

**Middle East Technical University
Department of Computer Engineering**

CENG 490 Senior Project

“BLUETOOTH” RESEARCH REPORT

For

RA-1

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How Bluetooth Works

There are lots of different ways that electronic devices can connect to one another. For example:

Many desktop computer systems have a CPU unit connected to a mouse, a keyboard, a printer and so on.

A personal digital assistant (PDA) will normally connect to the computer with a cable and a docking cradle.

A TV will normally connect to a VCR and a cable box, with a remote control for all three components.

A cordless phone connects to its base unit with radio waves, and it may have a headset that connects to the phone with a wire.

In a stereo system, a CD player and other audio devices connect to the receiver, which connects to the speakers.

When you use computers, entertainment systems or telephones, the various pieces and parts of the systems make up a community of electronic devices. These devices communicate with each other using a variety of wires, cables, radio signals and infrared light beams, and an even greater variety of connectors, plugs and protocols.

The art of connecting things is becoming more and more complex every day. A completely different way to form the connections, called Bluetooth is wireless and automatic, and has a number of interesting features that can simplify our daily lives.

The Problems

When any two devices need to talk to each other, they have to agree on a number of points before the conversation can begin. The first point of agreement is physical: Will they talk over wires, or through some form of wireless signals? If they use wires, how many are required -- one, two, eight, 25? Once the physical attributes are decided, several more questions arise:

Information can be sent 1 bit at a time in a scheme called serial communications, or in groups of bits (usually 8 or 16 at a time) in a scheme called parallel communications. A desktop computer uses both serial and parallel communications to talk to different devices: Modems, mice and keyboards tend to talk through serial links, while printers tend to use parallel links.

All of the parties in an electronic discussion need to know what the bits mean and whether the message they receive is the same message that was sent. In most cases, this means developing a language of commands and responses known as a protocol. Some types of products have a standard protocol used by virtually all companies so that the commands for one product will tend to have the same effect on another. Modems fall into this category. Other product types each speak their own language, which means that commands intended for one specific product will seem gibberish if received by another. Printers are like this, with multiple standards like PCL and PostScript

Companies that manufacture computers, entertainment systems and other electronic devices have realized that the incredible array of cables and connectors involved in their products makes it difficult for even expert technicians to correctly set up a complete system on the first try. Setting up computers and home entertainment systems becomes terrifically complicated when the person buying the equipment has to learn and remember all the details to connect all the parts. In order to make home electronics more user friendly, we need a better way for all the electronic parts of our modern life to talk to each other. That's where Bluetooth comes in.

Bluetooth Basics

Bluetooth is a standard developed by a group of electronics manufacturers that allows any sort of electronic equipment -- from computers and cell phones to keyboards and headphones -- to make its own connections, without wires, cables or any direct action from a user. Bluetooth is intended to be a standard that works at two levels:

It provides agreement at the physical level -- Bluetooth is a radio-frequency standard.

It also provides agreement at the next level up, where products have to agree on when bits are sent, how many will be sent at a time and how the parties in a conversation can be sure that the message received is the same as the message sent.

The companies belonging to the Bluetooth Special Interest Group, and there are more than 1,000 of them, want to let Bluetooth's radio communications take the place of wires for connecting peripherals, telephones and computers.

Other Wireless Connections

There are already a couple of ways to get around using wires. One is to carry information between components via beams of light in the infrared spectrum. Infrared refers to light waves of a lower frequency than human eyes can receive and interpret. Infrared is used in most television remote control systems, and with a standard called IrDA (Infrared Data Association) it's used to connect some computers with peripheral devices. For most of these computer and entertainment purposes, infrared is used in a digital mode -- the signal is pulsed on and off very quickly to send data from one point to another.

Infrared communications are fairly reliable and don't cost very much to build into a device, but there are a couple of drawbacks. First, infrared is a "line of sight" technology. For example, you have to point the remote control at the television or DVD player to make things happen. The second drawback is that infrared is almost always a "one to one" technology. You can send data between your desktop computer and your laptop computer, but not your laptop computer and your PDA at the same time.

These two qualities of infrared are actually advantageous in some regards. Because infrared transmitters and receivers have to be lined up with each other, interference between devices is uncommon. The one-to-one nature of infrared communications is useful in that you can make sure a message goes only to the intended recipient, even in a room full of infrared receivers.

The second alternative to wires, cable synchronizing, is a little more troublesome than infrared. If you have a Palm Pilot, a Windows CE device or a Pocket PC, you know about synchronizing data. In synchronizing, you attach the PDA to your computer (usually with a cable), press a button and make sure that the data on the PDA and the data on the computer match. It's a technique that makes the PDA a valuable tool for many people, but synchronizing the PDA with the computer and making sure you have the correct cable or cradle to connect the two can be a real hassle.

The Bluetooth Solution

Bluetooth is intended to get around the problems that come with both infrared and cable synchronizing systems. The hardware vendors, which include Siemens, Intel, Toshiba, Motorola and Ericsson, have developed a specification for a very small radio module to be built into computer, telephone and entertainment equipment. From the user's point of view, there are three important features to Bluetooth:

- It's wireless. When you travel, you don't have to worry about keeping track of a briefcase full of cables to attach all of your components, and you can design your office without wondering where all the wires will go.
- It's inexpensive.
- You don't have to think about it. Bluetooth doesn't require you to do anything special to make it work. The devices find one another and strike up a conversation without any user input at all.

Bluetooth Frequency

Bluetooth communicates on a frequency of **2.45 gigahertz**, which has been set aside by international agreement for the use of industrial, scientific and medical devices (ISM).

A number of devices that you may already use take advantage of this same radio-frequency band. Baby monitors, garage-door openers and the newest generation of cordless phones all make use of frequencies in the ISM band. Making sure that Bluetooth

and these other devices don't interfere with one another has been a crucial part of the design process.

Why is it called [Bluetooth](#)?

Harald Bluetooth was king of Denmark in the late 900s. He managed to unite Denmark and part of Norway into a single kingdom then introduced Christianity into Denmark. He left a large monument, the Jelling rune stone, in memory of his parents. He was killed in 986 during a battle with his son, Svend Forkbeard. Choosing this name for the standard indicates how important companies from the Baltic region (nations including Denmark, Sweden, Norway and Finland) are to the communications industry, even if it says little about the way the technology works.

Avoiding Interference: Low Power

One of the ways Bluetooth devices avoid interfering with other systems is by sending out very weak signals of 1 milliwatt. By comparison, the most powerful cell phones can transmit a signal of 3 watts. The low power limits the range of a Bluetooth device to about 10 meters, cutting the chances of interference between your computer system and your portable telephone or television. Even with the low power, the walls in your house won't stop a Bluetooth signal, making the standard useful for controlling several devices in different rooms.

With many different Bluetooth devices in a room, one might think they'd interfere with one another, but it's unlikely. We'll see why.

Avoiding Interference: Hopping

It is unlikely that several devices will be on the same frequency at the same time, because Bluetooth uses a technique called spread-spectrum frequency hopping. In this technique, a device will use 79 individual, randomly chosen frequencies within a designated range, changing from one to another on a regular basis. In the case of Bluetooth, the transmitters change frequencies 1,600 times every second, meaning that more devices can make full use of a limited slice of the radio spectrum. Since every Bluetooth transmitter uses spread-spectrum transmitting automatically, it's unlikely that two transmitters will be on the same frequency at the same time. This same technique minimizes the risk that portable phones or baby monitors will disrupt Bluetooth devices, since any interference on a particular frequency will last only a tiny fraction of a second. When Bluetooth-capable devices come within range of one another, an electronic conversation takes place to determine whether they have data to share or whether one needs to control the other. The user doesn't have to press a button or give a command -- the electronic conversation happens automatically. Once the conversation has occurred, the devices -- whether they're part of a computer system or a stereo -- form a network.

Bluetooth systems create a personal-area network (PAN), or piconet, that may fill a room or may encompass no more distance than that between the cell phone on a belt-clip and the headset on your head. Once a piconet is established, the members randomly hop frequencies in unison so they stay in touch with one another and avoid other piconets that may be operating in the same room.

Bluetooth Specs

- Here are some specification details from the Bluetooth Web site
- The devices in a piconet share a common communication data channel. The channel has a total capacity of 1 megabit per second (Mbps). Headers and handshaking information consume about 20 percent of this capacity.
- In the United States and Europe, the frequency range is 2,400 to 2,483.5 MHz, with 79 1-MHz radio frequency (RF) channels. In practice, the range is 2,402 MHz to 2,480 MHz. In Japan, the frequency range is 2,472 to 2,497 MHz with 23 1-MHz RF channels.
- A data channel hops randomly 1,600 times per second between the 79 (or 23) RF channels.
- Each channel is divided into time slots 625 microseconds long.
- A piconet has a master and up to seven slaves. The master transmits in even time slots, slaves in odd time slots.
- Packets can be up to five time slots wide.
- Data in a packet can be up to 2,745 bits in length.
- There are currently two types of data transfer between devices: SCO (synchronous connection oriented) and ACL (asynchronous connectionless).
- In a piconet, there can be up to three SCO links of 64,000 bits per second each. To avoid timing and collision problems, the SCO links use reserved slots set up by the master.
- Masters can support up to three SCO links with one, two or three slaves.
- Slots not reserved for SCO links can be used for ACL links.
- One master and slave can have a single ACL link.
- ACL is either point-to-point (master to one slave) or broadcast to all the slaves.
- ACL slaves can only transmit when requested by the master.

Reference: <http://www.howstuffworks.com>