated Bluetooth into their products yet (specification was released on July 1999). However, they are in the process of developing products that have Bluetooth inside. Given this situation, Bluetooth has not crossed

the chasm that separates initial diffusion momentum from a rapid diffusion of the technology. Once it does cross the chasm, SIG needs to deploy a different marketing strategy to attract the Early and Late Majority groups.

SIG companies will also have to change the marketing message in the future. As mentioned before, the number of attendees at the Bluetooth Developers Conference has grown from 350 to 1800 in one year's time. These conferences will still be held in order to educate adopters but at the same time, new marketing messages has to be sent once products reach the market in mid 2000. Therefore, developers and customers education will be needed in parallel in order to increase its chance of crossing the chasm.



Source: Moore, G. Chapters 1 and 2 in Crossing the Chasm

Exhibit 15 – Adoption life cycle

2.2 Why Did SIG Initiate Bluetooth?

The reasons that Ericsson, IBM, Intel, Nokia and Toshiba are the founding members deserve some attention. Under the name of technological advancement, the otherwise competitors (namely Toshiba vs. IBM and Ericsson vs. Nokia) are cooperating in developing and promoting Bluetooth technology. The SIG's objective of developing an open standard for wireless transference of data/voice based on a superior technology is a noble cause. However, the founding members also have economic incentives for investing their own financial and human resources in the project. These companies are, after all, for-profit entities.

2.2.1 SIG's Objectives

The main driver behind SIG's initiative in Bluetooth is the promise of having first access to a potentially powerful technology before any of its respective competitors. Given that timing is critical in a technological innovation, having first hand knowledge of a specific technology allows a company to capture value from the innovation and increase its competitive advantage.

- Having the technology first affords SIG members the precious time to plan and incorporate the latest technology into their products. This timing advantage allows the founding members to introduce their products faster to the market
- By being intimately involved in the development stage of a technology allows the SIG to put their agenda first, in terms of the direction and the timing of the development process

- The SIG, in a sense, is given the advantages of a first mover with respect to the technology. They are ahead of their competitors in incorporating Bluetooth into their products.

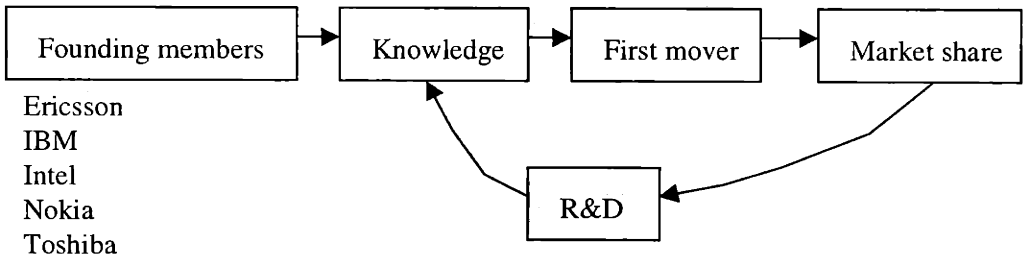


Exhibit 16 - Bluetooth and its reinforcing loop diagram

2.2.2 Collective Effort

At a first glance, it is curious how the specific companies came to be in the SIG. Some of the SIG members are traditional competitors. We contend that main drivers behind their cooperation are that Bluetooth's success depends on interoperability among different types of devices and a strong user base. Although traditional competitors, the members of SIG would ultimately benefit by combining forces to develop and push Bluetooth with their installed base. Furthermore, by deciding to join forces and develop Bluetooth, they are, in fact, deciding to compete not for the technology of Bluetooth but compete instead within the standard that Bluetooth is establishing. The collective effort also prevents the establishing of a competing, proprietary standard that they do not control. One can reason that the cost of aggressively

competing to establish a standard for wireless technology outweighed the benefits of winning such a war.

2.2.3 Intel's Objectives

Intel's reason for being one of the founding members deserves a closer look. Unlike the other members of SIG, Intel traditionally is not a manufacturer of a device that would use Bluetooth inside. Given that Intel generates revenue mainly by selling chips, it can be reasoned that Intel ultimately expects a successful launch of Bluetooth to translate to an increased sale of its chips and yet a stronger market presence in the mobile PC markets.

- Defensive tactic: Bluetooth has revolutionary potential for the entire data/voice world. Given that Intel currently targets these industries, it needs to be on top of the latest technologies that can affect its revenue base. Therefore, it would be Intel's interest to be involved in the technological development in order to maintain its market position.
- Marketing tactic: Intel prides itself on bringing latest technologies to the market. By leading a high profile initiative such as Bluetooth, Intel can sustain its image as being technologically innovative. It also brings some other benefits such as attracting brilliant people to work for the company.
- Diplomatic tactic: Intel is the only firm that does not have a major direct competitor in the SIG. In fact, the other members of the SIG are Intel's customers. Intel acts as a catalyst in the development and promotion process among the companies that would otherwise be competing against each other. By being the common thread among the other SIG members, Intel facilitates coordination and makes all of the members work together and on schedule.

- Supply chain management tactic: Helping its customers develop a technology that would ultimately lead to higher sales of their products translates to higher sales for Intel. Intel's proactive participation in the Bluetooth initiative is a way to ensure a healthy demand for its chips.
- Related product development: Intel is committed to be aligned with the Internet business. Combining Internet and Bluetooth may present opportunities for its own products.

2.3 How Can SIG Capture Value From Bluetooth Technology?

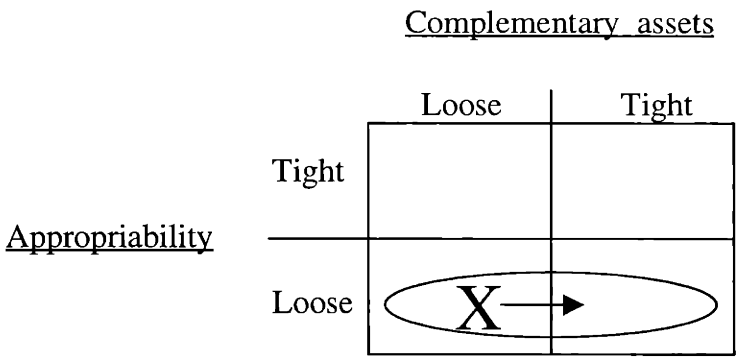
From a strategic perspective, the Bluetooth initiative needs the SIG structure. Bluetooth is a revolutionary technology that can make ordinary items, such as cellular phones and PDA's, into exceptional devices that facilitate transference and use of information for individual consumers. Bluetooth, therefore, can create a significant amount of value. However, given that the technology is based on an open standard, appropriability is loosely held. In order for a company to capture value from this technology, it needs complementary assets.

2.3.1 Complementary Assets

The SIG collectively possesses the necessary complementary assets, such as installed base, distribution channel, and the name brand for the members to extract value from Bluetooth. A successful application of Bluetooth hinges on an expansive adoption, firstly by the makers of data/voice devices and secondly by the consumers. Ericsson, IBM, Intel, Nokia and Toshiba represent strong name brands in their respective industries with significant market share to cause

such diffusion. As a group, these companies have enough clout to cause their respective industries to notice and eventually adopt Bluetooth technology, and they have a significant installed base to initiate adoption by the consumers.

Appropriability - loose in case of open standards
Complementary Assets - those necessary to translate an innovation into commercial returns



Source: Teece, David J. – California Management Review, spring 1998, Volume 40, N3,

Exhibit 17 – Complementary assets and appropriability

Even though appropriability is loose, SIG complementary assets (as described above) are important to capture value. In addition, every SIG member can develop its own complementary assets in order to extract value for itself. In Intel's case, for example, one of its most valuable assets is its strong relationship with the major OEM's. If we assume that Bluetooth is a commercial success, Intel can tighten its control of its complementary asset (namely, its relationship with the OEM's) by "bundling" its chips with the Bluetooth unit. In addition, given

that Intel's closest competitor, AMD, is not involved with Bluetooth, Intel's integral involvement with the Bluetooth technology would further enhance its competitive advantage over AMD.

2.3.2 Network Externality

Another reason why SIG structure is critical in developing a technology like Bluetooth is that there is a strong network effect for Bluetooth. The commercial success of Bluetooth depends heavily on the size of the installed base. As it is in the case for fax machines, at least two Bluetooth-enabled machines are needed for a minimal benefit for Bluetooth to be realized. Therefore, the more expansive the user base, the higher the benefit that consumers can realize.

Understanding that network markets have three characteristics named as: (a) they are tippy, given that co-existence of incompatible standards is unstable; (b) expectations about the ultimate size of networks are critical; and (c) a distinct history of technology adoption favors those products that entered earlier than later. Given these characteristics, Bluetooth benefits from SIG structure. With a tendency for the wireless communications market share to tip for one standard at the expense of the other, the existing installed base for each member of SIG would provide the critical initial foothold in the market share. In addition, the members of SIG collectively represent product groups targeted for initial adoption of the Bluetooth technology (i.e. computers and cell phones). The inter-operability among these devices increases the attractiveness of Bluetooth to the consumers and, therefore, encourages diffusion of the technology.

The fact that the members of SIG are industry leaders in their respective businesses would add credibility to an expected success of Bluetooth. If companies with strong name

brands, such as those in the SIG, invest time and money to introduce products that incorporate the technology, it sends a strong signal to the rest of the world that the technology has a high probability of success. This is important because it strengthens the expectation that the ultimate size of the network will be big. Seeing this expectation, the consumers will opt to purchase Bluetooth enabled products in order to benefit from a large network externality. This is a self-fulfilling prophecy as consumers adopt Bluetooth in masses with the expectation that everyone else will do the same. The effect of name brand on the expectation is magnified when the adopter list contains other major names, such as Sony, NEC, HP and others.

Given that network markets have the history of favoring those technologies that reach the markets first, having SIG makes strategic sense for Bluetooth. The combined expertise and the resources of SIG allowed Bluetooth to reach the markets faster and efficiently. Bluetooth may have been lost in the development stage if it were a truly open standard dependant on ad hoc participation (as in Linux). By having a few firms with vested interest in the success of Bluetooth working together as a team, the technology and the companies benefit from:

- Reaching the market in remarkable speed (less than 1 1/2 years).
- Economies of scale in marketing and development
- Sharing the risk and commitment to making Bluetooth happen
- Safely and efficiently introducing the technology to the market
- Increased chance of Bluetooth survival and becoming a standard

Once the technology crosses the chasm and reaches the early and late majority, users will encounter high switching costs and lock-in due to the learning and experience from using Bluetooth devices. The more Bluetooth users the market possesses, the more companies will innovate and the more added value consumers will receive. This will reinforce the loop that will drive different industries (other than high-tech) to join the world of Bluetooth.

2.4 Organizational Issues for Bluetooth Technology

The last reason that I cite for the need for the SIG can be seen in how the organizational issues were addressed in the development of the technology. We contend that through the partnership among the SIG members, Bluetooth was able to bypass the negative consequences that some organizations face in initiating and developing new technologies. The major challenges in undertaking a new initiative inside an organization are (a) allocating resources, (b) integrating and coordinating the new initiative with old efforts and (c) establishing the right incentive structure that would sustain the initiative.

These challenges pose an interesting question for the SIG and the development of the Bluetooth technology. On one hand, the SIG represents a quasi-start up company that was formed recently to develop Bluetooth. Therefore, it can be reasoned that relatively little effort is needed in coordination. On the other hand, members of the SIG are mature and established companies that already have their respective structures in place. It can be argued, therefore, that much effort in coordination is necessary in order to integrate the Bluetooth technology with the existing efforts at their respective organizations. When we analyze the actual coordination

among the SIG members, we can see that they have managed to strike a healthy balance of coordination vs. initiatives, as depicted in the graph below:

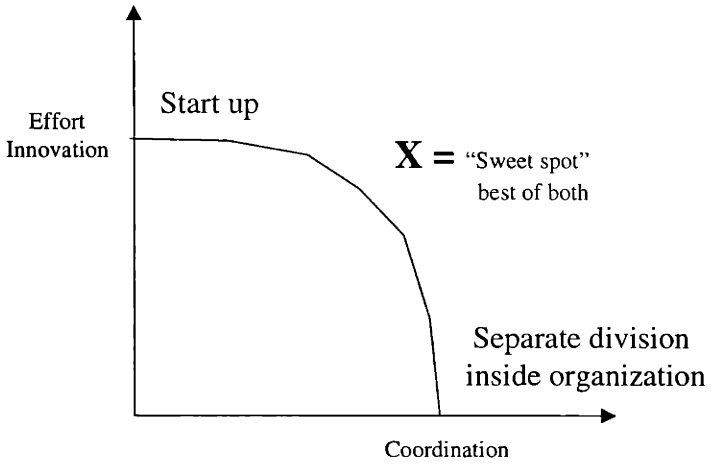


Exhibit 18 – Organizational issues

As an integral part of the joint-effort within the SIG, cross-organizational teams were formed with at least one representative form each of the founding companies. Cross-functional teams were also created across founding companies. Engineers from these companies got together to define the technical issues of the new standard. A total of more than 200 engineers were needed to bring Bluetooth Specification 1.0 to the market in less than 1 1/2 years.

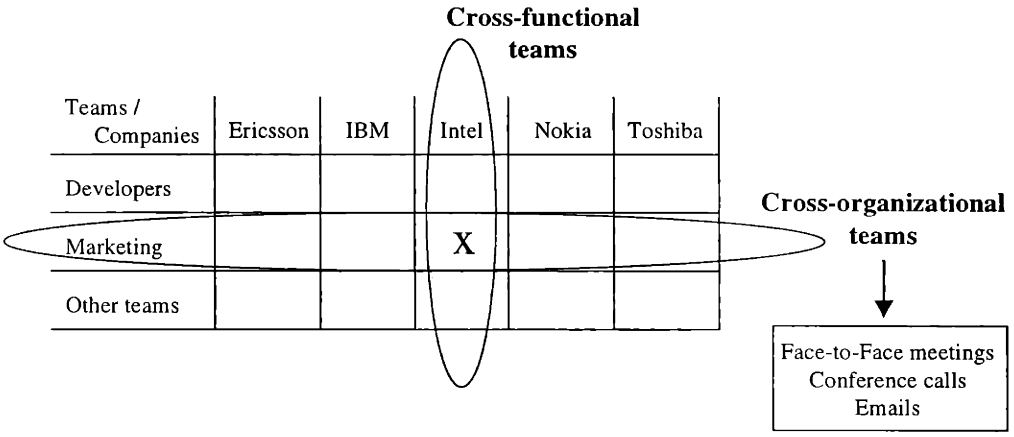


Exhibit 19 – Bluetooth teams

Marketing cross-organizational teams, for instance, get together every 3 months to decide how to market this new technology in order to make it cross the chasm and get to mass market. During these "face-to-face" meetings, important decisions for marketing strategies are made, such as the Bluetooth Developers Conference. Between these quarterly "face-to-face" meetings, conference calls are made weekly and emails are exchanged daily in order to maintain the cross-organizational teams working together toward a common goal. As one can see, a lot of cooperation and collective power are being put in place in order to bring this new standard to the market successfully.

Due to the collective effort, economies of scale in marketing and development emerged. Founding companies also share the risk and reputation to bring Bluetooth to the market. The 5 founding companies (as of December 1999) have reached a perfect balance, with Intel playing the role of catalyst in this process and assuring that competitors such as IBM-Toshiba and Ericsson-Nokia cooperate to achieve a common goal.

Chapter 3

Bluetooth E-commerce – A Futuristic Vision

3.0 E-commerce Introduction

Many technological innovations present tremendous opportunities for dramatic change in business practices. In the realm of electronic commerce, many of the business models currently being developed for business-to-consumer and consumer-to-consumer transactions are contingent upon consumers' presence on-line. Telecommunication providers have enabled individuals to transmit voice and data over networks with wireless technology, dramatically broadening the reach of network based commerce. However, these developments failed to create connectivity between end users independent of server-driven networks. This need will be filled by the advent of Bluetooth technology.

End-user connectivity holds the potential to revolutionize consumer-driven commerce in a three-step evolution. First, in traditional consumer markets, this connectivity will reverse the long-standing asymmetry of information into the consumer's favor. Consumers will make purchase decisions with more information about pricing and features from a broad spectrum of suppliers than ever before. This will place pressure on merchants to lower real prices and innovate to offer new ways to deliver value to savvy consumers. Second, in response to this pressure, merchants in traditional consumer markets will utilize the information available through this connectivity to innovate. To combat price pressure, companies will look to reestablish relationships with customers through bundled services and targeted promotions. End-user connectivity allows much more innovation than the Web alone because it allows real-time

interaction with consumers when they are not connected directly to networks. Finally, new consumer-driven commerce models will evolve. Many of these may take advantage of new-found connectivity between individuals who would otherwise count on networks. Companies will also use Bluetooth to serve customers in completely new ways that break even web-based molds of commerce.

Since most of the transactions and interactions between business-to-consumer and consumer-to-consumer will be done wirelessly, special attention should be given to security issues on Bluetooth technology in order to ensure the integrity of the transactions.

3.1 Bluetooth Communication Security

For e-commerce applications, special attention must be paid to security, encryption and authentication. Since radio signals can be easily intercepted, it is important that Bluetooth-enabled devices have built-in security to prevent eavesdropping or falsifying the origin of messages. The following link-level security features of the Bluetooth technology achieve these basic objectives:

- Authentication: prevents spoofing and unwanted access to critical data and functions.
- Encryption: prevents eavesdropping and maintains link privacy.

In addition to these link-level functions, frequency and the limited transmission range of Bluetooth-enabled devices – usually about 10 m – also helps to prevent eavesdropping. Due to the fact that applications and devices will have different demands on data security, flexibility in

the use of the link-level security is needed. The Bluetooth Specification 1.0 defines three security modes that cover the functionality and application of the device:

- Mode 1 - Non-secure

Mode 1 is used with devices having no critical applications. It bypasses the link-level security functions and is suitable for accessing, e.g., databases containing non-sensitive information. The automatic exchange of business cards is a typical example of non-secure data transfer.

- Mode 2 - Service-level security

This mode allows versatile access procedures, especially for running applications with different security requirements in parallel. (more detailed description is given below)

- Mode 3 - Link-level security

In this mode the link manager enforces security at a common level for all applications at the very beginning of the connection. Although less flexible, this mode is well suited to enforcing a common security level, and it is easier to implement than mode 2.

Link-level security

All link-level security functions are based on the concept of link keys. A secret link key is a 128 bit random number stored individually for each pair of devices. Each time these two devices communicate via Bluetooth transceivers, the link key is used for authentication and encryption, without any influence of the piconet topology. The most secure type of link key is a combination

key, derived from the input of both devices. For devices with low storage capabilities, there is also the option of choosing a unit key, which may be used for several remote devices. Additionally, for broadcasting, a temporary key is needed, which naturally cannot be used for authentication but prevents eavesdropping from outside the piconet (but not from members sharing this temporary key). Authentication requires no user in-put. It involves a device-to-device challenge and response scheme that requires a 128-bit common secret link key, a 128- bit challenge and a 32-bit response. For the first time only that two devices communicate, an initialization procedure is needed to create a common link key in a safe manner. This procedure is called pairing. The standard way of doing this assumes that the user has access to both devices at the same time. For first-time connection, pairing requires the user to key in a Bluetooth security code of up to 16 bytes or 128 bits into paired devices. However, when this is done manually, this code will usually be shorter. Although the Bluetooth security code is often referred to as a "PIN" (Personal Identity Number), it is not a code the user has to keep secret or memorize, as it is only used once. When for some reason a link key is deleted and the initial pairing must be repeated, any Bluetooth security code can be entered by the user again. In the case of low security requirements, it is possible to have a fixed code in devices having no man-machine interface to allow pairing. The pairing procedures involves:

- Generation of a common random number initialization key from the user-entered Bluetooth security code in paired devices. This is used once and then discarded
- Authentication which checks that the Bluetooth security code is identical in the paired devices

- Generation of a common 128-bit random number link key – stored temporarily or semi-permanently in paired devices

As long as this current link key is stored in both devices, no repetition of pairing is necessary. Only the normal procedure for authentication is carried out.

Encryption for the baseband link requires no user input. After successful authentication and retrieval of the current link key, this function generates a new encryption key from the link key for each communication session. A stream cipher algorithm is used that is well suited to hardware implementation. The encryption key length ranges between 8 – 128 bits depending on the level of security and export regulations. In addition, the maximum encryption length is hardware-restricted.

Service-level security

In security mode 2 it is possible to define security levels for devices and services. There are two levels of trust for devices:

- A trusted device, which has a fixed relationship (paired), is trusted and has unrestricted access to all services
- An untrusted device, which has no permanent fixed relationship (but possibly temporary), or which has a fixed relationship and is not trusted. Here the access to services is restricted.

A possible refinement is to set the trust level of a device specifically for services or a group of services. For services the requirement for authorization (permitted or denied access to a service), authentication (identifying 'who' is at the other end of the link) and encryption are set independently. Three security levels govern service access:

- Services that require authorization and authentication. Automatic access is only granted to trusted devices: other devices need manual authorization
- Services that require authentication only
- Services open to all devices

A default security level is defined to serve the needs of legacy applications. This default policy will be used unless other settings are found in a "security" database related to a service, e.g., an internal security information database.

Bluetooth security is not intended to replace existing network security features. For extremely high or special requirements (e.g. e-commerce or personalized instead of device-oriented authorization) additional application-level security mechanisms can be implemented. In the Bluetooth profiles this approach has already been used for synchronization, where OBEX authentication is used.

3.2 Empowering Consumers

As Bluetooth is introduced into a variety of consumer products, it will increase the power that consumers have in making purchasing decisions. The Bluetooth technology can empower the consumers by (a) making the flow of information more asymmetric in favor of the consumers and (b) simultaneously reducing search costs and increasing convenience of shopping. In effect, the Bluetooth technology would magnify the empowerment effect already prevalent in the Internet space.

Such a situation can be illustrated in the Bluetooth user model that allows retail stores to wirelessly send pricing and promotion information to the Bluetooth enabled cell phone that a customer would be carrying as he walks through a shopping mall. As the consumer walks by a store that has a special promotion, the personal device (i.e. cell phone or PDA) that the consumer is carrying will signal to the consumer that the specific store is having a sale or advertising certain prices that may be of interest. The consumer can then make a decision if he would make a purchase from the store. The consumer's power increases further when he is able to program his personal device to filter the information being transmitted to him. The consumer can set criteria for types of products and prices before entering the mall and allow only the information that falls within the criteria to be signaled to him. This limits the adverse effect of information overload, as all of the stores will be sending their information to any consumer passing nearby.

3.2.1 Information Asymmetry

As illustrated above, this technology facilitates asymmetric flow of information in favor of the consumers. (Note: This section assumes that the consumers can choose to keep their personal information from the stores. However, they may also choose to release information, such as product preferences, to the retail shops when such a reciprocity of information transference would yield an economic benefit for the consumers.) As the retail shops clamor to send their messages out to the shoppers walking nearby, the shopper is in the position to collect all the information being transmitted to him. He then has the choice of pursuing whichever product offerings he wants. Product information is almost seamlessly transferred from the stores to a potential purchaser without a reciprocal transference of information from the customer to the stores. As electronic commerce evolves, information will grow in importance and the possession of right information gives an advantage to the holder that he can turn into an economic advantage. In the same way, the Bluetooth technology puts more information in the hands of the consumers so that they can make more educated decisions.

This situation differs from the business-to-customer commerce over the Web. Although the consumer can obtain much more information over the Web with significantly less effort than the traditional way of purchasing, the Internet also allows the vendors to gather valuable information about the consumers visiting their Web sites. The vendors, in turn, use the information about their customers to better target their products and services and to ultimately capture more economic rent from the commerce. In the Bluetooth user model of above, the retail stores would not necessarily gain any information about the shopper passing by the store vicinity. Even if the stores were able to gather specific statistics on the owner of the Bluetooth

enabled device, the information would not be all that useful. Unlike on the Internet, there is little, if not zero, interaction between the customer and the store in the Bluetooth user model. The customer does not necessarily use the Bluetooth-enabled personal device to give feedback to the transmitted information. As such, even the store that ultimately receives the foot traffic of the customer would not have any more detailed data on the customer than name and address.

3.2.2 Reduced Search Costs

The seamless transfer of information from the store to potential purchasers is a great value added feature for the consumers because it effectively reduces search costs and increases the convenience in purchasing products. Because the consumer is being fed the information about a particular product from a particular store without having to go through the store, he is able to save time and effort in looking for products. He can even walk through the mall quickly to see what types of deals are being offered and comparison shop without having had to walk to every single store that sells what he is looking for. Further decreasing search costs is the user model that allows a Bluetooth-enabled "kiosk" in the middle of the mall that provides all of the information about product offerings from the stores in the mall. A shopper can filter the information at the kiosk and only pursue on foot those products that fit into his purchase criteria. This concept precludes the consumers from having to walk around the mall if he does not wish to do so.

This benefit is more acute when the consumer is shopping for specific products under a time constraint and he programs the criteria of the desired products into his Bluetooth-enabled cell phone. As the consumer shops around for a variety of goods, the Bluetooth technology will

act as an expansive antenna to capture relevant information from the area that the consumer himself may even miss. It allows the searching process to be more efficient by aiding the consumers in locating the desired products. Even when the consumer is looking at a product at any given time, the Bluetooth-enabled device will be able to signal to him on other products that meet his preset criteria.

It is important to note that while it gives more power to the consumers, the Bluetooth technology can be seen as another medium through which the retail stores can bombard the consumers with more advertising blitz. The consumers would be the winners as far as receiving a lot of information about products and thereby increasing competition among vendors. However, managing the flow of information will become increasingly critical in turning the information into a real advantage. When utilized effectively, Bluetooth will be more than another advertising tool for the retailers and become a powerful purchasing advantage for the consumers. The dynamics described above will have profound impacts on the economics of retailing in consumer-driven industries.

3.3 Shifting the Economics of Retailing

The Internet is gradually diminishing switching costs, market friction and barriers to entry that existed in the physical world. The switching cost of buying products from different web sites in the Internet could be estimated as the time required to re-enter credit card information in order to perform a transaction.

In traditional commerce, switching costs are much higher given the personal relationships that one tends to have with specific stores as well as the distance and convenience of location.

Consumers may get to know the product selection in the store and enjoy the personalized treatment offered by the owners or personnel at each store. If consumers desire to change stores, they have to reinvent many of the steps with the limitation of having few stores to choose from given distance constraints and the payoff between the "best" store and the most convenient location. Technologies such as Bluetooth will reduce some of these switching costs and market frictions by putting pressure on prices in the physical world and considerably increasing the consideration set.

3.3.1 Matching Merchants with Consumers

Bluetooth will allow a wide range of devices to communicate and transfer vast amounts of information. Merchants and customers can continuously share information about prices, product features, availability, and overall customer preferences. Merchants can gather this information to better serve their customers and simultaneously release information on special promotions, new product releases, etc. Reciprocally, consumers may enter the features of a product they are looking for in their device and set the maximum price they are willing to pay. The technology facilitates a transaction between a consumer and the merchant who otherwise may not have been matched up.

Bluetooth will then bring some of the features of the Internet world into the physical world. Customers would be able to select products by selecting features and price ranges they are

willing to pay. Customers can setup preferences and willingness to buy certain products at a specified price. Those merchants willing to sell at that price will then communicate the information to devices nearby their stores.

3.3.2 Merchant Response: Service Bundling

Another application of Bluetooth-enabled personal devices will be to help consumers make purchase decisions in the store. A consumer might use his PDA or cellular phone to check whether other stores offer the same product at a lower price just by inputting the barcode of the product and searching for the best offer (either by walking in stores within a given area or browsing through the web). The result of this increased transfer of information will be a decrease in prices in the physical world.

To avoid direct price comparisons, some merchants will react by providing services to augment their product offering. These add-on services could make it difficult for consumers to compare based on the single attribute of price and rebuild switching costs that had been dismantled by the technology's ability to disseminate information. The products and services will then be similar to an experience good where users perceive there is a high cost in attempting to use other brands given their current level of satisfaction with the existing brands. Companies will therefore concentrate on differentiating products based on other attributes other than price and providing or augmenting the product offering by using service as a differentiating factor. This will probably result in an increased variety of products and total customer solution bundles (product and service). From an economic perspective, Bluetooth will eventually decrease overall deadweight loss by allowing a much closer match between individual reservation price for a

given product or bundle. Consumers will now have a much wider variety of offerings to choose from and a much more efficient system to find the best match with their price elasticity of demand.

3.3.3 The End of Impulse Purchases

As Bluetooth technology proliferates, the entire business to consumer landscape will change. The spread of Internet has already dramatically decreased searching costs and in a number of industries has contributed to lower prices. However, one of the constraints has been the Internet access point. Consumers can search for products and prices on the Internet only from their home or office but cannot use this technology while at the point of sale. The number of entry points will grow with the proliferation of Internet-Bluetooth kiosks and Bluetooth Access Points that enable consumers to access networks at higher throughput and lower cost than cellular systems based connections. (Today, cellular system data rate equals to 9.6Kbps to 14.4Kbps and Bluetooth data rate equals to 1Mbps. Of course, over time, both technologies will evolve to higher speeds). With a linked personal device, consumers will be able to search for better options and prices even at the store (with Internet-Bluetooth access) and therefore make fewer impulse purchases traditionally caused by the absence of information.

These forces could lead to fundamental changes in the retail industry as consumers spend more time researching products across stores.

3.3.4 Wireless Platform for Consumer-to-Consumer (C2C) Transactions

Concurrently, inter-user communication could spawn a secondary market (consumer to consumer) as the cost of exchanging information between consumers sharply decreases. For example, if an individual wants to sell his car, the relevant information could be stored in a PDA, and if another individual is looking to purchase a similar used car, the two devices will exchange information and signal the users when in range. More broadly speaking, these and other transactions can be managed by Bluetooth interfaces.

3.4 Making the E-Wallet a Reality

Bluetooth will permanently alter consumer-to-business payment systems. The long awaited e-wallet is finally feasible from a technological point of view and the economic implications will be immense. A Bluetooth device will be able to transmit payment information and complete a transaction based on the specifications provided by the customer and merchants. Payments will be made seamlessly as the payment information is transferred from the customer to the merchant. The user will then be able to use a PDA or similar device to approve the charge into a "checking account". Credit cards have accelerated this process in the last decade, and Bluetooth could take this process to the next level as the need for cash payments decreases. The economic value of that information will be in further decreasing market friction and eventually contributing to a higher market efficiency. (Note that extra security will be needed to maintain the integrity of these transactions. The SIG members are currently working on this issue.)

3.5 Maintaining Privacy Amid Technological Advancement

Bluetooth will accelerate the transfer of information from merchants to customers and vice versa. This increase in traffic holds negative potential if companies collect and use this information adversely. Therefore, privacy policy must be considered when implementing Bluetooth technology, as some customers may not be willing to risk privacy violation in exchange for technological improvements.

The cost and complexity of storing customer information is rapidly decreasing. Merchants can store information and use this information to maximize their revenues and obtain maximum consumer surplus. On the other hand, consumers will be willing to provide some limited information regarding their preferences to facilitate transactions. Nevertheless, customers will probably be hesitant to share information that may negatively affect prices as merchants use data to segment the market. A model to prevent merchants from mishandling this type of information is already found on the Internet.

On the Internet, companies are self-regulated by using privacy policies and statements on the information they collect on users. Companies also have been using regulating bodies such as Trustee to increase the level of trust between the consumer and the web sites. In the real world, an Institution could oversee and regulate stores willingly to commit to certain privacy policies.

Bluetooth has one additional advantage over traditional Internet entry points: it is possible to use the high level of data encryption and authentication features to define the type and amount of data a consumer is willing to share with merchants. In the extreme case, a consumer might set his preferences in such a way as to receive information only and share none unless the device receives an explicit authorization. Once consumers get acquainted with the

technological capabilities of Bluetooth, they will be more willing to use e-commerce. The combined effect of the Internet and Bluetooth are likely to boost the emergence of "e-conomics", a completely new way of doing business. That said, this document and the work to date on Bluetooth only scratch the surface of opportunity that will unfold as the technology gains acceptance. The logical question, therefore, is how far can Bluetooth take us?

3.6 Bluetooth Beyond the Horizon – Excitement from other industries

Because of its convenience and easy of use, Bluetooth will enable a wide range of applications. Due to the industries represented by the founding developers, the first Bluetooth enabled devices are expected to be cellular phones, mobile computers, PDAs, and headsets. Other computing and telecommunications companies in the adopters list will shortly follow to stay competitive in their markets. The minor gap between the founding developers and the adopters will narrow as knowledge of the version 1.0 specifications becomes obsolete.

The freedom, simplicity and versatility of Bluetooth technology will extend its impact beyond computers and mobile peripheral devices, into other sectors such as the automobile and the airline industries. The automobile industry, for instance, can utilize Bluetooth technology for several business-to-consumer opportunities. Many of these applications will represent faster, more economical ways to perform current tasks on a single platform. Examples include:

- Wireless payment at gas stations
- Wireless payment of toll charges for bridges, tunnels, etc.
- Wireless payment for parking
- Wireless communication of car-specific data for repair and maintenance

In a similar manner, the airline industry can also utilize Bluetooth technology for several applications. For instance, imagine a passenger flying XYZ Airlines purchases a ticket online over their web site. The customer receives a code that allows the airline and he to track everything from payment to the seat assignment. A Bluetooth enabled mobile phone or PDA could speed up the process by making it wireless and automatic upon arrival at the Bluetooth enabled kiosk. The airline's device would read the customer's code from his PDA or cellular phone even inside his pocket and expedite the check-in process.

The limits are hard to assign because the technology is new. Application development will accelerate as the technology establishes itself as the de facto standard for short-range wireless communications. By facilitating inter-user communication, Bluetooth opens up significant opportunity in the Consumer-to-Consumer (C2C) and Business-to-Consumer (B2C) spaces of electronic commerce.

Chapter 4

Bluetooth Conclusion

4.0 Impact of Bluetooth

Giving the wide variety of industries and companies involved in this effort, examples of Bluetooth devices will range from remote control car radios and stereo systems to connecting microphone/earphone units with a mobile phone. Via desktop PCs, printers, faxes and network access points, Bluetooth will facilitate synchronization, printing and network access for PDAs and communicators.

Enterprises should start considering how Bluetooth will impact existing networking infrastructures, procurement and styles of working. For example:

- Field service: Service and maintenance tasks that require a technician to open a cover and plug in a terminal or analyzer today could be simplified by Bluetooth. The support technician would simply walk up to the machine and be able to connect wirelessly without any manual operation, saving time and money. Ticketing, vending and teller machines, among many others, could benefit from Bluetooth's functionality.

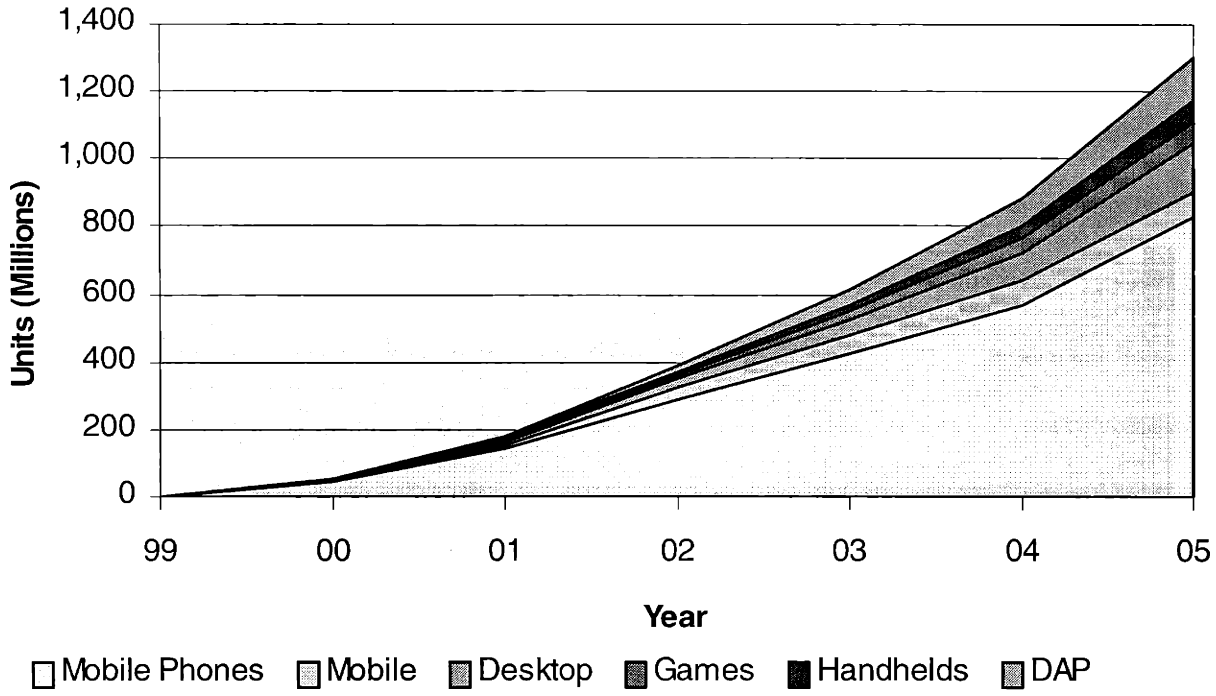
- Electronic payment: If ticketing and vending machines become Bluetooth-enabled, it becomes feasible for users to pay directly via a Bluetooth-enabled "electronic wallet" (e-wallet). Payment could be via e-cash, by being billed by the mobile network operator or

even direct debit. This could be extended to POS terminals and parking meters.

Eventually Bluetooth could eliminate queues of people waiting to pay at POS terminals.

Note: The first Coke machine Bluetooth enabled was presented at Telecom, in November 1999.

4.0.1 Potential size of the market



Mobile = Mobile Computers; DAP = Data Access Point

Source: Bluetooth Developers Conference in London – June 1999

Exhibit 20 – Potential size of the market

Therefore we are talking about several millions of Bluetooth enabled devices for the years to come.

4.0.2 Predictions and statistics

Research company Dataquest[10] has predicted that:

- 79 percent of digital handsets and more than 200 million PCs will incorporate Bluetooth technology by 2002
- By 2004, at least 75 percent of new mobile phones shipped will support direct e-cash payment via Bluetooth links to POS terminals and vending machines (0.7 probability).
- While early Bluetooth vendors will premium price their products, competition will commoditize Bluetooth functionality before 2003 (0.7 probability).

According to Ericsson[11]:

- Market Potential 2005: Mobile Phones + PCs + PDAs + Cordless phones + Access points + computers and phone peripherals = 1.5 Billion

According to Hewlett Packard [12]:

- HP alone sells 2 million printers/month = 24 million printers/year. HP is planning to replace the parallel cables from its printers for a wireless technology by 2003. (HP is in the Bluetooth adopters list)

[10] www.dataquest.com
[11] Bluetooth Developers Conference in London – June 1999
[12] www.hp.com

4.1 Conclusion and Challenges

The Bluetooth technology is an extraordinary phenomenon from both the technological and strategic perspectives. Technologically, Bluetooth can fundamentally change the way individuals transfer information. If the technology realizes a widespread acceptance (i.e. the manufacturers and ultimately the consumers), it can create much value for the consumers. The possibilities for user models for the technology are only limited by the imaginations of humans. Market participants can envision almost clearly how Bluetooth can affect commerce at large. Less clear at a first glance, is why and how the technology has been developed the way it has. It is only when we analyze this phenomenon with a strategic lens that the partnership among traditional competitors and the method of capturing value by the participating companies begins to make sense.

Another interesting aspect about Bluetooth is that it is a technology still at an early stage of diffusion. It has been met with much enthusiasm by the major high tech firms thus far. In order for Bluetooth to realize the full potential of a commercial success, there are key challenges that it has to overcome in the next few years. One of the challenges is to implement appropriate marketing strategy to ensure the adoption of the technology across the chasm and beyond. It takes a different marketing approach to reach the Innovators and Early Adopters than the groups in Early and Late Majority. Furthermore, the technology would also have to be communicated not only to the manufacturers of Bluetooth-enabled products but also to the consumers, the ultimate end-users of the products.

Another challenge that Bluetooth faces is the on-going management of the "consortium" atmosphere among the SIG members, as well as the rest of the companies in the adopters' list. What is unclear is the expected life of the consortium and the role that the SIG members would fulfill as the technology evolves and the adopters' list theoretically increases exponentially. This poses a major organizational issue that the founding members of the technology have to address in order to maintain the momentum of the Bluetooth phenomenon.

The final and greatest challenge for Bluetooth is to ensure device interoperability across different products and to ensure that products work together from day one. Bluetooth can not afford to let the customers do final testing and development. Getting this situation right requires the cooperation and willingness to share information from many companies, often competing companies. The challenge will be in keeping frequent, open communications amongst the SIG members, so that Bluetooth can improve and evolve rapidly and provide the high performance to meet market expectations.

Notwithstanding these challenges, Bluetooth hints at being the next standard for wireless transference of data. Much of the high tech industry is heeding to the hint and joining the effort. A successful launch of Bluetooth may encourage future initiatives and development of technologies with similar structure -- a new technology based on an open standard platform developed by traditional competitors looking to reap economic gain from exploiting complementary assets.

4.2 Who Wins

Less human intervention equals big cost savings for IT organizations. But what will it take to implement this great new technology? Lots of cooperation and self-interest will be essential. Interoperability and economies of scale will also be necessary factors to ensure that every company involved will benefit from the technology.

So who really wins? The end-user customer for sure, as long as it is simple, friendly, inexpensive, and a low-battery drain. Also, the manufacturers of the Bluetooth chipset will get a small fortune from the millions of devices that will embed the product. Wireless carriers will get new applications for their networks. Software developers will get to write the new and improved applications for their customers. Almost nobody loses, but "competitive" technologies! Even the dream of the smartwallet is now one step closer to reality.

Addendum

Ad1- The new Bluetooth Promoter Group

Santa Clara, Calif., Dec. 1, 1999

The five founding companies of the Bluetooth Special Interest Group (SIG), Ericsson, IBM Corporation, Intel Corporation, Nokia and Toshiba Corporation, today announced that 3Com Corporation, Lucent Technologies, Microsoft Corporation and Motorola Inc. will join them to form the Promoter group of the Bluetooth SIG. The charter of the Promoter group is to lead the efforts of the Bluetooth SIG, by creating a forum for enhancing the Bluetooth specification and providing a vehicle for interoperability testing. The acceptance of the Bluetooth wireless technology is unprecedented, with more than 1300 companies already having joined the SIG, as adopters, since its inception less than two years ago. The magnitude and reach of the Bluetooth specification, as well as the emergence of new applications led to the decision to broaden the group. Promoter group companies bring diversity, expertise and depth of experience to the Bluetooth SIG.

Bluetooth Promoter Group

By working together, the nine-company Promoter group will combine their respective skills to help drive the program forward. There is a wealth of experience among the Promoter group, providing an extensive array of potential solutions for wireless connectivity. There is also shared expertise in such areas as radio and computing technology, software development, and networking, which broadens the perspective and increases the depth of the vision in these areas.

The Bluetooth SIG is an excellent example of an organization whose whole is greater than the sum of its parts. While each company in the Promoter group has leveraged unique and complementary core competencies in the development and promotion of the Bluetooth technology, the specification and ultimately the product solutions will be the result of a concerted team effort.

Ad2 - Bluetooth awarded Best of Show Technology Award at Comdex '99

Three technologies were nominated for the Byte.com Best Technology Award at the Comdex Fall '99 exhibition held in Las Vegas on November 15–19. These technologies were biometrics, which includes software for identifying people's faces, hands and eyes; speech recognition technology as developed by Dragon Systems and Lernout and Hauspie; and Bluetooth technology.

After heated debate about which of these technologies has the biggest impact on the communications industry, the editorial staff of Byte.com finally decided on the Bluetooth technology.

Products and technologies are nominated based on presenting a significant new idea, innovation, impact on the industry, intelligent design, and great value. The awards are judged by members of the BYTE.com editorial staff.

Ad3 - WAP and Bluetooth technologies – Beyond cable replacement

Imagine that you arrive at RSJ Airport after a long flight. You turn on your mobile phone as you make your way to your connecting gate. Your mobile is the latest model, boasting support for both WAP and Bluetooth technologies. As you take a seat in the lounge, a short tone from you mobile alerts you. "RSJ Airport Information Service – OK to connect?" your handset inquires. You confirm the connection and are presented with a list of language options. After selecting your preferred language, you are given a list of options including Flight Information, duty-free Shopping, Airport Information and Restaurants. You select "Duty-Free Shopping", and use the resulting information to obtain directions to the nearest source of tax-free chocolates.

By combining two of the newest technologies available for portable devices, such a scenario is very likely to happen in the near future. While this example is a relatively simple application of WAP and Bluetooth communication, it demonstrates the real power behind the Bluetooth technology. Such a scenario is inconceivable in a cable-based environment. While the Bluetooth SIG has initially positioned the technology as targeted for simple cable replacement, the really interesting applications are the ones that go beyond this.