



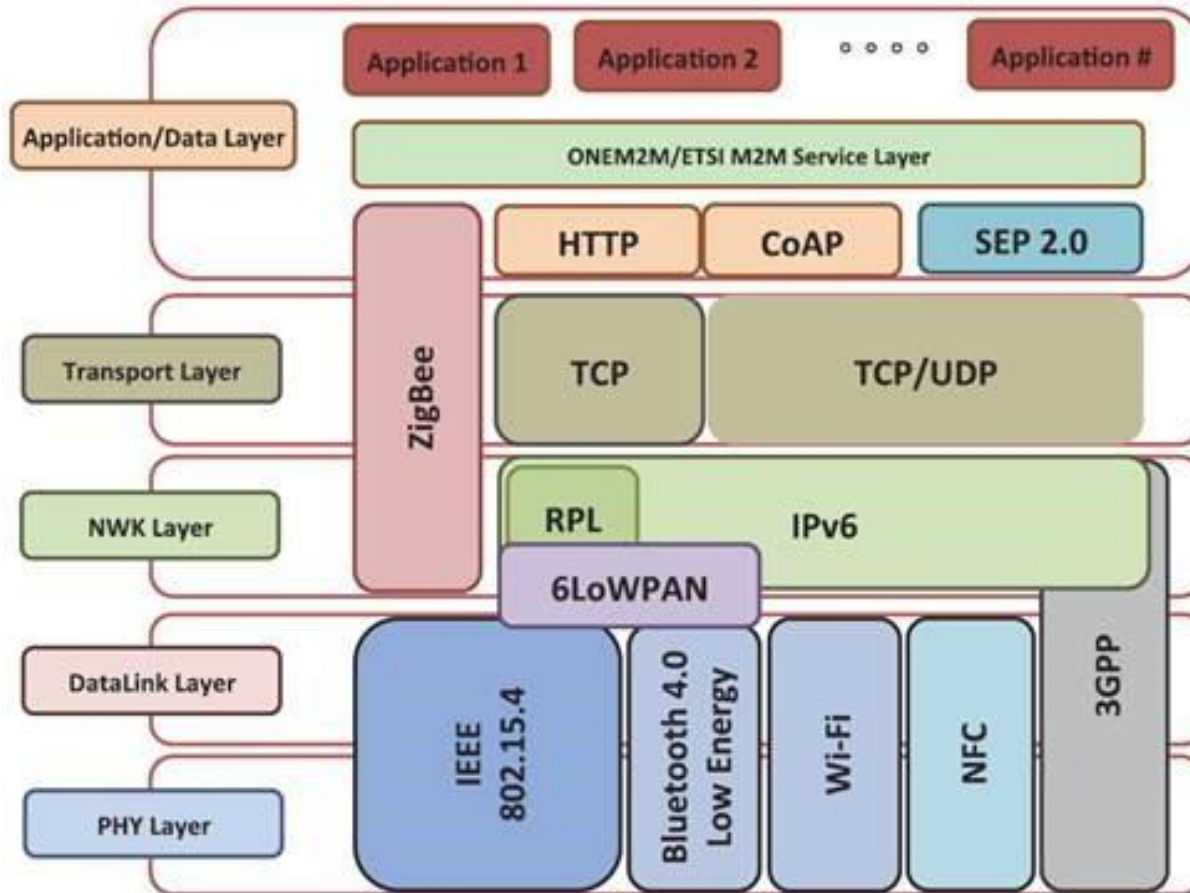
Communication Technologies - Bluetooth

22AIE211 Introduction To Communication & IoT

IoT Ecosystem

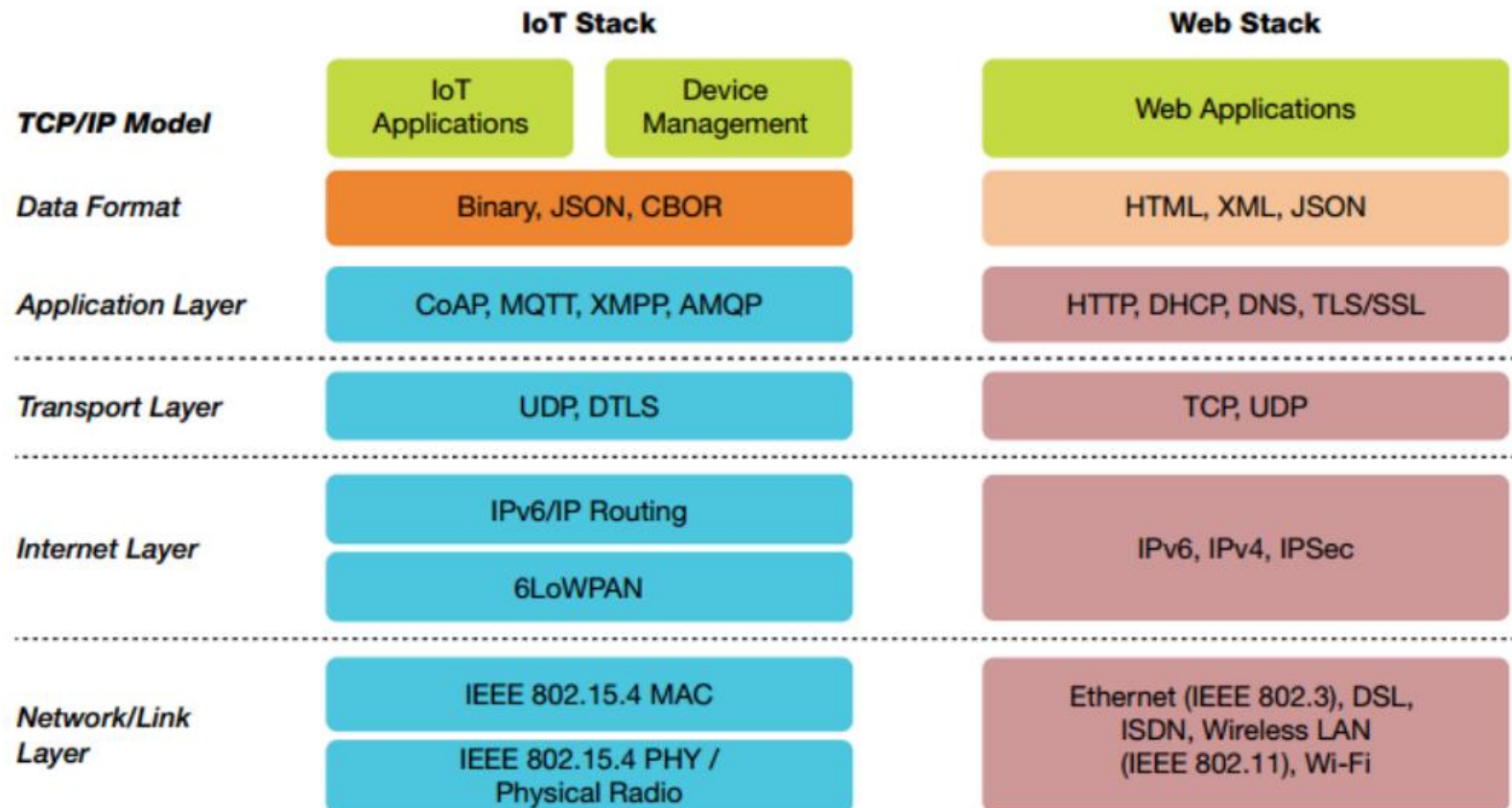
Applications	Smart Health, Smart Home, Smart Grid Smart Transport, Smart Workspaces, ...	Security TCG, Oath 2.0, SMACK, SASL, ISASecure, ace, CoAP, DTLS, Dice	Management IEEE 1905, IEEE 1451, ...
Session	MQTT , CoRE, DDS, AMQP , ...		
Routing	6LowPAN , RPL , 6Lo, 6tsch, Thread, 6-to-nonIP , ...		
Datalink	WiFi, Bluetooth Smart, ZigBee Smart, Z-Wave, DECT/ULE, 3G/LTE, NFC, Weightless, HomePlug GP , 802.11ah, 802.15.4 , G.9959, WirelessHART, DASH7, ANT+ , LoRaWAN, ...		
Software	Mbed, Homekit, AllSeen, IoTvity, ThingWorks, EVRYTHING , ...		
Operating Systems	Linux, Android, Contiki-OS, TinyOS, ...		
Hardware	ARM, Arduino , Raspberry Pi, ARC-EM4, Mote, Smart Dust, Tmote Sky, ...		

IoT protocol stack



Source: <https://www.postscapes.com/internet-of-things-protocols/>

IoT vs. Internet Protocol Stack



Functionality-based IoT Protocol Organization

- **Connectivity** (6LowPAN, RPL)
- Identification (EPC, uCode, IPv6, URIs)
- **Communication/ Transport** (WiFi, Bluetooth, LPWAN)
- Discovery (Physical Web, mDNS, DNS-SD)
- **Data Protocols** (MQTT, CoAP, AMQP, Websocket, Node)
- Device Management (TR-069, OMA-DM)
- Semantic (JSON-LD, Web Thing Model)
- Multi-layer Frameworks (Alljoyn, IoTivity, Weave, Homekit)

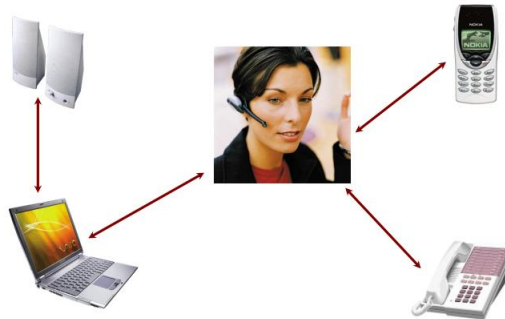
What is Bluetooth?

- “Bluetooth wireless technology is an open specification for a low-cost, low-power, short-range radio technology for ad-hoc wireless communication of voice and data anywhere in the world.”

One of the first modules (Ericsson)

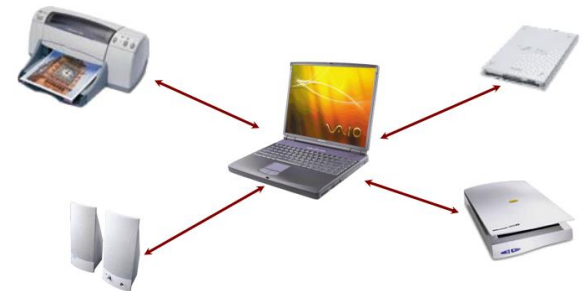


A recent module



Ultimate Headset

Cordless Computer



Bluetooth Goals & Vision

- Originally conceived as a cable replacement technology
- Short-Range Wireless Solutions
- Open Specification
- Voice and Data Capability
- Worldwide Usability
- Other usage models began to develop:
 - Personal Area Network (PAN)
 - Ad-hoc networks
 - Data/voice access points
 - Wireless telematics

When does it appear?

- 1994 – Ericsson study on a wireless technology to link mobile phones & accessories.
- 5 companies joined to form the Bluetooth Special Interest Group (SIG) in 1998.
- First specification released in July 1999

Technical features

<i>Connection Type</i>	Spread Spectrum (Frequency Hopping) & Time Division Duplex (1600 hops/sec)
<i>Spectrum</i>	2.4 GHz ISM Open Band (79 MHz of spectrum = 79 channels)
<i>Modulation</i>	Gaussian Frequency Shift Keying
<i>Transmission Power</i>	1 mw – 100 mw
<i>Data Rate</i>	1 Mbps
<i>Range</i>	30 ft
<i>Supported Stations</i>	8 devices
<i>Data Security –Authentication Key</i>	128 bit key
<i>Data Security –Encryption Key</i>	8-128 bits (configurable)
<i>Module size</i>	9 x 9 mm

Classification

Classification of devices on the basis of Power dissipated & corresponding maximum Range.

	POWER	RANGE
CLASS I	20 dBm	100 m
CLASS II	0-4 dBm	10 m
CLASS III	0 dBm	1 m

Typical Bluetooth Scenario

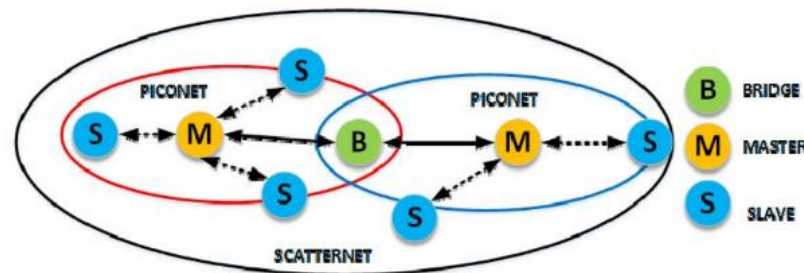
- Bluetooth will support wireless point-to-point and point-to-multipoint (broadcast) between devices in a piconet.
- Point to Point Link
 - Master - slave relationship
 - Bluetooth devices can function as masters or slaves

Piconet

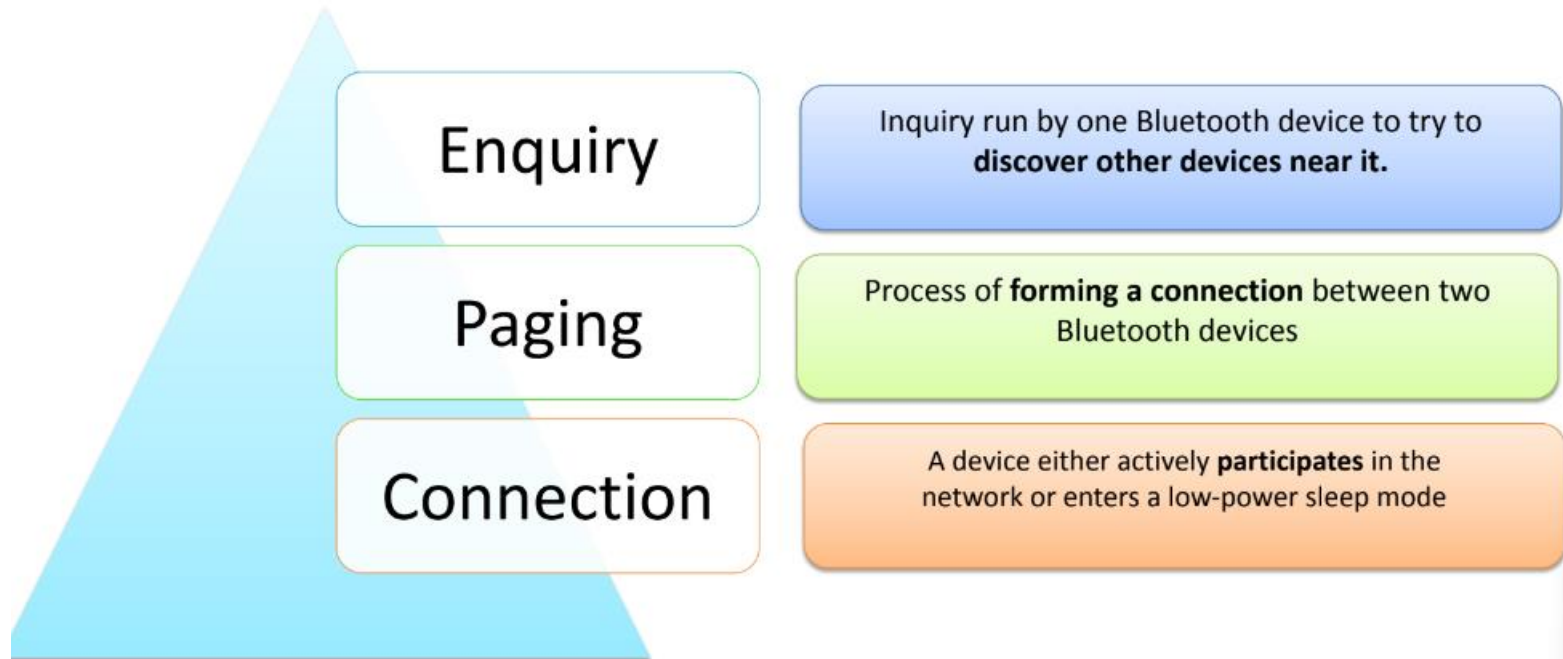
- When more than two Bluetooth devices communicate with one another, it is called a PICONET.
- A Piconet can contain up to seven slaves clustered around a single master.
- The device that initializes establishment of the Piconet becomes the master.
- The master is responsible for transmission control by dividing the network into a series of time slots amongst the network members, as a part of time division multiplexing scheme.

Features of Piconet

- Within a Piconet, the clock and unique 48-bit address of master determines the timing of various devices and the frequency hopping sequence of individual devices.
- Each Piconet device supports 7 simultaneous connections to other devices.
- Each device can communicate with several piconets simultaneously.
- Piconets are established dynamically and automatically as Bluetooth enabled devices enter and leave piconets.
- There is no direct connection between the slaves.
- All connections are either master-to-slave or slave-to-master.
- Slaves are allowed to transmit once these have been polled by the master.
- Transmission starts in the slave-to-master time slot immediately following a polling packet from the master.
- A device can be a member of two or more Piconets. A device can be a slave in one Piconet and master in another. However it cannot be a master in more than once Piconets.
- Devices in adjacent Piconets provide a bridge to support inner-Piconet connections, allowing assemblies of linked Piconets to form a physically extensible communication infrastructure known as Scatternet.



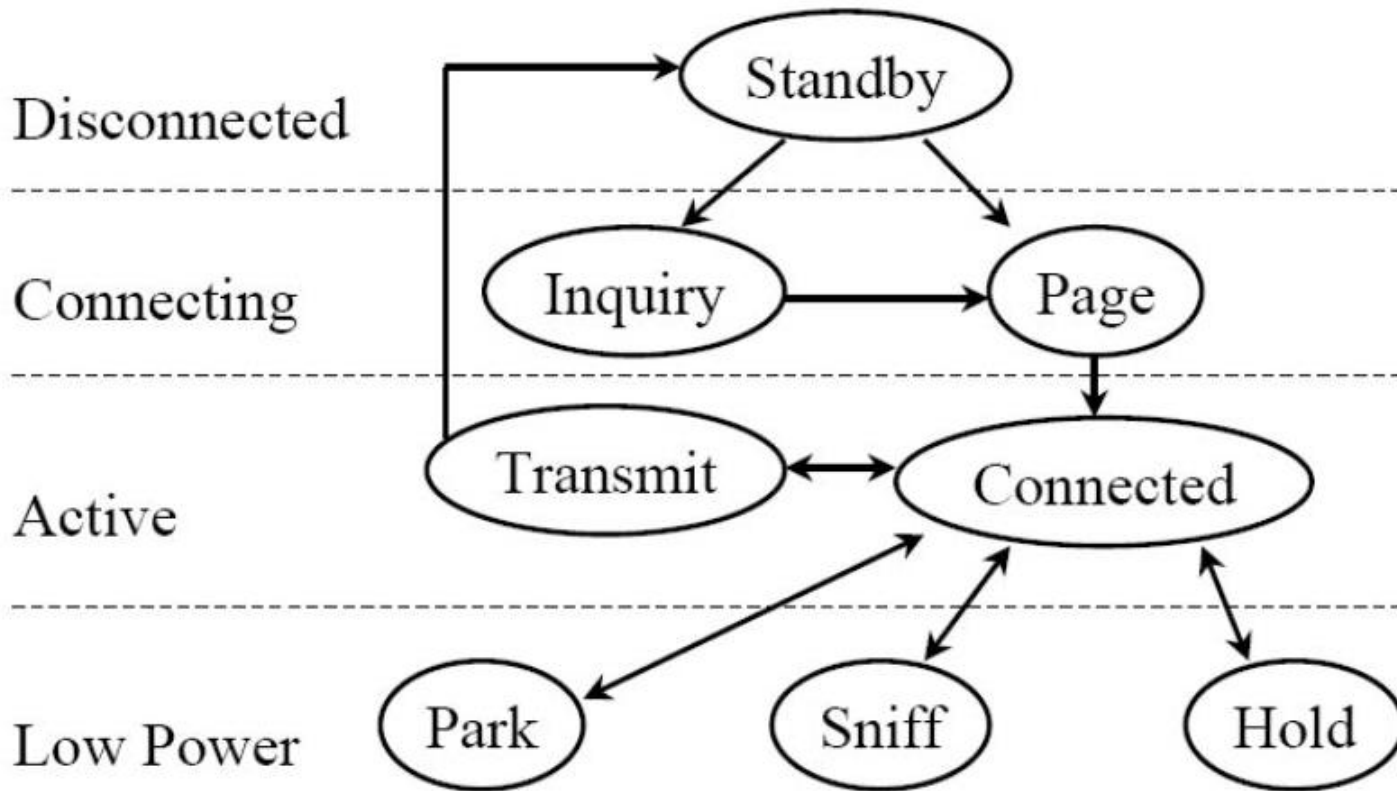
Bluetooth Connection Establishment



Bluetooth Modes

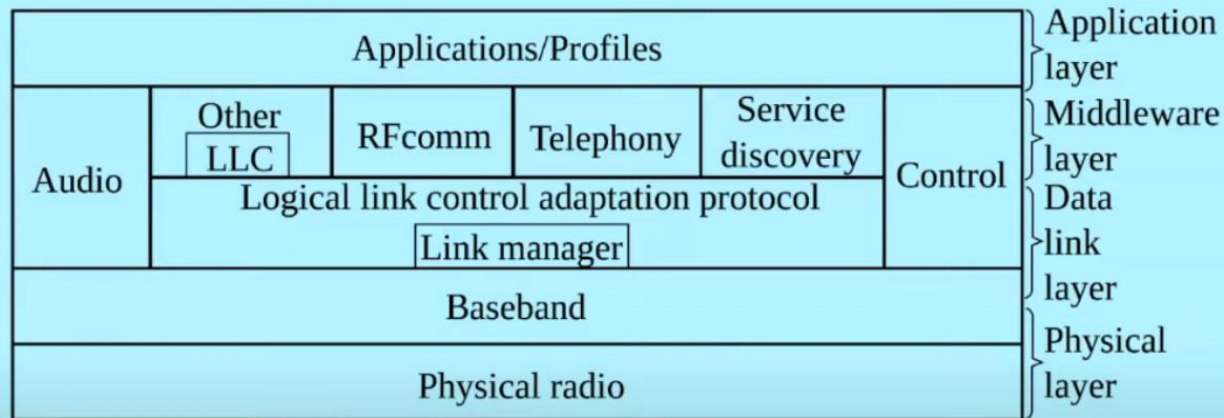


States of Bluetooth devices



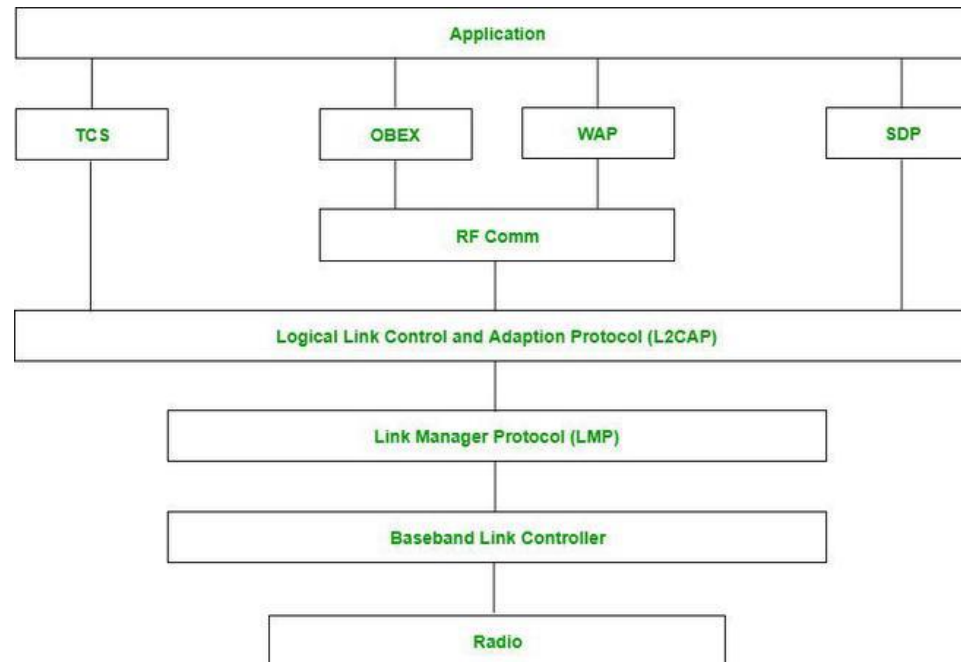
Bluetooth Architecture

BLUETOOTH PROTOCOL STACK LAYER



www.thecode11.com

Architecture



Radio (RF) layer

- It specifies the details of the air interface, including frequency, the use of frequency hopping and transmit power.
- It performs modulation/demodulation of the data into RF signals
- It defines the physical characteristics of Bluetooth transceivers.
- It defines two types of physical links:
 - connection-less and connection-oriented.

Baseband

- Physical layer of the Bluetooth.
- Manages physical channels and links.
- Other services include:
 - Error correction
 - Data whitening
 - Hop selection
 - Bluetooth security
- Manages asynchronous and synchronous links.
- Handles packets, paging and inquiry.

L2CAP

- The Logical Link Control and Adaptation Protocol (L2CAP).
- Layered over the Baseband Protocol and resides in the data link layer.
- Used to multiplex multiple logical connections between two devices.
- Provides connection-oriented and connectionless data services to upper layer protocols.
- Provides:
 - Protocol multiplexing capability
 - Segmentation and reassembly operation
 - Group abstractions

RFComm

- Radio Frequency Communications (RFCOMM).
- It is a cable replacement protocol used for generating a virtual serial data stream.
- RFCOMM provides for binary data transport .
- RFCOMM provides a simple reliable data stream to the user, similar to TCP.
- Supports up to 60 simultaneous connections between two BT devices.

Link Manager protocol layer

- It performs the management of the already established links which includes authentication and encryption processes.
- It is responsible for creating the links, monitoring their health, and terminating them gracefully upon command or failure.

Service Discovery Protocol (SDP)

- Enables applications to discover available services and their features.
- Addresses the unique characteristics of the Bluetooth environment such as, dynamic changes in the quality of services in RF proximity of devices in motion.
- Can function over a reliable packet transfer protocol.
- Uses a request/response model.

OBEX

- It is short for Object Exchange. It is a communication protocol to exchange objects between 2 devices.

WAP

- It is short for Wireless Access Protocol. It is used for internet access.

TCS

- It is short for [Telephony Control Protocol](#). It provides telephony service. The basic function of this layer is call control (setup & release) and group management for the gateway serving multiple devices.

Application layer

- It enables the user to interact with the application.

Applications

- Audio players
- Home automation
- Smartphones
- Toys
- Hands free headphones
- Sensor networks

Summary

- IoT protocol Stack
- Bluetooth