How Bluetooth Works

There are lots of different ways that electronic devices can connect to one another. 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. **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?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. 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](http://electronics.howstuffworks.com/cell-phone.htm) 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](http://electronics.howstuffworks.com/radio-spectrum.htm) 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.

**Other Wireless Connections**

There are already a couple of ways to get around wires usage. One is to carry information between components via beams of [light](http://electronics.howstuffworks.com/light.htm) in the **infrared** spectrum.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](http://electronics.howstuffworks.com/dvd.htm) 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](http://electronics.howstuffworks.com/laptop.htm), 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.

**Bluetooth** is intended to get around the problems that come with infrared systems. 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 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).

**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.

**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](http://electronics.howstuffworks.com/radio-spectrum.htm). 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 Piconets**

Let’s take a look at how the Bluetooth frequency hopping and personal-area network keep systems from becoming confused. Let’s say you’ve got a typical modern living room with the typical modern stuff inside. There’s an entertainment system with a stereo, a DVD player, a [satellite](http://electronics.howstuffworks.com/satellite.htm) TV receiver and a television; there's a cordless telephone and a personal computer. Each of these systems uses Bluetooth, and each forms its own personal-area network **piconet** to talk between main unit and peripheral.

The cordless telephone has one Bluetooth transmitter in the base and another in the handset. The manufacturer has programmed each unit with an **address** that falls into a range of addresses it has established for a particular type of device. When the base is first turned on, it sends [radio signals](http://electronics.howstuffworks.com/radio.htm) asking for a response from any units with an address in a particular range. Since the handset has an address in the range, it responds, and a tiny **network** is formed. Now, even if one of these devices should receive a signal from another system, it will ignore it since it’s not from within the network. Each piconet hops randomly through the available frequencies, so all of the piconets are completely separated from one another.

Now the living room has three separate networks established, each one made up of devices that know the address of transmitters it should listen to and the address of receivers it should talk to.

**Example: Half/Full Duplex**

Most of the time, a network or communications method either works in one direction at a time, called **half-duplex communication**, or in both directions simultaneously, called **full-duplex communication**. A speakerphone that lets you either listen or talk, but not both, is an example of half-duplex communication, while a regular telephone handset is a full-duplex device. Because Bluetooth is designed to work in a number of different circumstances, it can be either half-duplex or full-duplex.