

# **An Introduction to Bluetooth**

## **A Standard for Short Range Wireless Networking**

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***Abstract-Bluetooth is an emerging standard for short-range low-cost wireless connectivity for consumer devices and Personal Area Networks (PAN). It is a frequency hop spread spectrum system intended for worldwide operation in the unlicensed 2.45 GHz Industrial Scientific Medical (ISM) band. Bluetooth is more than just a radio; it is an entire networking standard. IEEE 802.15 is the developing standard [1].***

**This seminar will provide a look under the “logo” at the basic structure of Bluetooth, its capability to transmit both voice and data, and its software “stack.” It will also examine interference issues and some of the resources available for developing Bluetooth applications.**

### **Bluetooth Introduction**

Bluetooth is a short-range general-purpose wireless networking standard. Originally intended as a wire replacement for connections between computers, personal digital assistants (PDA), cell phones, and other devices, it has grown to become a personal area network (PAN) standard whose applications grow daily.

The Bluetooth Special Interest Group (SIG) has made the Bluetooth standard widely available [2]. The major promoters of the SIG are 3Com, Ericsson, IBM, Lucent, Microsoft, Motorola, Nokia, and Toshiba, but total the number of SIG members exceeds 2400. With this kind of industrial support, Bluetooth promises to become a significant market force.

The Bluetooth air interface operates in the 2400 – 2483.5 MHz Industrial Scientific Medical (ISM) band. The use of this frequency band permits unlicensed operation almost worldwide. In order to conform to the requirements of unlicensed operation, the Bluetooth radio link employs fast frequency hop (1600 hops/sec) spread spectrum.

### **Bluetooth Networking**

Bluetooth devices form ad hoc networks called piconets. Up to eight devices (a master and seven slaves) can simultaneously participate in a piconet. One device in the net becomes the master, and it controls the time synchronization, hopping sequence, and packet scheduling. It is also possible to connect multiple piconets to form a scatternet. Scatternets can operate simultaneously. These multiple piconets are not time synchronized and each employs a different hopping sequence.

In any one piconet only eight Bluetooth devices can be active, but an almost unlimited number of devices can be connected with scatternets and various inactive modes.

Figure 1 is block diagram of the Bluetooth stack. Everything above the host controller interface (HCI) is software. Applications interface with a Bluetooth device as they would a serial modem, a USB port, or a TCP/IP application. The interface software contains a service discovery protocol (SAP) that permits Bluetooth devices to exchange information about their capabilities. A Bluetooth audio headset can tell another

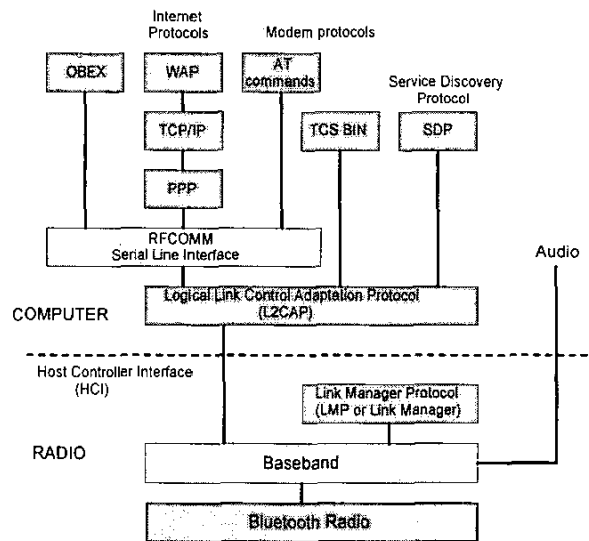


Figure 1: Bluetooth Stack. The functions above the HCI interface a Bluetooth device with applications software. The baseband and radio blocks are the control firmware and the air interface.

Bluetooth device that it can support audio, but it cannot act as a computer printer.

#### Bluetooth Radio and Baseband

The baseband and the radio functions below the HCI interface are firmware and radio hardware. These functions control the actual transmission and reception of data, frequency hopping, and packet formation.

The Bluetooth air link uses binary GFSK modulation with a raw data rate of 1 Mbps. The transmitter power for most Bluetooth devices is 0 dBm, and the receiver sensitivity is specified at -70 dBm. This results in a nominal range of 10 cm to 10 m. Transmitter power up to 20 dBm is permitted with the implementation of interference limiting power control. With the higher power, ranges up to 100 m are possible.

Bluetooth employs a time division duplex scheme. With 1600 hops/sec, time is divided into 625  $\mu$ sec slots. Transmission from the master to the slaves begins with the even numbered slots. Slaves respond in the odd numbered slots.

Bluetooth devices are capable of two types of connections. The first is a constant data rate synchronous connection oriented (SCO) link. The SCO link is used for voice transmission and a Bluetooth device can support up to three 64 kbps SCO links. An asynchronous connectionless link (ACL) is also possible. This is a packet data link with ARQ acknowledgment.

ACL packets can occupy one, three, or five consecutive time slots. Depending on the amount of forward error correction and the number of time slots used, the data throughput can range from 108.8 kbps for a symmetric channel to 732.2/56.6 kbps in an asymmetric channel. The Baseband block and the Link Manager Protocol in Figure 1 control the connection type and the packet structure.

Interference is a concern for any unlicensed wireless device. While the frequency hop provides some relief from narrowband interferers such as microwave ovens, Bluetooth employs both forward error correction and an acknowledgement structure. This makes it very robust, but unlike the "listen before transmit" protocol of IEEE802.11 wireless network devices, Bluetooth is "rude" because it keeps transmitting until a packet is acknowledged.

#### Conclusion

Bluetooth is a wireless networking standard with significant industry support. The standard specifies a frequency hop 2.4 GHz ISM band radio and a software interface.

[1] <http://standards.ieee.org/announcements/802151app.html>

[2] The Bluetooth technical specification, along with the current industry news, is available at <http://www.bluetooth.com>.