# A Survey of Bluetooth and ZigBee WPAN Standards

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*Abstract -* **This paper presents a comparative study of Bluetooth (IEEE 802.15.1) and ZigBee (IEEE 802.15.4); two types of IEEE 802.15 "wireless personal-area networks," (WPANs). Various parameters are considered for comparisons like efficiency, power consumption, channel bandwidth, data transfer rate, network flexibility, scalability, channel capacity, range (area covered), cost efficiency, circuit complexity/interfacing with different devices, security, network speed, protocol used, protocol stack size, network topology, types of network. The result of this study will be very helpful in choosing the techniques for different types of application in a very efficient manner.**

*Keywords* **- Wireless Personal Area Networks, ZigBee, Bluetooth, ISM band**

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## I. INTRODUCTION

A Wireless Personal Area Network (WPAN) is a low range network based on IEEE 802.15 standard confined to a few meters, which is used to interconnect devices around an individual person's workplace. The various IEEE standards for WPAN are 802.15.1(Bluetooth), 802.15.3 (High Rate WPAN), 802.15.4(Low Rate WPAN/ZigBee), 802.15.6(Body Area Network),802.15.9(Key Management Protocol), 802.15.10 (Layer Two Routing),802.15.7 (Visible Light Communication), 802.15.8 (Peer Aware Communication), 802.15.9 (Key Management Protocol), 802.15.10 (Layer Two Routing); as mentioned in table 1 [1]. In this paper we are comparing the two most popular IEEE WPAN standards 802.15.1 (Bluetooth) and 802.15.4 (ZigBee).

Table 1 WPAN IEEE Standards

| S. no. | IEEE Standard | Objective |
|---|---|---|
| 1 | 802.15.1 | WPAN (Bluetooth) |
| 2 | 802.15.3 | High Rate WPAN |
| 3 | 802.15.4 | Low Rate WPAN (ZigBee) |
| 4 | 802.15.6 | Body Area Network |
| 5 | 802.15.7 | Visible Light Communication |
| 6 | 802.15.8 | Peer Aware Communication |
| 7 | 802.15.9 | Key Management Protocol |
| 8 | 802.15.10 | Layer Two Routing |

*Bluetooth:*

It is a wireless technology used for data communication over a short distance using ultra high frequency radio waves in the (Industrial Scientific and Medical) ISM band (2.4 to 2.485 GHz). It is generally used for building personal area networks for both fixed as well as mobile devices.

A Bluetooth device/module contains a Bluetooth radio and software that makes it easy to connect with other device. When two Bluetooth devices want to communicate, they use handshake signals and hence pairing takes place. The communication between the two Bluetooth devices is possible only in a short range. Bluetooth supports wireless ad-hoc network network, which is a decentralized network, it does not rely on a pre existing infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks [2].

Bluetooth supports two topologies: piconet and scatternet. Piconet is nothing but the connection of two or a maximum upto eight Bluetooth devices among which one device acts as master and the others acts as slave. Scatternet is formed when two or more piconets interconnect. Interconnection is formed when a member of one piconet (either the master or any one of the slaves) elects to participate as a slave in the other piconet. It supports communication between more than eight devices.

*ZigBee:*

It is a wireless technology which is used to create personal area networks using very low power radios waves for short range low data rate transfer. It is based on IEEE 802.15.4 standard. It is considered to be simpler and less expensive as compared to other wireless technologies such as Bluetooth.

It has a defined rate of 250 Kbit/s and uses a mesh network to send data over long distances. ZigBee is generally used in applications which involve low data rate but need long battery life and secure networking. A ZigBee network is secured using a 128 bit symmetric encryption.

It operates in the ISM band which ranges 2.4 GHz to 2.485 GHz. However the frequencies of transmission differ from country to country. In USA and Australia ZigBee operates at 915 MHz, in Europe at 868 MHz and in China at 784 MHz and the Data rates vary from 20 kbps for 868 MHz band to 250 Kbit/s for 2.4 GHz band [3].

There are mainly three kinds of ZigBee devices available which are ZigBee coordinator, ZigBee Router, ZigBee End Device. ZigBee Coordinator: It forms the base of the network and acts as a bridge to other networks. There is generally one ZigBee coordinator in each network. It also stores information about the network. It also stores the security keys. ZigBee Router: It acts as an intermediate router passing on data from other devices. ZigBee End Devices: It can only talk to the node which is known as parent node. i.e. either a coordinator or a router. However it cannot relay data from other devices. This technique/method helps in increasing the battery life as the node can be asleep for a significant amount of time. It requires least amount of memory and therefore is less expensive as compared [4].

## II. DIFFERENCES BETWEEN BLUETOOTH AND ZIGBEE:

Thought Bluetooth and ZigBee fall under IEEE802.15 standard but they have many differences in their operational behaviour. A few differences are mentioned in table 2 and discussed here.

The battery life of the ZigBee module is greater by a considerable amount as compared to Bluetooth however it is not rechargeable. Bluetooth is used throughout the world at 2.4 GHz where as the operational frequency of ZigBee varies from country to country. In USA and Australia ZigBee operates at 915 MHz, in Europe at 868 MHz and in China at 784 MHz and the Data rates vary from 20 Kbps for 868 MHz band to 250 Kbps for 2.4 GHz band [3]. ZigBee is generally considered to be used within a PAN whereas Bluetooth is generally used in the WPAN. The amount of nodes that can be connected to each other using ZigBee is more than 65,000 nodes whereas Bluetooth can only be used to connect 8 nodes. ZigBee is widely recognised to have a self healing network where in case a node is damaged then the entire network is not disturbed. The neighbouring nodes of the damaged node create a reverting loop and prevent information from being sent to the damaged node and make the network more stable. However Bluetooth does not have this technology. The ZigBee module has a lower data rate of about 250kbps whereas Bluetooth can be used to send data at a rate of 1mbps. A Bluetooth network can have a point to point master-slave method which involves one master and up to seven slaves. While a ZigBee device can be connected in a star mesh and other generic topologies. It also allows different ZigBee based technologies can be connected to each other in form of a cluster. Atypical ZigBee network consists of three types of nodes: ZigBee Coordinator, ZigBee Router, and ZigBee Endpoint. ZigBee works on the Direct Spread Spectrum technique. In which the original signal is mixed and extracted from a pseudo random code at the transmitting and receiving end. On the other hand Bluetooth works on the Frequency hopping spread spectrum technique in which the carrier signal is made to vary in terms of frequencies. ZigBee is designed to exchange operational instructions but not very much variety of data whereas Bluetooth can be used to exchange data such as text, multimedia etc. And therefore ZigBee consumes significantly less power than its Bluetooth counterpart. And in that sense, is more energy efficient. Table 3shows the potential applications of the two technologies and recommendations based on the existing literature.

Table 2 Comparison table of Bluetooth and ZigBee

| S.No. | Parameter | Bluetooth | ZigBee |
|---|---|---|---|
| 1. | Versions/Types | 2.0, 2.1, 3.1, 4.0, etc | ZigBee & ZigBee Pro |
| 2. | Modulation technique | Frequency Hopping Spread Spectrum (FHSS) | Direct Sequence Spread Spectrum (DSSS) |
| 3. | Protocol Stack Size | 250 K Bytes | 28 K Bytes |
| 4. | Battery | Intended For Frequent Recharging | Not Rechargeable |
| 5. | Maximum Network Speed | 1 Mbps | 250 Kbps |
| 6. | Network Range | 1 or 100 meters depending on radio class | 70 to 400 meters |
| 7. | Typical Network Join Time | 3 Seconds | 30 Milli-Seconds |
| 8. | Channel Bandwidth | Up-to 1 MHz | 0.3MHz, 0.6MHz, 2MHz |
| 9. | Types Of Computer Networks | Wide PAN | PAN |
| 10. | Number Of Cell Nodes | Min. 2 & Max. 8 | More Than 65,000 Nodes |
| 11. | Self Healing Network | No | Yes |
| 12. | Network Topology | Point To Point Master Slave | Star, Mesh ,Cluster, etc. |
| 13. | Data Transfer Rate | 1Mbps | 250 Kbps |
| 14. | Power Consumption | More | Less than Bluetooth |
| 15. | Data Type | More type of data can be exchange | Less  type of data can exchange |
| 16. | Frequency Hopping | Yes | No |
| 17. | Channel spacing | 1 MHz | 5 MHz |

| 18. | Number Of Channel | Based on different regions USA & Europe - 79, Japan, France and Spain – 23 [5] | 16 channels for 2450 MHz band, 10 channels for 915 MHz band, 1 channel for 868 MHz [5] |
|---|---|---|---|
| 19. | RF Frequency Band | ISM bands country wise as mentioned below: USA and Europe-2400 to 2483.5MHz, Japan-2471 to 2479MHz, France-2445 to 2475MHz, Spain-2446.5 to 2483.5MHz [5]. | 868MHz in Europe 915 MHz in Australia/USA, 2450 MHz worldwide |

### III. APPLICATION BASED RECOMMENDATIONS:

This section presents various applications of WPAN. In consideration with the existing literature application based recommendation of the use of technique among Bluetooth and ZigBee is suggested. A detailed analysis is present in table 3.

When it comes to building/home/lighting automation then we should prefer to use ZigBee technology as it provides us with greater number of nodes with higher battery life, flexible bandwidth and a relatively large range of communication.

ZigBee also stands out when it comes to Health care applications. ZigBee provides us with a reliable patient monitoring system which is critical criteria in such application.

In case of remote control and input/output devices it has No line-of-sight or field-of-vision limitations and provides a secure data transfer. And can be used to connect a lot of nodes together in a running network which is a major advantage in these the applications.

The latest addition to the ZigBee family is the ZigBee SIM card can also replace the current SIM card technology and can be used for high value services without using the 4G/3G infrastructure. The ZigBee SIM card makes ZigBee a highly valuable asset when it comes to the telecom services.[11]

But when it comes to High data rate transfer then ZigBee loses to Bluetooth because the biggest advantage of Bluetooth is that it can transmit high volumes of data wirelessly in a secure manner at higher data rate.

Table 3 Application based recommendation among Bluetooth and ZigBee

| S.No. | APPLICATION | BLUETOOTH | ZIGBEE | Remarks | |
|---|---|---|---|---|---|
| | | | | Bluetooth | ZigBee |
| 1 | Building/home/lighting Automation[8,12] | • Less number of nodes<br>• Requires frequent charging<br>• Bandwidth is fixed and therefore wasted (1 MHz) | • Greater number of nodes<br>• Long battery life<br>• Flexible bandwidth 0.3 0.6 & 2 MHz<br>• Flexible network covers homes of all sizes<br>• Easily compatible with multiple sensors and easy to install<br>• BACnet approved | | ✓ |
| 2 | Health Care [11] | • Less number of nodes<br>• Wastage of bandwidth | • Greater number of nodes<br>• Power efficient<br>• Reliable remote patient monitoring | | ✓ |
| 3 | Multimedia services(Audio, video) [11] | • High data rate<br>• Sufficient bandwidth<br>• More efficient for multimedia services | • Insufficient bandwidth<br>• Low data rate<br>• Less efficient for multimedia services | ✓ | |
| 4 | Input devices (mice, keyboards etc.) [11] | • Less number of nodes<br>• Wastage of bandwidth<br>• Requires frequent charging | • Supports Multi touch and gesture commands<br>• Greater number of nodes<br>• Secure data transfer<br>• Affordable<br>• Over the air upgrades and programmability option<br>• Interference avoidance mechanism<br>• No line-of-sight or field-of- | | ✓ |

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|---|---|---|---|---|---|
| | | | vision limitations<br>• Long battery life | | |
| 5 | Remote Control[11] | • Less number of nodes<br>• Requires frequent charging<br>• Insufficient range | • No line-of-sight or field-of-vision limitations<br>• Long battery life and less battery consumption<br>• Greater number of nodes<br>• Remote locator<br>• Higher range (70 to 400m)<br>• Allows for true interoperability between vendors products | | ✓ |
| 6 | Telecom services [9,10] | | • Peer-to-Peer data sharing services<br>• interference avoidance mechanism<br>• ZigBee SIM card<br>• value-added services<br>• mobile gaming<br>• location-based services<br>• secure Mobile Payments [6].<br>• Phones with SIM cards can easily be upgraded by user<br>• Frees up precious high value 3G/4G infrastructure for delivery of more appropriate high value services [7]. | | ✓ |

## IV. CONCLUSION:

At the end we conclude that applications which involve low data rate and higher transmission range such as building/home automation, health care and remote control access ZigBee should be a preferred choice over Bluetooth. However, if we have a high data rate requirement such as Audio/video applications then we should prefer to use Bluetooth technology. As it provides reliable data transfer in case of high data rate personal area networks.

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