Bluetooth

- Bluetooth is a short-range wireless technology standard
- exchanging over short distances and building personal area networks (PANs).
- most widely used mode, transmission power is limited to 2.5 milliwatts
- very short range of up to 10 metres (33 ft).
- It operates on frequency in the ISM bands, from 2.402 GHz to 2.48 GHz.
- It is mainly used as an alternative to wire connections, to exchange files between nearby portable devices and connect cell phones and music players with wireless headphones.
- Bluetooth is managed by the Bluetooth Special Interest Group (SIG)
- The IEEE standardized Bluetooth as IEEE 802.15.1, but no longer maintains the standard.
- A manufacturer must meet Bluetooth SIG standards to market it as a Bluetooth device.
- The name "Bluetooth" was proposed in 1997 by Jim Kardach of Intel, one of the founders of the Bluetooth SIG.

Aim of Bluetooth

- Global usage
- Voice and data handling
- The ability to establish ad-hoc connections
- Very small size, in order to accommodate integration into variety of devices
- Negligible power consumption in comparison to other devices for similar use
- Competitively low cost of all units, as compared to their non-Bluetooth correspondents

Components of Bluetooth

- An RF portion for receiving and transmitting data
- A module with a baseband microprocessor
- Memory
- An interface to the host device (such as a mobile phone, Palm devices)

Bluetooth protocol stack

Bluetooth Radio

- The Bluetooth radio (layer) is the lowest defined layer of the Bluetooth specification.
- It defines the requirements of the Bluetooth transceiver device operating in the 2.4-GHz ISM band.

baseband and Link Control

- enables the physical RF link between Bluetooth units making a connection.
- The baseband handles channel processing and timing
- The link control handles the channel access control
- There are two different kinds of physical links
  - synchronous connection oriented (SCO)
    - an SCO link supports real-time audio traffic
  - asynchronous connectionless (ACL)
    - an ACL link carries data packets

- Audio is really not a layer of the protocol stack, but it is shown here because it is uniquely treated in Bluetooth communication.
- Audio data is typically routed directly to and from the baseband layer over an SCO link.

Link Manager Protocol

- The Link Manager Protocol (LMP) is responsible for link setup and link configuration between Bluetooth devices, managing and negotiating the baseband packet sizes.
- The LMP manages the security aspects, such as authentication and encryption, by generating, exchanging, and checking link and encryption keys.

HCI

- The HCI provides a command interface to the radio, baseband controller, and link manager.
- It is a single standard interface for accessing the Bluetooth baseband capabilities, the hardware status, and control registers.

L2CAP

- Logical Link Control and Adaptation Protocol (L2CAP) shields the upper-layer protocols from the details of the lower-layer protocols.
- It multiplexes between the various logical connections made by the upper layers.

RFCOMM

- Serial ports are one of the most common communications interfaces used in computing and communication devices.
- The RFCOMM protocol provides emulation of serial ports over L2CAP.
- RFCOMM provides transport capabilities for upper-level services that use a serial interface as a transport mechanism.
- RFCOMM provides multiple concurrent connections to one device and provides connections to multiple devices.

SDP (Service Discovery Protocol)

- SDP provides a means for applications to query services and characteristics of services.
- Unlike in an LAN connection, in which one connects to a network and then finds devices, in a Bluetooth environment one finds the devices before one finds the service.
- In addition, the set of services available changes in an environment when devices are in motion.
- Hence SDP is quite different from service discovery in traditional network-based environments.
- SDP is built on top of L2CAP.

Bluetooth Network Encapsulation Protocol (BNEP)

- Bluetooth-enabled devices will have the ability to form networks and exchange information. For these devices to interoperate and exchange information, a common packet format must be defined to encapsulate layer 3 network protocols.
- BNEP encapsulates packets from various networking protocols, and the packets are transported directly over L2CAP.

- BNEP is an optional protocol developed after Bluetooth specification version 1.1 but based on the 1.1 version of the specification.

Telephony Control Protocol Specification (TCS)

- defines the call control signaling for establishment of voice and data calls between Bluetooth devices.

- It is built on L2CAP.

- Adopted protocols such as OBEX (OBject EXchange) and the Internet Protocol (IP), are built on one of the protocols discussed earlier (e.g., OBEX is built on RFCOMM, and IP is built on BNEP).

Bluetooth Profiles

- To provide interoperability the end product developed by various vendors must follow a common standard defined in the profile
- The profile provides procedures and messages (termed as capabilities) that needs to be implemented to provide Bluetooth applications in a standardized ways

General Access Profile

- The main purpose of this profile is to provide its facilities to the lower layer profiles.
- Ensures that all other profiles are able to establish a baseband link
- Profile defines
    - Basic requirements for smooth functioning of devices
    - Generic procedures for device discovery
    - Link management
    - Procedures for security
    - Device parameters accessible to the user through user interface
- Operation Modes
    - Discoverability
    - Connectability
    - Pairability
    - Security

Serial Port Profile

- The Serial Port Profile defines the protocols and procedures that shall be used by devices using Bluetooth for RS232 (or similar) serial cable emulation
- This profile supports two types of devices
    - Type 1 devices emulating serial port to support serial port applications
    - Type 2 devices
- The Serial Port Profile uses RFCOMM for the purpose of serial port emulation
- The initiator is a device that sets the RFCOMM connection and the other device, which responds, is called responder
- Initially this profile has to acquire the Bluetooth address of the device at other end of the RFCOMM connection

Headset Profile

- This defines the facilities require to make and receive hands-free voice calls from headset to cellular phone
- It can also transfer voice calls to other devices.
- This profile defines two major roles:
    - Audio Gateway (AG)
    - Headset

General Object Exchange Profile

- Defines the protocols and procedures that shall be used by the applications providing the usage models
- The usage model can be, for example, Synchronization, File Transfer, or Object Push model
- Uses IrDA's OBEX objects to transfer the data between Bluetooth devices
- Two roles are define server device and client device
- Information is transferred using OBEX objects with the help of header that contains count, name, type
- Authentication process is mandatory

File Transfer Profile

- This profile transfers data between any numbers of Bluetooth devices
- It uses the capabilities provided by OBEX
- This profiles pulls or pushes the OBEX objects thus transferring the information
- The file transfer profile provides various operations required for this purpose
- This operations can be file copy, delete etc
- In addition to this, browsing capabilities using OBEX objects are provided
- Various OBEX operations are used to implement the file transfer profile

Bluetooth Versions

- Version 1.0
- Version 1.1
- Version 2.0: Enhance Data Rate
- Version 2.1: Secure Simple Pairing
- Version 3.0: High Speed with 802.11 WiFi Radio
- Version 4.0: Low Energy Protocol
- Version 4.1: Indirect IoT device connection
- Version 4.2: IPv6 protocol support
- Version 5.0: 4x range, 2x speed

Bluetooth Low Energy (Bluetooth LE / BLE / BTLE)

- a wireless personal area network technology designed by Bluetooth SIG
- The original specification was developed by Nokia in 2006 under the name Wibree
- which was integrated into Bluetooth 4.0 in December 2009 as Bluetooth Low Energy.
- intended to provide considerably reduced power consumption and cost while maintaining a similar communication range.
- Natively support Bluetooth Low Energy
    - Mobile OS - iOS, Android, Windows Phone and BlackBerry

- Desktop OS - macOS, Linux, Windows 8, Windows 10 and Windows 11, .