Bluetooth:

History:

The developers of this wireless technology first used the name "Bluetooth" as a code name, but as time passed, the name stuck.

The word "Bluetooth" is taken from the 10th century Danish King Harald Bluetooth. King Bluetooth had been influential in uniting Scandinavian Europe during an era when the region was torn apart by wars and feuding clans.

The founders of the Bluetooth SIG felt the name was fitting because:
1) Bluetooth technology was first developed in Scandinavia, and
2) Bluetooth technology is able to unite differing industries such as the cell phone, computing, and automotive markets. Bluetooth wireless technology simplifies and combines multiple forms of wireless communication into a single, secure, low-power, low-cost, globally available radio frequency.

Invented in 1994 by L. M. Ericsson, Sweden

Named after Harald Blaatand “Bluetooth”, king of Denmark 940-981 A.D.

Bluetooth SIG founded by Ericsson, IBM, Intel, Nokia and Toshiba in Feb 1998

More than 1900 members today

Bluetooth version 4.0 and 4.1 has been released

Definition:

Bluetooth is a universal radio interface, operates on 79 channels in the 2.4 GHz frequency band with 1 MHz carrier spacing that enables electronic devices to connect and communicate wirelessly via short-range (10-100 m), ad-hoc networks.

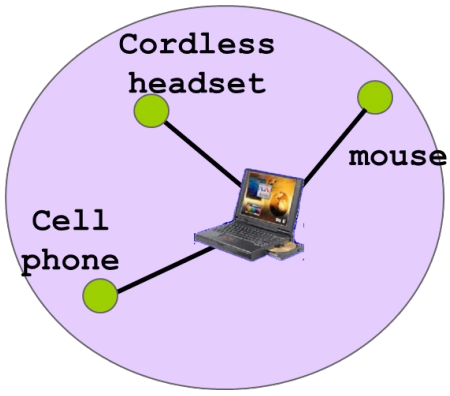
Key Features:

- Peak data rate: 1 Mbps, Low power consumption, Low cost (Components (radios and chips) and device adapters are cheaper).
- Affordable and appropriate technology.
- Younger technology and therefore is less mature.
- Ability to simultaneously handle both voice and data
- Line of sight not required
- connection of peripheral devices (loudspeaker, joystick, headset)
- support of ad-hoc networking (small devices, low-cost)
- bridging of networks (e.g., GSM via mobile phone - Bluetooth – laptop)

- Simple, cheap, replacement of IrDA, low range, lower data rates(2.4 GHz, FHSS, TDD, CDMA)
- Formation of Piconet (a collection of Bluetooth devices which are synchronized to the same hoping sequence)

Motivation for Bluetooth:

- Ubiquitous Computing environment of intelligent networked devices
- Mobile access to LANs/Internet
- Home Networking
- Automatic Synchronization of data
- Voice applications - hands-free headset



Started as a Cable replacement technology

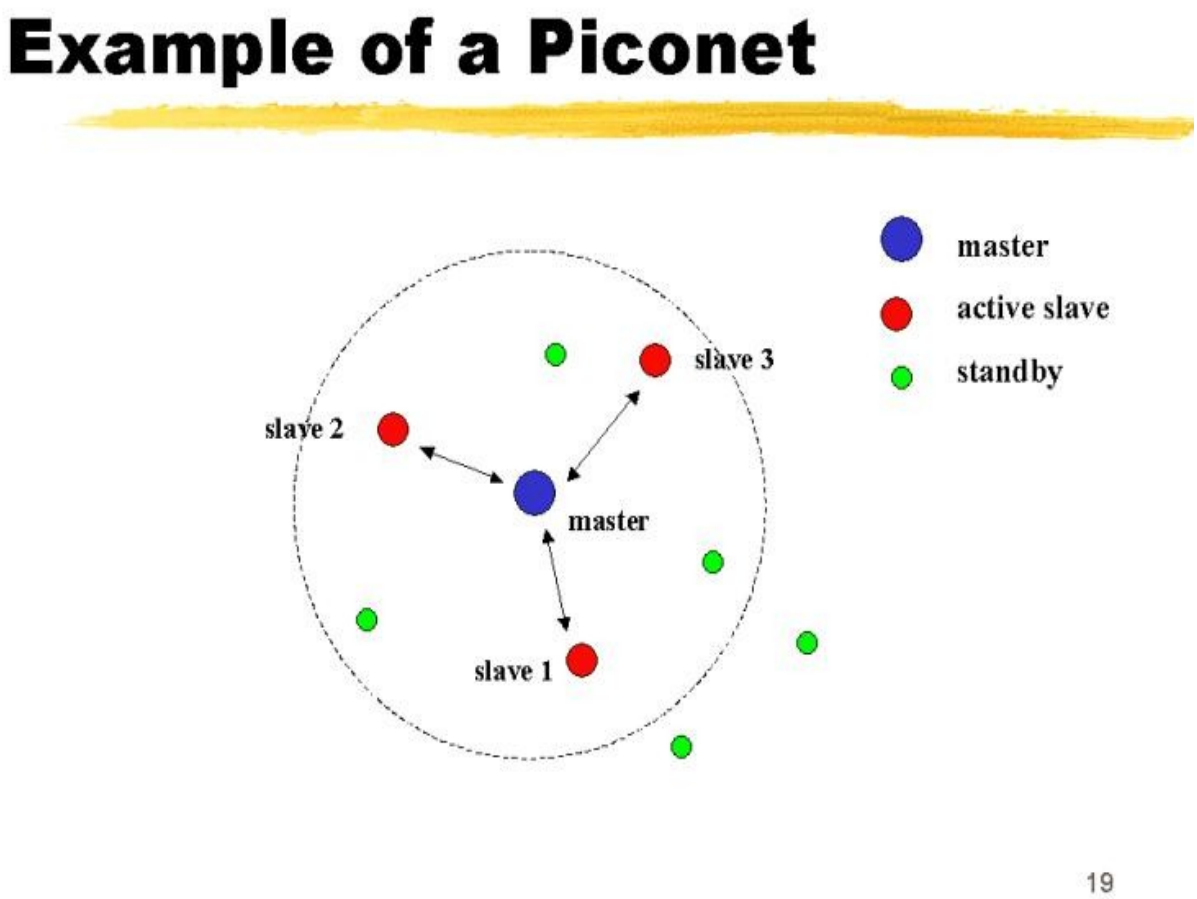
System Challenges:

- Work across a diverse set of devices with varying computing power and memory
- Dynamic environment - the number, location and variety of devices changing - connection establishment, routing and service discovery protocols have to take this into consideration
- Unconscious connection establishment
- Size of the implementation should be small. The power consumption should not be more than a fraction of the host device.

Piconets, Masters and Slaves:

- In principle each unit is a peer with the same hardware capabilities
- Two or more Bluetooth units that share a channel form a piconet (Bluetooth Network)

- One of the participating units is becomes the master (by definition the unit that establishes the piconet).
- Participants may change roles if a slave unit wants to take over as master
- Only one master (primary station) in a piconet. Up to 7 slaves (Secondary station).
- The reason for the upper limit of eight active devices, is the 3-bit address used in Bluetooth.
- The communication b/w primary and secondary can be one to one or one-to-many.



Device Addressing:

- **Bluetooth Device Address (BD_ADDR)**

  Unique 48 bit address

- **Active Member Address (AM_ADDR)**

3 bit address to identify active slave in a piconet

- **MAC address of Bluetooth device**

  All 0 is broadcast address

- **Parked Member Address (PM_ADDR)**

  8 bit parked slave address

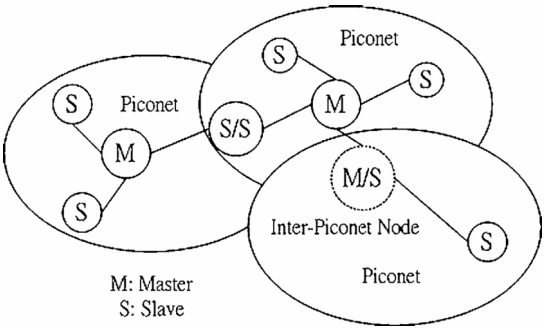
Scatter nets:

A group of overlapping Piconets is called a Scatter net

- Users in a piconet share a 1 Mbps channel – individual throughput decreases drastically as more units are added
- The aggregate and individual throughput of users in a scatter net is much greater than when each user participates on the same piconet
- Collisions do occur when 2 Piconets use the same 1 MHz hop channel simultaneously. As the number of Piconets increases, the performance degrades gracefully.
- Two additional types of Devices:
  - Parked Devise (P): Cannot actively participate in the piconet i.e. they do not have a connection, but are known & can be reactivated within some milliseconds. If a parked devices wants to communicate and there are already 7 active slaves, one slave has to switch to park mode to allow the parked device to switch to active mode. More than 200 devices can be parked. This lead to the idea of forming groups of Piconets called scatternet.
  - Devices in Stand-By (SB): do not participate in the piconet

Inter-piconet communication:

- A unit may participate in more than one piconet on a TDM basis.
- To participate on a piconet it needs the master's identity and the clock offset.
- While leaving the piconet it informs the master.
- The master can also multiplex as slave on another piconet. But all traffic in its piconet will suspended in its absence.



System Architecture:

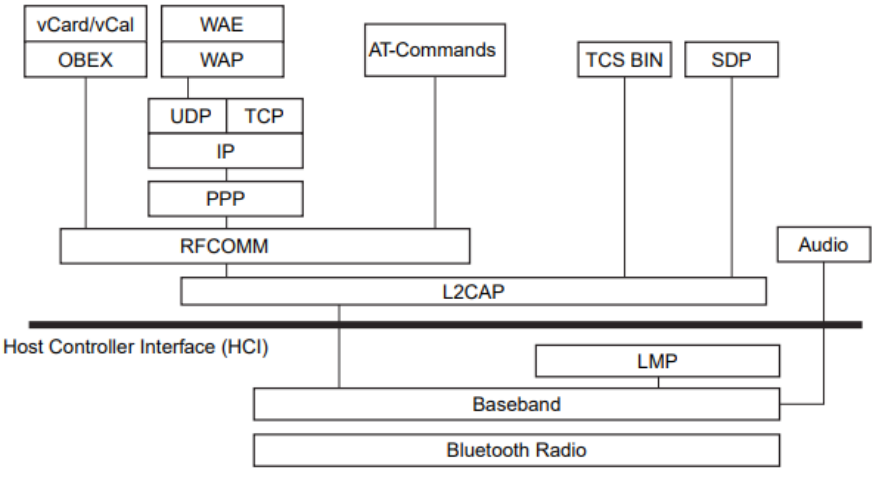


Fig.1 Bluetooth protocol stack

The Radio, Baseband and Link Manager are on firmware. The higher layers could be in software. The interface is then through the Host Controller (firmware and driver). The HCI (Host Controller Interface) interfaces between the baseband and L2CAP provides a command interface to the baseband controller and link manager and access to the hardware status and control registers. The HCI Interface defined for Bluetooth are UART, RS232 and USB. Audio Applications may directly use the Baseband layer after encoding the audio signals.

The Bluetooth Protocol stack can be divided into a core specification and profile specification. The core protocols of Bluetooth comprise the following elements:

- **Radio:** Specification of the air interface, i.e. frequencies, modulation and transmit power.
- **Baseband:** Description of basic connection establishment, packet formats, timing and basic QoS parameters (Bandwidth, Latency, Error rate)
- **Link manager Protocol:** Link set-up and management between devices including security functions and parameter negotiation. Link Manager handles

  - Piconet management (attach/detach slaves, master- slave switch)

- Link Configuration (low power modes, QoS, packet type selection)

-Authentication, pairing, encryption, synchronization, capability negotiation, QoS negotiation, Power control

- **Logical Link Control and adaptation protocol (L2CAP):** Adaptation of higher layers to the baseband (connection & connection-oriented services). Its functions include

1. Protocol multiplexing
2. Segmentation and reassembly
3. QoS specifications
4. Signaling channel for connection request, config. Etc.

Higher layers:

SDP: Service Discovery Protocol: Devices discovery in close proximity plus querying of service characteristics Service Discovery Protocol – runs on a client server model. Each device runs only one SDP server and one client may be run for each application.

RFCOMM: It is cable replacement Protocol that emulates a serial line interface following RS-232 standards.

- This allows for a simple replacement of serial line cables and enables many legacy applications and protocols to run over Bluetooth.
- It supports multiple serial ports over single physical channels

BNEP is used for transferring another protocol stack's data via an L2CAP channel. Its main purpose is the transmission of IP packets in the Personal Area Networking Profile. BNEP performs a similar function to SNAP in Wireless LAN.

Application: This layer basically deal in performing different applications such as audio, N/W, telephony, management

- **A UART (Universal Asynchronous Receiver/Transmitter)** is the microchip with programming that controls a computer's interface to its attached serial devices. Specifically, it provides the computer with the RS-232C Data Terminal Equipment (DTE) interface so that it can "talk" to and exchange data with modems and other serial devices. The UART converts the bytes it receives from the computer along parallel circuits into a single serial bit stream for outbound transmission.
- **TCS BIN (Telephony Control Protocol Specification- Binary):** describes a bit-oriented protocol that defines call control signaling for the establishment of voice and data calls between Bluetooth devices. It also describes mobility and group management functions.
- **The Bluetooth Network Encapsulation Protocol (BNEP)** Bluetooth devices communicate with each other by using standard networking protocols to transport control and data packets over a network. Devices may use protocols such as TCP,

IPv4 or IPv6. These protocols have dissimilar network packet formats. To provide seamless transmission of network packets over the L2CAP layer in the protocol stack, an intermediate protocol is required that encapsulates dissimilar network packet formats as a standard common format. The Bluetooth Network Encapsulation Protocol (BNEP) provides this encapsulation by replacing the networking header, such as an Ethernet header, with a BNEP headers.

Bluetooth Profiles:

- A Bluetooth profile is a specification that defines the minimum requirements that the Bluetooth device must support in a specific usage scenario. These requirements define the end-user services and the features and procedures that the Bluetooth device must support to enable interoperability with peer devices.
- There are two types of profiles: conforming and interoperability.
  - Conforming profiles define the core requirements for Bluetooth devices and are available by default. E.g. generic access, service discovery, cordless telephony, intercom , serial port, headset, dial-up networking, Fax, LAN access, file transfer & synchronization
  - Interoperability profiles, which are based on the conforming profiles, define the minimum requirements for Bluetooth devices to support specific applications. Bluetooth profiles have implicit and explicit dependencies on each other. E.g. Advanced audio distribution, PAN, audio video remote control, basic imaging, hands-free
- To use Bluetooth wireless technology, a device shall be able to interpret certain Bluetooth profiles, which are definitions of possible applications and specify general behaviors that Bluetooth enabled devices use to communicate with other Bluetooth devices. These profiles include settings to parameterize and to control the communication from start. Adherence to profiles saves the time for transmitting the parameters anew before the bi-directional link becomes effective. There are a wide range of Bluetooth profiles that describe many different types of applications or use cases for devices.

Bluetooth Air Interface Choices Made:

ISM Band-

- Global Availability
- License Free

2,400-2,483.5 MHz in Europe and US

2,471-2,497 MHz in Japan

Frequency Hopping-

- Interference from baby monitors, garage door openers, cordless phones and microwave ovens.
- Spread-Spectrum for interference suppression
- FH supports low power, low cost radio implementations