# A copy to the official Bluetooth website !

# A global specification for wireless technology.

The Bluetooth Technology answers the need for short-range wireless connectivity within three areas:

- Data and Voice access points
- Cable replacement
- Ad hoc networking

The Bluetooth specification specifies a system solution comprising hardware, software and interoperability requirements.

The Bluetooth radio operates in a globally available 2.4 GHz ISM band, ensuring communication compatibility worldwide.

**Data and Voice access points**
The Bluetooth technology facilitates real-time voice and data transmissions. The technology makes it possible to connect any portable and stationary communication device as easily as switching on the lights.

You can, for instance, surf the Internet and send e-mails on your portable PC or notebook regardless of whether you are wirelessly connected through a mobile phone or through a wire-bound connection (PSTN, ISDN, LAN, xDSL).

**Cable replacement**
The Bluetooth technology eliminates the need for numerous, often proprietary, cable attachments for connection of practically any kind of communication device.
Connections are instant and they are maintained even when devices are not within line of sight. The range of each radio is approximately 10 meters, but it can be extended to around 100 meters with an optional amplifier.

**Ad hoc networking**
A device equipped with a Bluetooth radio establishes instant connection to another Bluetooth radio as soon as it comes into range.
Since the Bluetooth technology supports both point-to-point and point-to-multipoint connections, several piconets can be established and linked togeteher ad hoc. The Bluetooth topology is best described as a multiple piconet structure.

**General :**
Qestion: - What is Bluetooth - a technology, a standard, an initiative, or a product?
Bluetooth is the codename for a technology specification for small form factor, low-cost, short range radio links between mobile PCs, mobile phones and other portable devices. The Bluetooth Special Interest Group is an industry group consisting of leaders in the telecommunications and computing industries that are driving development of the technology and bringing it to market.

# Technology Overview

The technology is an open specification for wireless communication of data and voice. It is based on a low-cost short-range radio link, built into a 9 x 9 mm microchip, facilitating protected ad hoc connections for stationary and mobile communication environments.

Codename: Bluetooth.
A Global Specification for Wireless Connectivity.

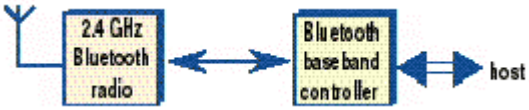
Bluetooth technology allows for the replacement of the many proprietary cables that connect one device to another with one universal short-range radio link. For instance, Bluetooth radio technology built into both the cellular telephone and the laptop would replace the cumbersome cable used today to connect a laptop to a cellular telephone. Printers, PDA's, desktops, fax machines, keyboards, joysticks and virtually any other digital device can be part of the Bluetooth system. But beyond untethering devices by replacing the cables, Bluetooth radio technology provides a universal bridge to existing data networks, a peripheral interface, and a mechanism to form small private ad hoc groupings of connected devices away from fixed network infrastructures. Designed to operate in a noisy radio frequency environment, the Bluetooth radio uses a fast acknowledgement and frequency hopping scheme to make the link robust. Bluetooth radio modules avoid interference from other signals by hopping to a new frequency after transmitting or receiving a packet. Compared with other systems operating in the same frequency band, the Bluetooth radio typically hops faster and uses shorter packets. This makes the Bluetooth radio more robust than other systems. Short packages and fast hopping also limit the impact of domestic and professional microwave ovens. Use of Forward Error Correction (FEC) limits the impact of random noise on long-distance links. The encoding is optimized for an uncoordinated environment.

Bluetooth radios operate in the unlicensed ISM band 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 1Mb/s. 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 kb/s synchronous (voice) link. The asynchronous channel can support an asymmetric link of maximally 721 kb/s in either direction while permitting 57.6 kb/s in the return direction, or a 432.6 kb/s symmetric link.

The different functions in the Bluetooth system are:

- a radio unit (see Radio section )
- a link control unit (see Baseband section)
- link management (see Link Management section)
- software functions (see Software Framework ,PC, Telephone and Others sections)




**Definitions**
Piconet: a collection of devices connected via Bluetooth technology in an ad hoc fashion.A piconet starts with two connected devices, such as a portable PC and cellular phone, and may grow to eight connected devices.All Bluetooth devices are peer units and have identical implementations. However,when establishing a piconet, one unit will act as a master and the other(s) as slave(s) for the duration of the piconet connection.

Scatternet: Multiple independent and non-synchronized piconets form a scatternet

Master unit: the device in a piconet whose clock and hopping sequence are used to synchronize all other devices in the piconet.

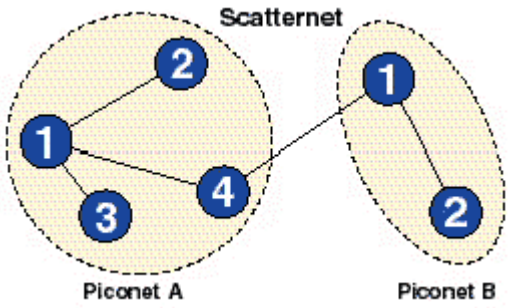
Slave units: all devices in a piconet that are not the master.

Mac address: 3-bit address to distinguish between units participating in the piconet.

Parked units: devices in a piconet which are synchronized but do not have a MAC addresses.

Sniff and hold mode: devices synchronized to a piconet can enter power-saving modes in which device activity is lowered.

**Network topology**
The Bluetooth system supports both point-to-point and point-to-multi-point connections. Several piconets can be established and linked together ad hoc, where each piconet is identified by a different frequency hopping sequence. All users participating on the same piconet are ynchronized to this hopping sequence. The topology can best be described as a multiple piconet structure.




The full-duplex data rate within a multiple piconet structure with 10 fully-loaded, independent piconets is more than 6 Mb/s. This is due to a data throughput reduction rate of less than 10% according to system simulations based on 0dBm transmitting power (at the antenna).

**Voice**
Voice channels use the Continuous Variable Slope Delta Modulation (CVSD) voice coding scheme, and never retransmit voice packets. The CVSD method was chosen for its robustness in handling dropped and damaged voice samples. Rising interference levels are experienced as increased background noise: even at bit error rates up 4%, the CVSD coded voice is quite audible.

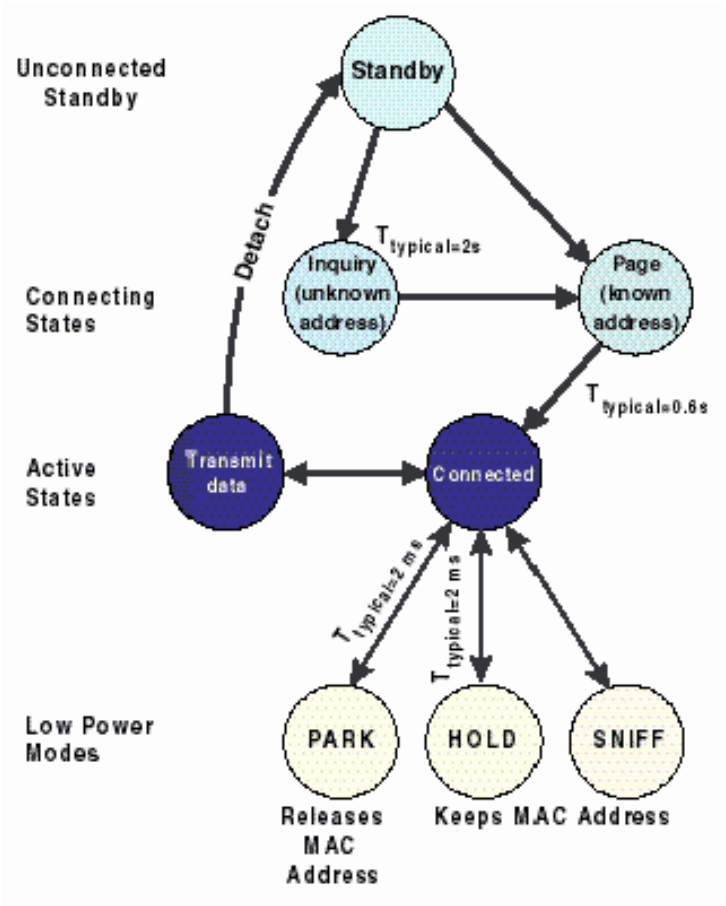
**Radio**
The Bluetooth air interface is based on a nominal antenna power of 0dBm. The air interface complies with the FCC rules for the ISM band at power levels up to 0dBm. Spectrum spreading has been added to facilitate optional operation at power levels up to 100 mW worldwide. Spectrum spreading is accomplished by frequency hopping in 79 hops displaced by 1 MHz, starting at 2.402 GHz and stopping at 2.480 GHz. Due to local regulations the bandwidth is reduced in Japan, France and Spain. 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.

**Baseband**
The baseband describes the specifications of the digital signal processing part of the hardware - the Bluetooth link controller, which carries out the baseband protocols and other low-level link routines.

**Establishing network connections**
Before any connections in a piconet are created, all devices are in STANDBY mode. In this mode, an unconnected unit periodically "listens" for messages every 1.28 seconds. Each time a device wakes up, it listens on a set of 32 hop frequencies defined for that unit. The number of hop frequencies varies in different geographic regions; 32 is the number for most countries (except Japan, Spain and France).
The connection procedure is initiated by any of the devices which then becomes master. A connection is made by a PAGE message if the address is already known, or by an INQUIRY message followed by a subsequent PAGE message if the address is unknown.
In the initial PAGE state, the master unit will send a train of 16 identical page messages on 16 different hop frequencies defined for the device to be paged (slave unit). If no response, the master transmits a train on the remaining 16 hop frequencies in the wake-up sequence. The maximum delay before the master reaches the slave is twice the wakeup period (2.56 seconds) while the average delay is half the wakeup period (0.64 seconds).
The INQUIRY message is typically used for finding Bluetooth devices, including public printers, fax machines and similar devices with an unknown address. The INQUIRY message is very similar to the page message, but may require one additional train period to collect all the responses.
A power saving mode can be used for connected units in a piconet if no data needs to be transmitted. The master unit can put slave units into HOLD mode, where only an internal timer is running. Slave units can also demand to be put into HOLD mode. Data transfer restarts instantly when units transition out of HOLD mode. The HOLD is used when connecting several piconets or managing a low power device such as a temperature sensor. Two more low power modes are available, the SNIFF mode and the PARK mode. In the SNIFF mode, a slave device listens to the piconet at reduced rate, thus reducing its duty cycle. The SNIFF interval is programmable and depends on the application. In the PARK

mode, a device is still synchronized to the piconet but does not participate in the traffic. Parked devices have given up their MAC address and occasional listen to the traffic of the master to re-synchronize and check on broadcast messages.

If we list the modes in increasing order of power efficiency, then the SNIFF mode has the higher duty cycle, followed by the HOLD mode with a lower duty cycle, and finishing with the PARK mode with the lowest duty cycle.




**Link types and packet types**
The link type defines what type of packets can be used on a particular link. The Bluetooth baseband technology supports two link types:

- Synchronous Connection Oriented (SCO) type (used primarily for voice)
- Asynchronous Connectionless (ACL) type (used primarily for packet data)

Different master-slave pairs of the same piconet can use different link types, and the link type may change arbitrarily during a session. Each link type supports up to sixteen different packet types. Four of these are control packets and are common for both SCO and ACL links. Both link types use a Time Division Duplex (TDD) scheme for full-duplex transmissions. The SCO link is symmetric and typically supports time-bounded voice traffic. SCO packets are transmitted over reserved intervals. Once the connection is established, both master and slave units may send SCO packets without being polled. One SCO packet types allows both voice and data transmission - with only the data portion being retransmitted when corrupted. The ACL link is packet oriented and supports both symmetric and asymmetric traffic. The

master unit controls the link bandwidth and decides how much piconet bandwidth is given to each slave, and the symmetry of the traffic. Slaves must be polled before they can transmit data. The ACL link also supports broadcast messages from the master to all slaves in the piconet.

**Error correction**
There are three error-correction schemes defined for Bluetooth baseband controllers:
- 1/3 rate forward error correction code (FEC)
- 2/3 rate forward error correction code FEC
- Automatic repeat request (ARQ) scheme for data.

The purpose of the FEC scheme on the data payload is to reduce the number of retransmissions. However, in a reasonably error-free environment, FEC creates unnecessary overhead that reduces the throughput. Therefore, the packet definitions have been kept flexible as to whether or not to use FEC in the payload. The packet header is always protected by a 1/3 rate FEC; it contains valuable link information and should survive bit errors. An unnumbered ARQ scheme is applied in which data transmitted in one slot is directly acknowledged by the recipient in the next slot. For a data transmission to be acknowledged both the header error check and the cyclic redundancy check must be okay; otherwise a negative acknowledge is returned.

**Authentication and Privacy**

The Bluetooth baseband provides user protection and information privacy mechanisms at the physical layer. Authentication and encryption is implemented in the same way in each Bluetooth device, appropriate for the ad hoc nature of the network. Connections may require a one-way, two-way, or no authentication. Authentication is based on a challenge-response algorithm. Authentication is a key component of any Bluetooth system, allowing the user to develop a domain of trust between a personal Bluetooth device, such as allowing only the owner's notebook computer to communicate through the owner's cellular telephone. Encryption is used to protect the privacy of the connection. Bluetooth uses a stream cipher well suited for a silicon implementation with secret key lengths of 0, 40, or 64 bits. Key management is left to higher layer software.
The goal of Bluetooth's security mechanisms is to provide an appropriate level of protection for Bluetooth's short-range nature and use in a global environment. Users requiring stalwart protection are encouraged to use stronger security mechanisms available in network transport protocols and application programs.

**Link Management**
The Link Manager (LM) software entity carries out link setup, authentication, link configuration, and other protocols.
The Link Manager discovers other remote LM's and communicates with them via the Link Manager Protocol (LMP). To perform its service provider role, the LM uses the services of the underlying Link Controller (LC).

**Services provided:**

- Sending and receiving of data
- Name request. The Link Manager has an efficient means to inquire and report a name or device ID upto 16 characters in length.
- Link address inquiries.
- Connection set-up.
- Authentication.
- Link mode negotiation and set-up, e.g. data or data/voice. This may be changed during a connection.
  - ❖ The Link Manager decides the actual frame type on a packet-by-packet basis.
  - ❖ Setting a device in sniff mode. In sniff mode, the duty cycle of the slave is reduced: it listens only every M slots where M is negotiated at the Link manager.
  - ❖ The master can only start transmission in specified time slots spaced at regular intervals.
  - ❖ Setting a link device on hold. In hold mode, turning off the receiver for longer periods saves power. Any device can wake up the link again, with an average latency of 4 seconds. This is defined by the Link Manager and handled by the Link Controller.
  - ❖ Setting a device in park mode when it does not need to participate on the channel but wants to stay synchronized. It wakes up at regular intervals to listen to the channel in order to re-synchronize with the rest of the piconet, and to check for page messages.

**Software Framework**

Bluetooth devices will be required to support baseline interoperability feature requirements to create a positive consumer experience. For some devices, these requirements will extend from radio module compliance and air protocols, up to application-level protocols and object exchange formats. For other devices, such as a headset, the feature requirements will be significantly less. Ensuring that any device displaying the Bluetooth "logo" interoperates with other Bluetooth devices is a goal of the Bluetooth program.

Software interoperability begins with the Bluetooth link level protocol responsible for protocol multiplexing, device and service discovery, and segmentation and reassembly. Bluetooth devices must be able to recognise each other and load the appropriate software to discover the higher level abilities each device supports. Interoperability at the application level requires identical protocol stacks. Different classes of Bluetooth devices (PC's, handhelds, headsets, cellular telephones) have different compliance requirements. For example, you would never expect a Bluetooth headset to contain an address book. Headsets compliance implies Bluetooth radio compliance, audio capability, and device discovery protocols. More functionality would be expected from cellular phones, handheld and notebook computers. To obtain this functionality, the Bluetooth software framework will reuse existing specifications such as OBEX, vCard/vCalendar, Human Interface Device (HID), and TCP/IP rather than invent yet another set of new specifications.

Device compliance will require conformance to both the Bluetooth Specification and existing protocols. The Software Framework is contemplating the following functions:

- Configuration and diagnosis utility
- Device discovery
- Cable emulation
- Peripheral communication
- Audio communication and call control
- Object exchange for business cards and phone books Networking protocol

**PC General**
Usage models and implementation examples with a notebook PC focus are described in this section. The Bluetooth Specification contemplates interfaces where the radio modules may be integrated into notebook personal computers or attached using PC-Card or USB.
Notebook PC usage models include:

- Remote networking using a Bluetooth cellular phone.
- Speakerphone applications using a Bluetooth cellular phone
- Business card exchange between Bluetooth notebooks, handhelds, and phones.
- Calendar synchronisation between Bluetooth notebooks, handhelds, and phones.

Bluetooth technology is operating system independent and not tied to any specific operating system. Implementations of the Bluetooth Specification for several commercial operating systems are in development. For notebook computers, the implementation of the Bluetooth Specification in Microsoft Windows98 and NT 5.0 using WDM and NDIS drivers is being contemplated.* Customer-visible interoperability is promoted by requiring minimal levels of software functionality, such as speakerphone, on notebook computers.)
*Third-party brands and names are the property of their respective owners.

**Telephone**
Usage models and implementation examples focused on the digital cellular phone are described in this section. The Bluetooth Specification contemplates interfaces where the radio modules may be integrated directly into cellular handsets or attached using an add-on device.
Phone usage models include (are not constrained to):

- Wireless hands-free operation using a Bluetooth headset.
- Cable-free remote networking with a Bluetooth notebook or handheld computer.
- Business card exchange with other Bluetooth phones, notebook or handheld computers.
- Automatic address book synchronisation with trusted Bluetooth notebooks or handheld computers.

The Bluetooth compliance document will require digital cellular phones to support some subset of the Bluetooth Specification. The Bluetooth contingents within the telephony Promoter companies are working with their fellow employees involved in the Wireless Application Protocol (WAP) Forum to investigate how the two technologies can benefit from each other.

**Others**
Usage models and implementation examples centered on other contemplated Bluetooth devices include:

- Headsets
- Handheld and wearable devices
- Human Interface Device (HID) compliant peripherals
- Data and voice access points

The wireless headset will support untethered audio for phones and provide phone-quality audio for notebook computers operating in sound-sensitive environments. The Bluetooth compliance document will specify the various parts of the Specification and existing specifications required by different classes of peripherals.