

Bluetooth



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0. INTRODUCTION

We all have experienced the inconvenience that arises when we start connecting peripherals to a computer, or when we connect other electronic devices, with a lot of cables that becomes difficult to control. Then we start to think how easy it would be if all these connections were done using a different way from the physical cables, like infrareds, radio or microwaves.

The companies of computer science and telecommunications needed to develop an opened, low cost interface to make easier the communication between devices without using cables. This is the origin of the technology which key name is "Bluetooth". This is a fact nowadays, but now another problem arises and is that there are a lot of standards and technologies, incompatible between them. What we need now is a universal, valid device for the connection of all kinds of peripheral, and that works in a transparent way for the user. This is Bluetooth.

Opposite to other current technologies, like infrared promoted by the IrDA (Infrared Data Association) or DECT, Bluetooth has the support of the industry of computer science and telecommunications, which in some way guarantees the success. Although there is a high number of manufacturers who incorporate the interface IrDA in their telephones, included Ericsson, Motorola and Nokia, the use turns out to be frustrating for many users who treat without success to download information from their PC or PDAs to their mobile telephones, or vice versa. The devices that Bluetooth incorporates are recognized and speak each other in the same way as a computer does it with the printer. The low price of these products means that the incorporation in any device supposes a low cost for the manufacturer and the user.

1. HISTORY

In the year 1994, the company of telecommunications ERICSSON, began a study to investigate the viability of a radio low cost interface between mobile telephones and the accessories. The objective was to eliminate the cables between the mobile telephones and cards of PCs, headsets, desktop devices, etc. At the beginning of 1997, Ericsson comes closer other manufacturers of portable devices to increase the interest in this technology. The motive was simple: in order that the system was successful and really usable, a critical quantity of portable devices should use the same technology.

In February, 1998, five companies, Ericsson, Nokia, IBM, Toshiba and Intel, founded a Group of Special Interest (SIG). This group contains the perfect mixture in the business area: two leaders of the market in mobile telephony, two leaders of the market in computers laptop and a leader of the market in technology of processing of digital signs.

The goal was to establish the creation of a global specification for connectivity without wires of short scope. 20 and 21 of May, 1998, Bluetooth's consortium was announced to the general public of London (England), San Jose (California) and Tokyo (Japan). That global announcement provokes the adoption of the technology for several companies. The intention of the consortium was to establish a standard device and software that controls it.

Before going into technical details it would be interesting to give an explanation about the origin of the name and the symbol of Bluetooth. Everybody has a mobile with Bluetooth and it's symbol, but few people know the reason of them, so it would be interesting to clarify these points in the next page.

1.1. The name “Bluetooth”

All the people have a mobile phone with the Bluetooth system but few of them know the reason of the name, but it is a peculiar name: Blue-tooth. Someone has a tooth with blue color? Yes, the name comes from a king, Harald I Bluetooth:

Harald I Bluetooth (Danish Harald Blåtand) was the King of Denmark between 940 and 985 AD. The name "Blåtand" was probably taken from two old Danish words, 'blå' meaning dark skinned and 'tan' meaning great man. He was born in 910 as the son of King Grom The Old (King of Jutland, the main peninsula of Denmark) and his wife Thyre Danebold (daughter of King Ethelred of England). Like many Vikings, Harald considered it honorable to fight for treasure in foreign lands. When Harald's sister Gunhild was widowed after the death of the violent Norwegian king Erik Blood Axe, she came to Denmark to seek Harald's help in securing control of Norway. Harald took the opportunity to seize control himself. By 960 he was at the height of his powers, ruling over both Denmark and Norway. He was baptized by a priest named Poppo, sent by the German emperor. He then created a monument that read: "King Harald raised this monument to the memory of Grom his father and Thyre his mother. Harald conquered all of Denmark and Norway and made the Danes Christian". These words were also carved in stone called rune stones. Harald was killed in a battle in 985. Harald completed the country's unification begun by his father, converted the Danes to Christianity, and conquered Norway. The expansion begun by Harald in Norway was continued by his son Sweyn I, who conquered England in 1013. Under Sweyn's son Canute there grew up a great Anglo-Scandinavian kingdom that included parts of Sweden.

Source: <http://www.cs.utk.edu/~dasgupta/bluetooth/history.htm>

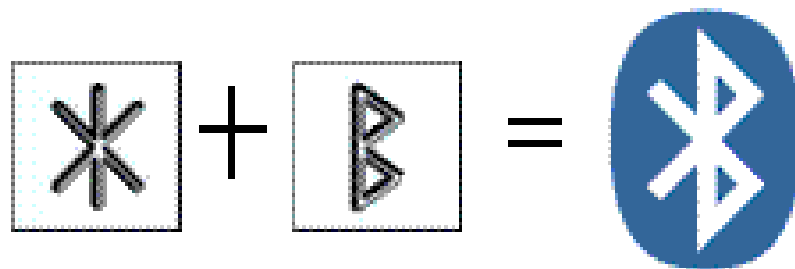
The reason of the name is that in the 10th century the king Harald II of Denmark, nicknamed "blue tooth" because of a disease that was giving him this coloration to his denture, reunified under his reign numerous small kingdoms that existed in Denmark and Norway and that were working with different rules, ... the same thing that does the technology Bluetooth, promoted by Ericsson (Sweden) and Nokia (Finland), two Scandinavian countries.



Source: <http://www.cs.utk.edu/~dasgupta/bluetooth/history.htm>

1.2. The symbol of Bluetooth

As famous as the name is the Bluetooth symbol. Everybody can recognize this symbol like the Bluetooth icon, but again few of them knows the origin. Bluetooth's logo combines the representation of the Nordic runes Hagalaz (transcribed by 'H') and Berkana (transcribed by 'B') in the same symbol. This is, HB like Harald Blåtand the king:



Source: <http://www.odinismo.com/forum/viewtopic.php?p=8687&sid=1e04b752361e0767bbc7abab1e025a70>

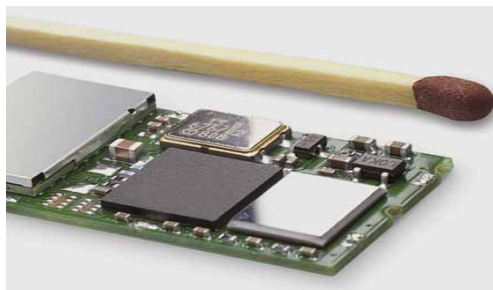
2. WHAT IS BLUETOOTH?

Bluetooth is a standard used in links of radio of short scope, destined to replace wired connections between electronic devices like cellular telephones, Personal Digital Assistants (PDA), computers, and many other devices. Bluetooth technology can be used at home, in the office, in the car, etc. This technology allows to the users instantaneous connections of voice and information between several devices in real time. The way of transmission used assures protection against interferences and safety in the sending of information.

Between the principal characteristics, must be named the hardiness, low complexity, low consume and low cost. The Bluetooth is a small microchip that operates in a band of available frequency throughout the world. Communications can realize point to point and point multipoint.

2.1. How it works?

Every device will have to be equipped with a microchip (transceiver) that transmits and receives in the frequency of 2.4 GHz that is available in the whole world (with some variations of bandwidth in different countries). Besides the information, there are three channels of voice available.



Source: <http://www.monografias.com/trabajos11/blue/blue.shtml>

The information can be exchanged to speeds of up to 1 megabit for second (2 megabits for second in the Second Generation of this Technology). A scheme of “frequency hop” (jumps of frequency) allows to the devices to communicate inclusive in areas where a great electromagnetic interference exists. Besides that is provided with schemes of encryption and check.

2.2. Frequency Bands

The standard Bluetooth operates in the band of 2,4 GHz. Though worldwide, this band is available, the width of the band can differ in different countries. This is the frequency of band of the scientific and medical industries 2.45 GHz (ISM*). The ranges of the bandwidth in The United States and Europe are between 2.400 to 2.483,5 MHz and it covers part of France and Spain. The ranges of the bandwidth in Japan are between 2.471 to 2.497 MHz.

So the system can be used worldwide due to that the transmitters of radio covers 2.400 and 2.500 MHz and it is possible to select the appropriate frequency. This ISM* is opened for any system of radio and must take care of the interferences of monitors for baby, the controls for doors of garages, the wireless telephones and the microwave ovens (the source with higher interference).

ISM: *The industrial, scientific and medical (ISM) radio bands were originally reserved internationally for the use of RF electromagnetic fields for industrial, scientific and medical purposes other than communications. In general, communications equipment must accept any interference generated by ISM equipment.*

Source: http://en.wikipedia.org/wiki/ISM_band

Country	Frequency Range	RF Channels	
Europe* & USA	2400 - 2483.5 MHz	$f = 2402 + k$ MHz	$k = 0, \dots, 78$
Japan	2471 - 2497 MHz	$f = 2473 + k$ MHz	$k = 0, \dots, 22$
Spain	2445 - 2475 MHz	$f = 2449 + k$ MHz	$k = 0, \dots, 22$
France	2446.5 - 2483.5 MHz	$f = 2454 + k$ MHz	$k = 0, \dots, 22$

Source: http://www.mobileinfo.com/bluetooth/air_&_band.htm

2.3. Power

The equipment of transmission are qualified in 3 groups according to the level of power of emission, as we can see below. The recipient equipment must possess a sensibility of at least 70 dBm, and the rate of admissible mistake must be a minor or equal to 0,1 %.

Device Power Class	Maximum Permitted Power <u>mW(dBm)</u>	Range (approximate)
Class 1	100 mW (20 dBm)	~100 meters
Class 2	2.5 mW (4 dBm)	~10 meters
Class 3	1 mW (0 dBm)	~1 meter

Source: <http://en.wikipedia.org/wiki/Bluetooth>

The chip is going to be incorporated in portable devices and powered by batteries, that's why it must have a very limited consumption of power (up to 97 % less than a mobile telephone). If the Bluetooth devices do not exchange information, then

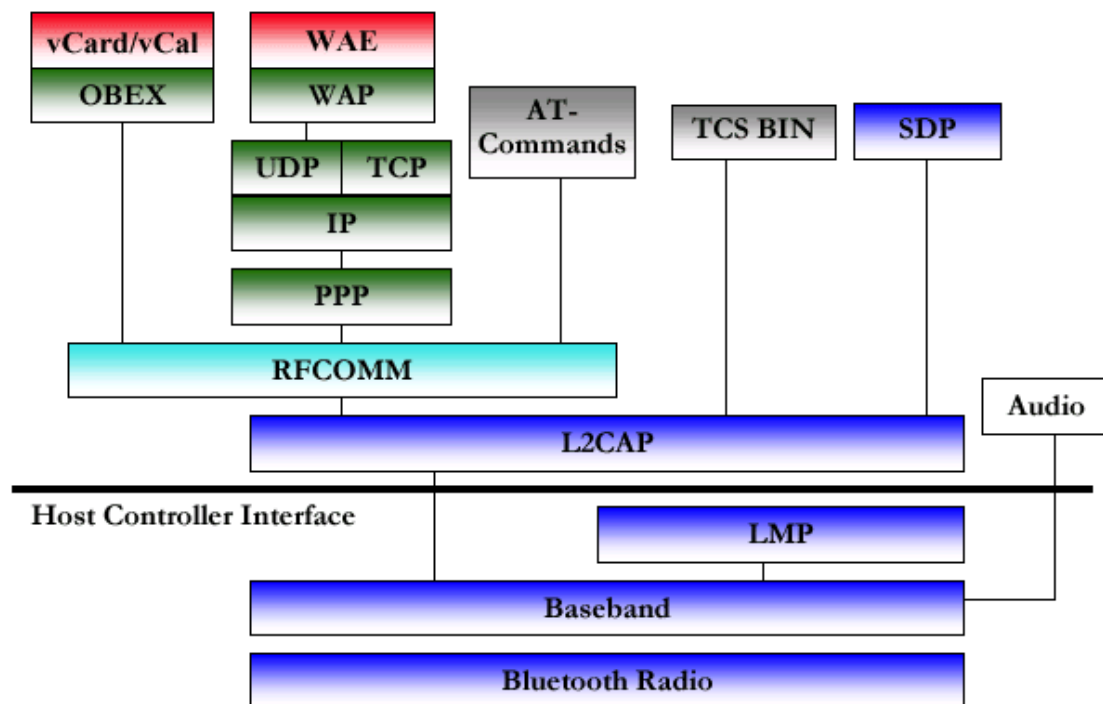
they establish the way of "wait" to save energy, staying to the scout of messages. The power of transmission that is used as specification is of 1 mW for a scope of 10 m, 100 mW for a scope of up to 100 m.

2.4. Scope

The connections have a maximum range of 10 meters, though using amplifiers it is possible to come up to 100 meters, but creating some distortion interferes. Maybe it doesn't look too much, but it is necessary to remember that these devices were created by the intention of using them in closed environments and little distances.

2.5. Protocols

Different applications can operate under different sets of protocols; nevertheless, all of them have a link of information and a physical cap common Bluetooth. The figure below shows the set of protocols:



Source: <http://www.cs.utk.edu/~dasgupta/bluetooth/blueprotocols.htm>

We are not going to study in detail all the protocols because it would take too long and this is technically too complex for the aim of this work. Anyway I included this mention about the Bluetooth protocols because I found a lot of information about that point.

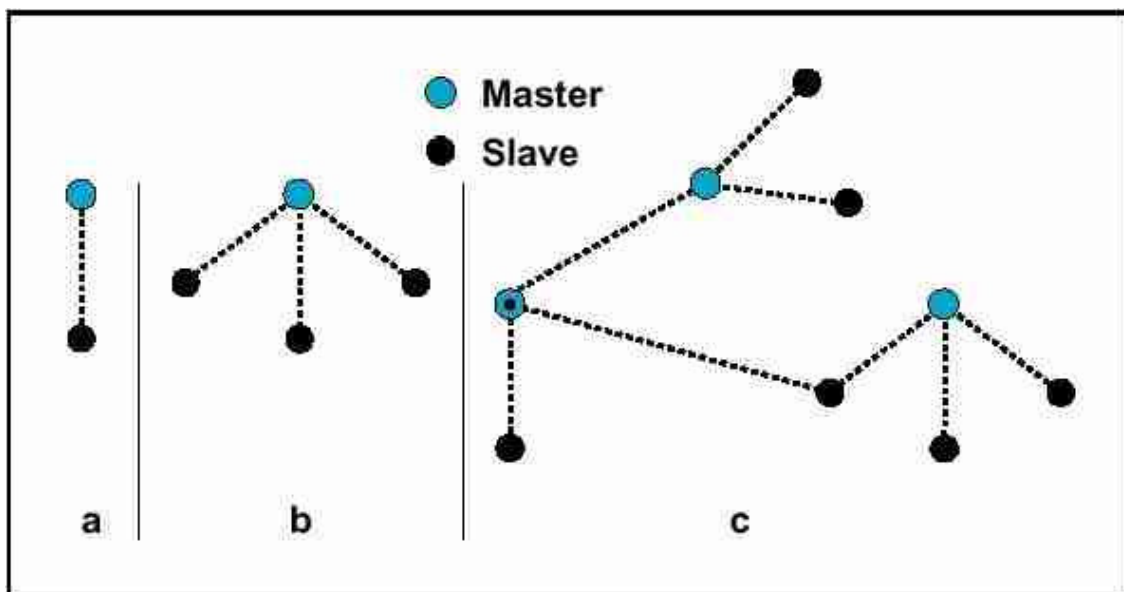
2.6. Interferences

If we take a look to interferences with other devices, it is necessary to have care with those who operate in the same band. For example the same as there is prohibited the use of mobile telephones in the planes, it is possible to prohibit the use of any another device that incorporates a Bluetooth chip, because it can interfere with the elements of navigation. But this can be a problem because it has been designed to maintain a constant communication, even in movement, and inside briefcases, and it can be working even inadvertently for the user.

3. BLUETOOTH IN THE NETS

One of the biggest advantages, and where we can see the versatility of the design of the Bluetooth technology, is in the easy confection and arrangement of nets between different devices of Bluetooth technology. Bluetooth has been designed to operate in a multi-user environment. Presents two types of possible configurations, which can expand to a considerable number of elements to expand this way the networks and sub-networks. The structure that handles this technology is composed, in the more basic form, by what it is named a Piconet and in an a bit more complex structure which it is named a Scatternet. Up to eight users or devices can form a "piconet" and even ten "piconets" can coexist in the same area of coverage. If we realize that every link is codified and protected against interference and loss of link, Bluetooth can be considered to be a wireless very sure short scope network.

The Piconet are several devices that are in the same radio of coverage where they share the same channel and that is constituted between two and eight of these units. Every device has the unique direction of 48 bits, based on the standard IEEE 802.11 for WLAN, whereas the Scatternet formed by the connection of a Piconet to other one, with a maximum of interconnections of ten Piconets. In the following figure it is possible to observe and understand with major facility these two configurations.



Source: <http://www.palowireless.com/INFOTOOTH/tutorial/baseband.asp>

In the figure "a" we can observe the simplest Piconet which is constituted by two devices. In the "b" figure we have a Piconet constituted by four of these devices. The "c" figure is an example of a Scatternet that possesses three Piconet, one constituted for four units, the other one for two and the last one for 3 units respectively.

The equipment that share the same channel will divide the resources and the capacity of this one. Though the channels have a bandwidth of one 1Mhz, as more users join to the Piconet, minor resources they will have for each user.

That is the reason why the Scatternet was introduced to solve the problem of the low bandwidth that every user of a Piconet has if they find great quantity of connected units. The performance, as a whole and individually of the users of a Scatternet is major than the one that has every user when takes part in the same channel of 1 MHz.

4. MAIN APPLICATIONS

Bluetooth's applications are very varied and allow changing radically the form that the users interact with the mobile telephones and other devices. Inside the field of the technology, the application is immediate because it allows an easy, instantaneous communication, in any place and low cost. We cannot forget the impact in the way of realizing the processes, on having replaced the conventional means and having made new business and applications possible.

· *More prevalent applications of Bluetooth:*

- *Wireless control of and communication between a mobile phone and a hands-free headset. This was one of the earliest applications to become popular.*



Source: http://en.wikipedia.org/wiki/Image:Bluetooth_headset.jpg

- *Wireless networking between PCs in a confined space and where little bandwidth is required.*

- *Wireless communications with PC input and output devices, the most common being the mouse, keyboard and printer.*

- *Transfer of files between devices with OBEX (a kind of communications protocol).*

- *Replacement of traditional wired serial communications in test equipment, GPS receivers, medical equipment, bar code scanners, and traffic control devices.*

- *For controls where infrared was traditionally used.*

- *Sending small advertisements from Bluetooth enabled advertising hoardings to other, discoverable, Bluetooth devices.*

- *Two seventh-generation game consoles, Nintendo's Wii and Sony's PlayStation 3 use Bluetooth for their respective wireless controllers.*
- *Dial-up internet access on personal computer or PDA using a data-capable mobile phone as a modem.*

Source: <http://en.wikipedia.org/wiki/Bluetooth>

5. SECURITY

Bluetooth is an open system so it can have some security risks. Nowadays a lot of mobile phones and other different devices include Bluetooth and in some cases the people who buy those devices don't now even that the Bluetooth system is operating. There are some opinions which say that Bluetooth is unsecure in the encryption and some other technical aspects but most of the information I found about Bluetooth security is quite technical. Anyway I think that some information about Bluetooth security must be included in this inform, because security is one subject of our subject. So I decide to include the clearer and simple text I found about Bluetooth security, with the link below:

Today's wireless world means that data is being sent invisibly from device to device and person to person. This data, in the form of emails, photos, contacts, addresses and more needs to be sent securely. Bluetooth wireless technology has, from its inception, put an emphasis on security while making connections among devices. The Bluetooth Special Interest Group (SIG), made up of more than 8,000 members, has a Security Expert Group. It includes engineers from its member companies who provide critical security information and requirements as the Bluetooth wireless specification evolves.

Developers that use Bluetooth wireless technology in their products have several options for implementing security. And there are three modes of security for Bluetooth access between two devices:

- Security Mode 1: non-secure.*
- Security Mode 2: service level enforced security.*
- Security Mode 3: link level enforced security.*

The manufacturer of each product determines these security modes. Devices and services have different security levels. For devices, there are two levels: "trusted

device" and "untrusted device." A trusted device has already been paired with one of your other devices, and has unrestricted access to all services.

Services have three security levels:

- Services that require authorization and authentication.*
- Services that require authentication only.*
- Services that are open to all devices.*

Source: <http://bluetooth.com/Bluetooth/Technology/Works/Security/>

6. CONCLUSION

Bluetooth is a standard used in links of radio of short scope, destined to replace wired connections between electronic devices like cellular telephones, Personal Digital Assistants (PDA), computers, and many other devices. Every year we have to add new peripherals to our computers and the need to replace the wired connections is more important every year. That is why the Bluetooth technology is going continue expanding with the support of the industry of Computer science and of Telecommunications, which in some way guarantees the success.

One of the biggest attractions of the implementation of this technology is the creation of networks, with the Bluetooth technology is possible to form different networks in the same geographical point, with relatively high speed of transmission. Anyway the Bluetooth technology has a limited scope, this characteristic of limited scope presents a great disadvantage if we try to implement a net in one extensive geographical area.

Another positive aspect that presents this technology is the easy manipulation and configuration of networks and sub-networks inside the same space with the implementation of diverse Piconets interlaced across Scatternets with different configurations.

7. WEBGRAPHY

- These are the web pages that I used to make this work:

<http://www.bluetooth.com/bluetooth/>

http://en.wikipedia.org/wiki/Bluetooth_Special_Interest_Group

<http://en.wikipedia.org/wiki/Bluetooth>

<http://www.palowireless.com/bluetooth/>

<http://www.cs.utk.edu/~dasgupta/bluetooth/history.htm>

<http://www.monografias.com/trabajos11/blue/blue.shtml>

<http://www.odinismo.com/forum/viewtopic.php?p=8687&sid=1e04b752361e0767bbc7abab1e025a70>

<http://www.cs.utk.edu/~dasgupta/bluetooth/blueprotocols.htm>

<http://www.palowireless.com/INFOTOOTH/tutorial/baseband.asp>

http://progtutorials.tripod.com/Bluetooth_Technology.htm

<http://bluetooth.com/Bluetooth/Technology/Works/Security/>