

# Bluetooth Technology -Architecture, Applications, and Issues: A Literature Survey

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**Abstract** - Bluetooth is a modern wireless short-range RF technology that is designed to communicate wirelessly between various machines. The popularity of Bluetooth as a technology grows as time flies by and is still growing and is being embraced in today's world. In this paper, we have embraced a way for brief survey on Bluetooth technology that will explain the architecture, issues, and applications.

**Key Words:** Bluetooth, Bluetooth Technology, Mobile Communication, Mobile device, Wi-Fi, Bluetooth Low Energy

## 1. INTRODUCTION

Bluetooth is a technology for wireless communication that uses radio frequency signals with digitally embedded information. It was originally intended for the sharing of data over short distances and was specified by the IEEE 802.15.1 standard. The distance between the two electronic devices is much less than the transmission of data. The technology's key goals are to promote contact between mobile and fixed devices or between two mobile devices, to remove cables and connectors between devices, and to facilitate data synchronization between two personal devices. Fig-1 shows different types of Bluetooth technology.



Fig-1. Bluetooth Technology

Over short distances between fixed and mobile devices Bluetooth are used to exchange data using UHF radio waves. This is managed by the Bluetooth interest Group (SIG). It is a system in which connections are made between a master and slave. During a piconet it has ability to communicate with seven devices maximum. These connections are maintained until they're broken, either by deliberately disconnecting the 2 or by the link becoming so poor that communications can't be maintained - typically this happens because the devices leave of range of every other. It is generally initiated manually by a device user.

The Bluetooth link for the device is formed visible to other devices.

One of the benefits of Bluetooth is that even non-technical people can use it easily and effectively. Bluetooth technology has been considered for indoor position systems as a competitor to Wi-Fi, especially since the widespread adoption of Bluetooth Low Energy (BLE), thanks to its availability, low cost, and really low power consumption, which allows fixed emitters to run on batteries for several months or maybe years. Bluetooth is often used to interconnect various home appliances like refrigerator, oven, home security system, lights, etc., which may all be controlled by a Bluetooth enabled PDA or mobile. Furthermore, when Bluetooth data rates become higher it can be used to interconnect speakers, display monitors, to a multimedia player without the use of cables. This will enable easy exchange of digital multimedia to connect across devices at home and make a truly wireless home.

Initially, as a cable replacement to enable information sharing among devices, Bluetooth wireless technology included many cell phones, laptops, digital cameras, palmtops. Its recent broader view is providing a set of delicious dishes such as web connectivity, online gaming, and many more. However, any time a user is transmitting or receiving information, he can be exposed to spammers, hackers, and attackers. Bluetooth security supports encryption and authentication. A basic pairing procedure is employed when the two intended devices communicate for the primary time. These features are supported by a secret key-link that's shared by those pair of devices. The security is predicated on a 3-mode model, including; one an unsecured mode, two, a service level secured mode, and three, a link-level secured mode. According to the Bluetooth SIG, all attacks which are intended against the Bluetooth protocol are literally against some specific implementations and therefore the protocol used, itself is actually secure.

A wireless microphone for PC audio, PA systems, or camera accessories is a Bluetooth microphone. It's also commonly used in education, webinar, conference, and more. Bluetooth Loudspeaker app is to wirelessly connects a phone to a nearby Bluetooth speaker or connect to an amplified speaker or PC. Now, our Android device acts as the microphone and the speaker of Bluetooth becoming a

remote loudspeaker. The speaker converts the signals (voltage spikes) into sound and the microphone, converts sound into signals. This can be used in street performance to sing karaoke small celebrations classrooms etc. Wireless and largely portable speakers aimed at listening are Bluetooth speakers. They are easy to transport around since they're wireless. Additionally, for a connection like in wired speakers, you do not have to encounter the problems of untangling and dragging wires. Bluetooth speakers can be used with smartphones, laptops, and a range of other compatible devices. Unlike Wi-Fi operated speakers, Bluetooth speakers don't require a Wi-Fi link. Bluetooth speakers possess similar technologies to car speakers and cell phones. The audio is shipped from the origin through airwaves to the Bluetooth device. Support for the Bluetooth network stack is included in the Android platform, which allows a smartphone to wirelessly share data with various different Bluetooth devices. Via the Android Bluetooth APIs, the application system provides access to Bluetooth features. These APIs enable applications connects other nearby Bluetooth devices wirelessly, allowing wireless features from point-to-point and multipoint.

In this paper, we have presented a survey on Wireless Communication and Bluetooth technologies. This paper is divided into seven sections. The first section is an introduction to Bluetooth and Wireless communication. In the second section, we have mentioned the building blocks of the Bluetooth device. The third section, thus, explains the architecture. In the fourth detail, the review process has been done. It includes the work carried out by the authors, a brief note on the methodology, and a conclusion. In section five, issues and challenges are explained for Bluetooth and Wireless communication. In section six applications of Bluetooth are discussed and in the last section conclusion and future of Bluetooth and wireless communication is explained.

## 2. BUILDING BLOCKS OF BLUETOOTH DEVICE

Classic Bluetooth standard protocol stack is formed by two blocks; the Host and a Controller. These two are generally separately implemented in Bluetooth BR/EDR devices. More recent Bluetooth products, however, have an increased integration standard. In most of the Bluetooth unit, the key building blocks that exist are the following:

- The program that uses the stack interface of the Bluetooth protocol to enforce a specific use case.
- A host that includes the Bluetooth protocol stack's upper layers.
- A controller that comprises the lower levels, including the radio, of Bluetooth protocol stack.

Fig-2. Shows the configuration of Integrated and external processor BLE hardware. A common communication protocol which includes the host and a controller called the

Host Controller Interface (HCI) is provided by the Bluetooth specifications. This facilitates interoperability between that hosts and controller(s) when established by different entities. In a single integrated circuit or system-on-chip (SoC) unit these key building blocks can be used or they can be seen split and executed into more than one IC connected through an acceptable communication interface and protocol (UART, USB, SPI, or other).

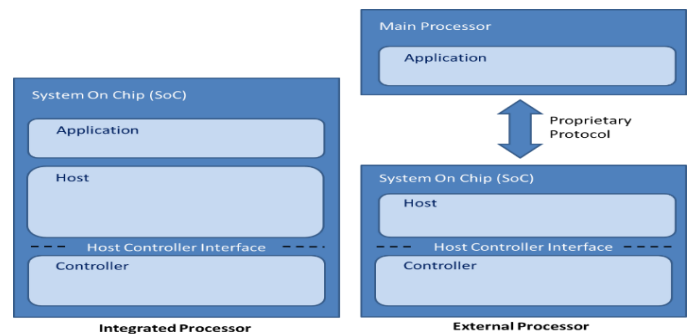


Fig-2. Integrated vs external processor BLE hardware configurations

The external processor opts for powerful computing devices such as smartphones and tablets, with the corresponding HCI protocol that can be either standard or proprietary. This technique also enables the incorporation of additional BLE networking with specialized microcontrollers without changing the overall design. Either as Central Devices or Peripheral Devices, BLE devices may have two separate functions. Typically, cell phones or PCs that have a higher CPU processing capacity are core devices. While some sensors or low-power devices that attach to the central computer are typically peripheral devices. In one of two ways, a BLE computer can speak with neighbouring devices: broadcasting and connections.

Broadcasting is the process of sending all the listening device's information out. We describe two positions when we talk about broadcasting: broadcaster and observer. The broadcaster regularly sends non-connectable advertisement packets to anyone prepared to accept them. While the Observer scans the region repeatedly to obtain the packets, Then, when the Advertisement Packet is received by the Observer, it can request the Scan Response Data. It is important to notice that Broadcasting is that the only way a tool can transmit data to quite one peer at a time.

## 3. BLUETOOTH ARCHITECTURE

It is a technology for the Wireless Personal Area Network (WPAN) and is used to transmit data within smaller distances. It was first brought up by Ericson in 1994. It functions at 2.4 to 2.485 GHz in the unlicensed, commercial, science and medical (ISM) band. The number of devices which can be easily connected to it simultaneously is 7 (maximum). Bluetooth is up to 10 metres long. Depending upon the version, it offers data

rates of up to 1 Mbps or 3Mbps. FHSS (Frequency hopping spreading) is the spreading process it utilizes.

There are two types of networks in the architecture of Bluetooth: piconet and scatternet.

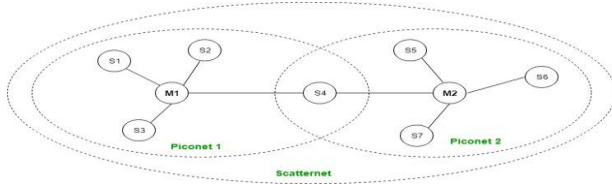


Fig-2. Piconet and scatternet

Piconet is one type of Bluetooth network containing seven secondary nodes which are also active called slave nodes and one primary node called the master node. We may therefore assume that there are 8 active nodes in total that are present at a distance of 10 metres. There may be a one-to-one or one-to-many connections between the primary and its subsequent secondary nodes. There is only potential contact between the master and the slave; there is no chance of slave-slave communication. It also has 255 parked nodes, which are secondary nodes and, unless converted to the active state, do not engage in communication.

Using various piconets, it is shaped. In one piconet, a slave that is present will serve as master or we can claim main in another piconet. In one piconet, this sort of node will receive message from the master and delivers intended message to its slave to the other piconet where functioning as a slave. A node of this form is referred to as a bridge node. In two piconets, a station cannot be master.

#### 4. A LITERATURE REVIEW

[1] An application for programmable personal mobile communication devices which is useful for people to attend meetings, conferences, classrooms and the like is developed and described. The app allows the user to act as a moderator/host of a meeting in one case or as an attendee/participant of the meeting in another.

The working principle is the processing of voice signals from a user of the mobile communications device at the meeting into local wireless network signals through an app on the programmable personal mobile communications device; sending the local wireless network signals through the app on the programmable personal mobile communications device, the local wireless network signals transformed into voice signals and broadcast over the amplified system to attendees/participants at the meeting; receiving survey form over the local wireless network through the app, the survey form having queries associated with the meeting and sending a user response to the survey form back over the local wireless network through the app; here the procedure is coordinated through the app on the programmable personal mobile communications device. Individuals could use their personal Smartphones

as microphones to address others within the room via the general public address or sound amplification system however this system depends on the native wireless network or Wi-Fi. Wi-Fi needs a power supply and without it, it might not work as an amplifying system.

The authors [2] have studied various scheduling algorithms, since it has a direct impact on the transmission performance of the whole Bluetooth system. In this paper, the improvement of Bluetooth MAC layer scheduling algorithm for QoS is proposed. The Bluetooth standard suggests a simple polling scheduling policy RR, but RR has the disadvantage of being inefficient and unable to provide QoS services for high priority traffic. The simple polling scheduling policy RR recommended by Bluetooth standard is improved to the scheduling policy based on the priority of device service type. The improved protocol uses different service strategies by distinguishing between different service priorities. Experiments show that the improved scheduling algorithm can achieve QoS support based on service priority. The average number of packets and average delay is less and with better overall performance. The experimental results verify that the improved Bluetooth MAC protocol implements the function of providing service based on service priority. The service quality of high-priority services is guaranteed and the system has better transmission performance.

In this paper [3], authors have carried out a study on varied Bluetooth wireless technologies. The study includes operating of Bluetooth, Future Bluetooth hotspot technology, technology challenges. They conclude that Bluetooth is a wireless technology that can do far more than simply replace data cables between devices. With the release of the Bluetooth version 3.0 specification supporting higher data rates, Bluetooth is clearly an honest alternative for Wireless Personal Area Networks. The utilization of Bluetooth by mobile phone manufacturers has been an excellent driver for this technology alongside the push from the Bluetooth special interest group. To further increase the market share, Bluetooth SIG should quickly address a bit of the security and interoperability problems. They recommend that the device vendors should strictly adhere to the SIG's Bluetooth specification and address interoperability problems on their own initiative also. This could increase users trust during this technology and also create a healthier market place.

The [4] paper implements protocols with two new security levels of protection for simple and secure pairing of Bluetooth. These protocols commit for IO capability and for public keys. This ensures that the data hits the legitimate pairing devices that in the initial stage minimize the Man-In-The-Middle attack and enhance the link/session key. The SAGEMATH program is used to produce the SSP and SSP-APKE-DECE modules in the form of \*. Sage directories. In 'C', the Bluetooth protocol stack was introduced to include the SSP protocol and SSP-APKE-DECE protocol proposed. The protocol uses the encryption-decryption

AES-CCM encryption-authentication algorithm as it offers authenticity and confidentiality. Notations used in calculations concerning Master modes as per Input-Output capability of devices. In version 2.1+EDR (Enhanced Data Rate), SIG implemented SSP with four new association modes according to system Input-Output (I/O) capability. For those devices which have keyboards and displays, the numeric comparison mode is used.

One of the connecting devices lowers its security level in most of the pairing cases to match the security level of the device that is least efficient. The majority of attacks are focused on problems of this nature. The authors conclude that the SSP-APKE-DECE is successfully executed in the current SSP by improving two additional protection layers. The protocol gives complete forward confidentiality as the new one is created for each pairing session. Consequently, a new session/link key is always created. As the sequence of exchange of nonce and the commitment values does not cause the attacker to synchronize his computer with valid devices, the protocol avoids reflection attacks. The pairing time of SSPAPKEDECE is more comparable to SSP because of the additional security layers. Nonetheless the improved protection of the proposed protocol compensates for the increased pairing time overhead.

[5] Here, the authors have done a literature survey on various aspects of Bluetooth related to versions, applications, features of scatter net and piconet and Bluetooth Protocol Stack and have discussed the fundamentals of communication, connection and pairing and bonding mechanisms. To make pairing possible between devices Bluetooth is a powerful technology using air interface. It allows us to exchange files, text, images, etc., over a network with a humongous range of about 60 meters. It can be used as a portable or fixed device. Also, for data transfer enhanced trustful security techniques have been built. It is observed that due to cost and competition from other standards they have hindered the widespread acceptance, but Bluetooth does offer a viable solution to many devices that might not have wireless connectivity without it.

[6] With the massive penetration of smartphone devices in day-to-day life, mobile app development becomes a popular trend. Designing as well as implementation of the smart home application is an Internet-of-Things (IoT) topic that needs to be explored more. There are major challenges which are, capable for automatic adjustment with different operating system (OS), simple yet efficient, compact, interactive and battery consumption.

The paper aims to develop an Android-based low-power mobile application for smart homes. This application design is intended to cover the multi-control scheme (i.e., hard control, soft-control, and monitoring). To investigate into the battery consumption, the authors have analyzed the idle-active condition and different color themes (i.e., red, green, and blue). The app developed can run on

various smartphone devices and its android OS version (J, K, L, and M). The important findings of their research work are indifference tests of the main theme color. They suggest to a developer to notice the value of luminous efficiency if make App with low power consumption. If we think most people use OLED display for their smartphone, we recommended you use a green or not bright color theme for your app. Because green led has efficient battery consumption than others and has a long lifetime than blue which has a short lifetime. They conclude that for an application to be efficient, they have developed an app and paired it with multiple-devices like microphones and speakers. Bluetooth is a better solution for less power consumption of the mobile.

[7] Wireless communication is the fastest increased growth in technology and has become a very interesting area of research for researchers in the electronics world. It involves the transmission of data without the use of cables or wires. In this paper, a method has been proposed to transmit the voice signals wirelessly using Bluetooth. A microphone or an audio device can be used to input the voice signal to the controller. The controller may be Arduino ATmega 328P which is used to downsample/upsample the data and a wireless device may be a Bluetooth or ZIGBEE is used for wireless communication. Here, a wireless signal transmission system that uses a low-power 8-bit micro-controller with high-speed ADC's, DAC's and peripheral devices are used. This makes the system more cost-effective, faster, and reliable. Traditional systems that use wires to transmit the signals require greater power and are expensive.

The [8] paper gives an overview of the current state of Bluetooth and WLAN (Wi-fi) technology. The study covers a brief and precise introduction to the principles of this technology, major and current and envisaged fields of application, and also it addresses overview of the technologies in terms of services. The author has presented an overview of the two most popular wireless standards, with a comparison in terms of capacity, network topology, security, QoS support, and power consumption.

The [9] authors have analyzed the description of the technology in terms of its network infrastructure, hardware, and software, and also the Error corrections and retransmission. They have done a comparison of Bluetooth with other technologies. The authors have carried out an analysis of macro analytical view including the business implications, advantages of the technology, its role in the global third 3G wireless schemes. They have presented the applications and future potentials of Bluetooth.

In this paper [10], novel features of Bluetooth LE and its applicability in 6LoWPAN networks are presented. They have identified and discussed the issues and challenges like: a secure and reliable multi-hop communication in Bluetooth LE-connected 6LoWPAN networks, How to secure the currently available broadcast communication

and group communication in Bluetooth LE-connected 6LoWPAN networks, open-source and open-licensed Bluetooth LE software stack for resource-constrained IoT devices, open Bluetooth LE hardware with register-level details disclosed in datasheets, support for 6LoWPAN header compression in smartphones and Bluetooth LE gateways, and experimental evaluation of IoT protocols over Bluetooth LE.

## 5. ISSUES AND CHALLENGES IN THE FIELD OF BLUETOOTH TECHNOLOGY

The Bluetooth radio operates in the unlicensed 2.4 GHz ISM (Industrial, Scientific, and Medical) band. Since 2.4 GHz is the absorption frequency of the water molecule, microwave ovens also operate in this band. So, one limitation of Bluetooth is that Microwave ovens are a source of major interference. It implies that radio waves in Bluetooth radio communications cannot penetrate water. Two or a lot of devices sharing a similar channel in Bluetooth kind a piconet. There are one master device and up to seven active slave devices in a piconet. The interference in Bluetooth wireless communication should increase with the increasing number of piconets this is often thus as a result of Bluetooth communication uses a frequency hopping system that hops indiscriminately from amongst a complete of 79 frequencies. As the number of piconets increases, the probability that two frequencies in adjacent piconets are the same increases. This results in packet collisions requiring retransmission. A detailed study on this is required through simulation of a Bluetooth piconet.

A major problem with device discovery in Bluetooth is that, because of the timing involved for inquiries and pages, it can take a long time before devices are discovered and the actual data transmission begins.

Due to short battery lifetimes, mobile devices typically have limited energy available for computing and communications. Preserving battery energy in mobile devices should be a critical consideration in designing protocols for mobile computing. This issue ought to be thought of through all the layers of the protocol stack.

## 6. APPLICATION DOMAINS FOR BLUETOOTH TECHNOLOGY

Here we discuss the application domain of Bluetooth Technology. Bluetooth allows a maximum of Eight devices to communicate in a small network called a piconet. The maximum number of Bluetooth wireless devices that can be paired varies depending on which model of the unit is used. In the Bluetooth radio, ten piconets can coexist in the same coverage range. To provide secure connection, each link is encoded and protected against snooping and interference.

Using short-range wireless property Bluetooth provides support for 3 general application areas: information and

voice access points- Bluetooth permits voice and information transmissions by providing wireless association of stationary and moveable communication devices, Cable replacement-Bluetooth eliminates the necessity for varied, typically proprietary cable attachments for the association of much any quite communications device. The range of each radio is approximately 10 m, it can be extended to 100 m with an optional amplifier and Ad hoc networking connections. These are instant and are maintained even when devices are not within the line of sight. A Bluetooth radio-enabled device can establish a connection to another Bluetooth radio as soon as it comes into range.

Bluetooth software [9] ought to permit cardiac sufferers to be monitored thru their cell phones. Instead of being limited to nearby location networks in the hospital, sufferers may be everywhere within the range of their Bluetooth-compatible mobile phones. A Bluetooth device could turn picks up signals directly from the patient's heart monitor and convey it to the mobile phone and communicates the information to the monitoring system present in the hospital. The complex and tedious task of networking between the computing devices has the power of connected devices and it is done by the Bluetooth network installed in the office. Employees can connect to the network anywhere within the office.

The latest additions to the Bluetooth standard [10] make it very attractive communication primitive for crowd-sourced sensing. Crowdsourcing has become an increasingly common way to collect open data from the general public.

## 7. CONCLUSIONS

Bluetooth technology is a very important technology which, without the use of wires, can make communication possible within the range between devices. Bluetooth offers seamless communication that enables several immersive and highly transparent customized services to be explored. Bluetooth is a technology for wireless communication that allows devices to link to each other via secure pairing. It also has different features to link multiple devices and perform different tasks, such as a duplex network connection. Likewise, the addition of Radio Direction Finder program.

To attain promising connectivity for IoT devices of all sizes, Bluetooth Low Energy (BLE) is added to the network stack. The cost and energy consumption for running the applications is cut down using this technology. These characteristics facilitate Bluetooth with an acceptable acting platform for IoT devices. In this review research on Bluetooth Technology, we conclude that IoT endpoint devices tend to adopt the modern age of Bluetooth technology because of their outstanding speed, excellent range, robust protection, and improved accessibility.

Bluetooth as a generation is exciting with its traits and large commercial enterprise potential, and destiny will display which component the improvement of the entire subject of wi-fi communications will take and what's going to be the function of Bluetooth on this improvement.

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