

A survey: Issues and challenges of communication technologies in WBAN

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Abstract

Wireless Body Area Network (WBAN) refers to a group of small intelligent electronic devices placed on the human body to monitor its vital signals. It provides a continuous health monitoring of a patient without any constraint on his/her normal daily life activities through the health care applications. Due to the strong heterogeneous nature of the applications, data rates will vary strongly, ranging from simple data at a few Kbits/s to the video stream of several Kbits/s. Data can also be sent in bursts, which means that it is sent at a higher data rate during the bursts. This study covers the main requirements of communication technologies that are used in WBAN comprise of two major parts. The first part, which presents the short-range classification, gives a specialized outline of a few standard wireless technologies that are short-ranged. These are introduced as contenders for intra-BAN communications for communications inside a Body Area Network (BAN) and between the elements.

Keywords: WBAN, Health monitoring, Communication technologies, Short-range, Long range

1. Introduction

WBAN system can be defined as a set of wired or wireless electronic devices that come together to build a system that continuously monitors the patient's vital signals through the sensors on his body. There are different types of wave transfer modes adopted in WBAN systems, in this thesis explain the main characteristics of these types and clarify the type of difference between them, where only one of the media recommended by the researcher is highlighted based on the efficiency shown in several previous studies. The types of communication technologies that are used in WBAN comprise of two major parts. The first part, which presents the short-range classification, gives a specialized outline of a few standard wireless technologies that are short- ranged. These are introduced as contender for intra-BAN communications for communications inside a Body Area Network (BAN) and between the elements. The advantages and disadvantages from a WBAN viewpoint are additionally featured in the first part. At long last, a one next to the other examination of the competitor innovations just as the justification for the utilization of the MICS band [1]. A depiction of different long- range cell wireless technologies, which could be conveyed for extra-BAN interchanges, is given in the subsequent part. This includes correspondences between a WBAN and other outer Wide Area Networks (WANs), which is comprehensive of the cell versatile systems, and the

Internet. Toward the finish of this area, the advantages and disadvantages of every one of the advancements as far as throughput and inactivity are exhibited. This brought about a one next to the other correlation of the long-go remote advances that is to be sure understandable [2].

2. WBAN communication

2.1. Short-range WBAN communication

IEEE 802.15.1 (Bluetooth)

Bluetooth refers to a short-range communication standard within approximately 10 m and a data rate of 3 Mbps. Its high bandwidth and low latency features have promoted its use in health care. Besides, it is evident that it supports many mobile platforms. However, due to its high-power consumption, it is avoided in health care monitoring applications. Additionally, it is found to be suitable for latent and bandwidth-sensitive scenarios [3]. Bluetooth devices are divided into three different categories. This is dependent on their ability to transfer a maximum range of power, which at the same time decides the most extreme transmission range of the Bluetooth radio as delineated in Table 1.

Table 1. Bluetooth power classes [4]

Power Class	Maximum Output Power	Radio reach
Class 1	100mW (20 dBm)	~ 100 meters
Class 2	2.5mW (4 dBm)	~ 10 meters
Class 3	1W (0 dBm)	~ 1 meter

Fig. 1 provides details on the Bluetooth protocol stack comprises of a layered architecture that includes various protocols.

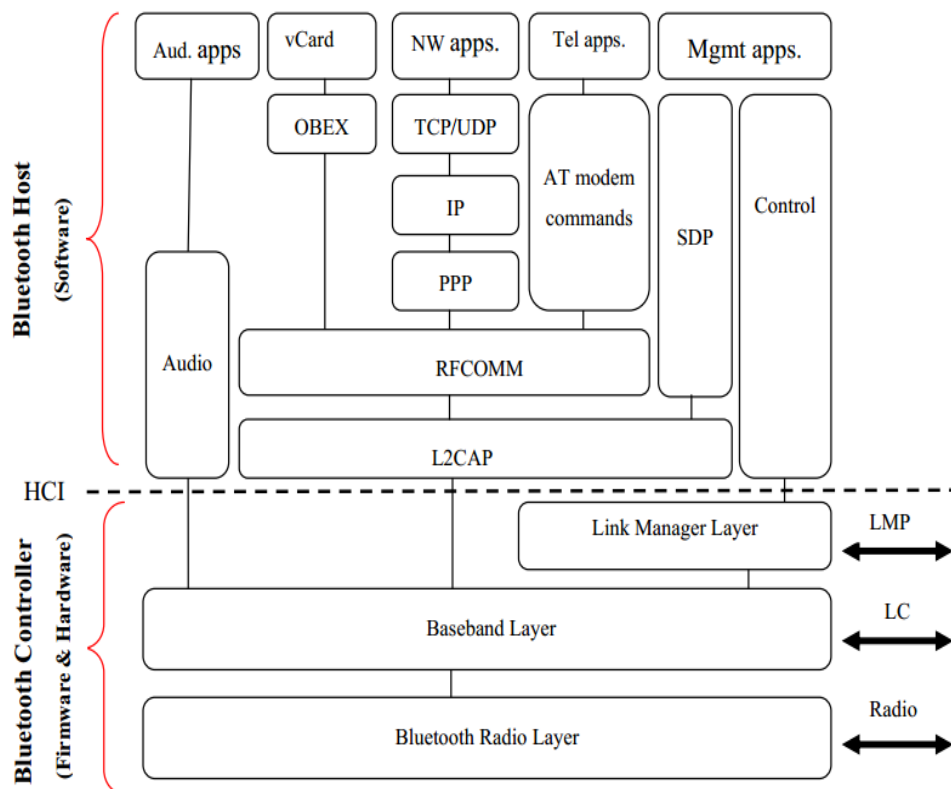


Figure 1. Bluetooth protocol stack [5]

These protocols can be named Being a lower level protocols, link substitution protocols, communication

control conventions, and embraced conventions [6][7]:

- Being a lower-level protocol, the Bluetooth Core System (BCS) protocols incorporates the Radio Frequency (RF) convention, Link Control (LC) convention, Link Manager (LM) convention, and Logical Link Control and Adaptation Protocol (L2CAP). Furthermore, all Bluetooth applications require an assistance layer convention known as the Service Discovery Protocol (SDP).
- Cable substitution protocol incorporates an information stream that is straightforward and solid to the client, that are accessible additionally works as a vehicle layer for OBEX over Bluetooth.
- Telephony control protocols clarifies the call control flagging set up from voice and information calls inside Bluetooth devices.

Bluetooth limitations and shortcomings:

- Power consumption: Battery lifetime may not last for weeks as a lot of power and time are consumed due to lengthy synchronization by the Bluetooth device.
- Limitations in networking:
- Formation of a system: Once the ace of a built-up system moves away, the entire system breakdown, consequently programmed system arrangement isn't bolstered. This component clashes with the necessities of powerfully evolving systems.
- Connection arrangement: It is delayed firing up an association, for example up to the request for five seconds. Request systems, which are protracted, interfere with information moves and interchanges that are continuous. In addition, if the two gadgets are at the same time in the Inquiry State, a Bluetooth Inquiry will come up short.
- Protocol stack that is heavy and complex:
- Additional overheads: For the implementation of Bluetooth stack, processing resources and additional memory is needed. This may not be accessible for the asset confined sensor gadgets that are explicitly utilized in BAN applications [5].

Ultra-Wideband-IEEE 802.15.3

Ultra-Wideband (UWB) is a radio transmission technology, which is highly rated, ultra-low-powered and short-ranged. It is fit for moving information at a rapid. This is finished by using more extensive data transfer capacity in contrast with the conventional "restricted band" radio transmission advancements. The utilization of UWB innovation for Personal Area Networks (PAN) has a few points of interest as it gives low power utilization (~1mW/Mbps) and high information rate (up to 480 Mbps). These highlights make UWB appropriate for WBAN applications on the grounds that WBAN applications require high data transfer capacity and low power utilization [4]. IEEE 802.15.3, the standard name given to UWB innovation for PAN applications, works in 2.4GHz ISM band and goes for a RF front-end and baseband processor upgraded for short-extend transmission. It shows a present channel of under 100 mA and a little structure factor for incorporating into shopper gadgets. In contrast with WLAN (IEEE 802.11) and Bluetooth (IEEE 802.15.1), single-bearer PHY is utilized in UWB (IEEE P802.15.3). This is to decrease intricacy and power utilization. The first IEEE 802.15.3 PHY combined with Trellis-Coded Modulation (TCM) having multi-bit images and accomplishes 11 to 55 Mbps top information rate covering 10–30 m is wanted to speed-range strategies.

Two up-coming measures dependent on UWB innovation, specifically "WiMedia UWB" and "Remote USB", are constrained by WiMedia Alliance. WiMedia UWB uses low-fueled, rapid UWB innovation. It grants information of up to 480 Mbps going inside a few meters and information of roughly 110 Mbps a way off of up to 10 m. The low paces of effective of UWB customer items is because of the restricted advancement in

UWB principles improvement, high beginning execution cost, and fundamentally lower usage and execution toward the beginning. This brought about a few UWB sellers to stop activities in the years 2008 and 2009 [8].

ZigBee – IEEE 802.15.4

Based over the IEEE 802.15.4, in light of WPAN as a standard, ZigBee is a short- ranged wireless technology that works by low power, minimal effort, and low-rate. A definitive point of ZigBee is expanded battery life, progression in systems administration abilities, minimal effort, and reliability [9]. Home computerization, industrialization, remote control, smart labels, sensor systems, therapeutic field, and observing applications are a portion of the uses of ZigBee. Discharged in 2007, the ZigBee stack contains two stack profiles. Stack profile 1 (ZigBee) is utilized for home and light business purposes. It offers a littler impression in RAM and glimmer, where both offer full work systems administration and work with all ZigBee application profiles. Then again, stack profile 2 otherwise called ZigBee Pro houses highlights like multi-throwing, many-to-one directing, and elevated level security with Symmetric Key Exchange (SKKE). Direct Sequence Spread Spectrum (DSSS) is utilized by the IEEE 802.15.4 PHY to battle against potential high impedance levels in the unlicensed recurrence groups utilized. Contingent upon the recurrence band, two physical layers are characterized; the 868/915 MHz PHY and the 2,450 MHz PHY. Table 2 demonstrates a portion of the attributes of ZigBee including most extreme information rate and land inclusion.

Table 2. ZigBee frequency band and their characteristics [8]

Frequency band	Availability	Radio Channels	Max Data Rate	Data Modulation
868MHz	Americas	1	20kbit/s	BPSK
915MHz	Europe	10	40kbit/s	BPSK
2.4GHz	Global	16	250kbit/s	16-ary orthogonal

The table demonstrates that the 2.4GHz PHY permits higher information rate contrasted with the other two and it is additionally accessible around the world. This makes it a superior inclination for BAN applications. Be that as it may, 2.4 GHz ISM recurrence band has its very own shortcomings, for example extensive body constriction and most noteworthy impedance level happened because of the conjunction of the species IEEE 802.11b (WiFi) and 802.15.1 (Bluetooth) just as different remote advancements on this band. Figure 2.8 demonstrates that ZigBee manufactures a Network (NWK) layer and an Application (APL) layer over the IEEE 802.15.4 MAC and PHY layers [7]. Fundamental correspondence capacities of the physical radio are given by the PHY layer, while administration is given by the MAC layer accordingly permitting single-jump correspondence interfaces between gadgets. Capacities like directing and multi-jump that are required for making distinctive system topologies are offered by the NWK layer. An Application Support Sub-layer (APS), the ZigBee Device Object (ZDO), and the ZigBee applications as characterized by the client or architect are incorporated into the application layer. The ZDO is liable for the administration of the general gadget, while the APS gives administrations to ZDO just as to ZigBee applications [9].

Decreased Function Device (RFD) and Full Function Device (FFD) are the two kinds of gadgets characterized by IEEE.802.15.4. RFDs are subsets of the IEEE 802.15.4 and don't go about as facilitator. FFDs have a full execution of IEEE 802.15.4 and they can be considered as end-gadgets, facilitators, or switches in a WPAN. The IEEE 802.15.4 MAC layer underpins five sorts of MAC outlines that incorporate the reference point outline, information outline, affirmation outline, MAC order edge, and super edge. The facilitator characterizes the arrangement of the super frame [12]. The Network Layer of ZigBee supports star, tree and work topologies. Three sorts of gadgets are being characterized by ZigBee dependent on their systems administration abilities [13]:

- ZigBee Coordinator (ZC) being the most dominant gadget in ZigBee organize, starts a ZigBee arrange and permits other ZigBee gadgets (end-gadgets and switch gadgets) to join the system. Signal edges can likewise

be sent for synchronizing the gadgets in the system.

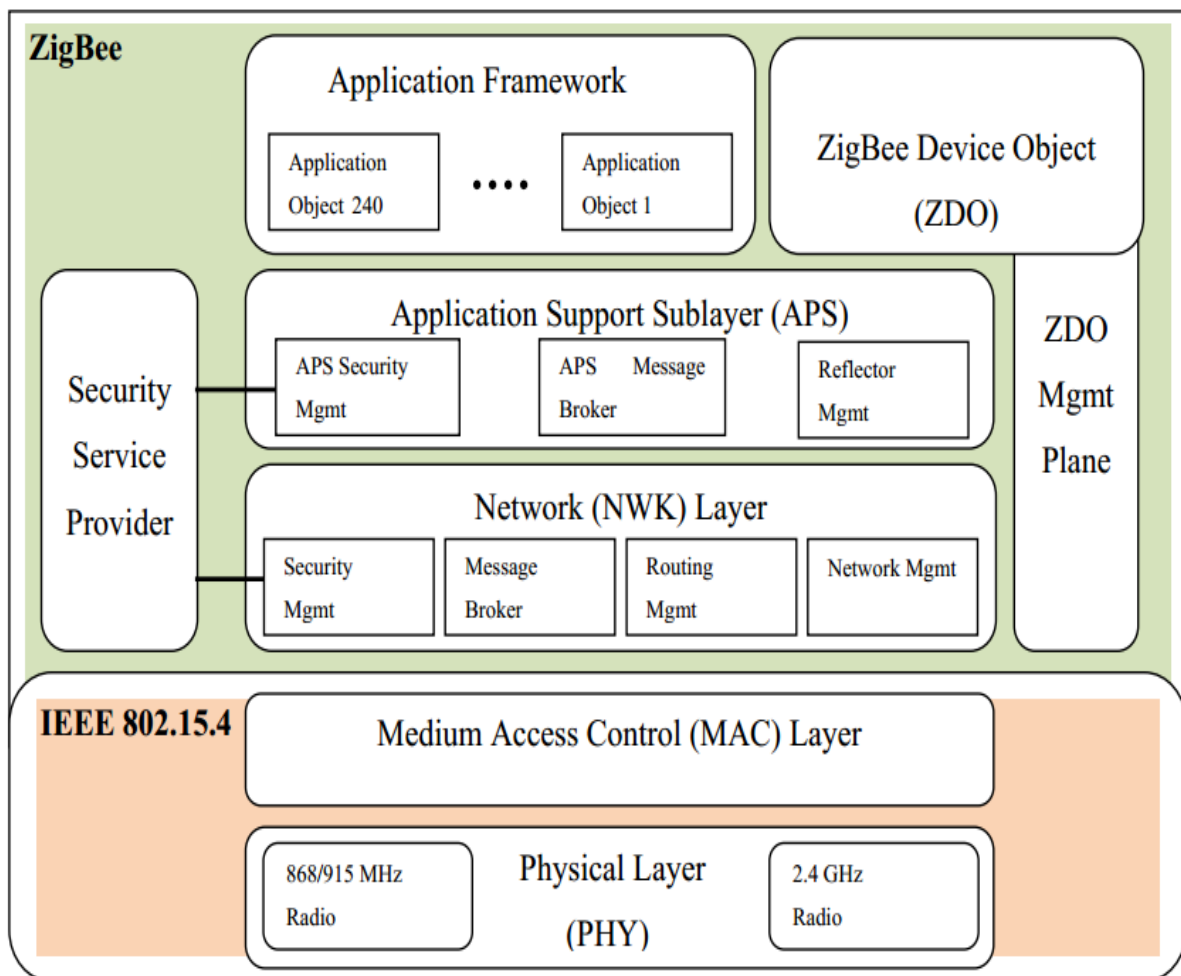


Figure 2. ZigBee protocol stack [10]

- ZigBee Router (ZR): A ZigBee switch has a few possibilities like having the option to hand-off and course messages between both the gadget and the supporting gadget.
- ZigBee End Device (ZED): This kind of gadgets can send their messages to parent gadgets (organizer and switch gadgets), however they are not ready to hand-off or course messages that are produced by different gadgets. Subsequently, these gadgets require less memory and expend less power in contrast with the switch and organizer gadgets. This is on the grounds that they just take into account their own messages and they are not required to be wakeful more often than not. Truth be told, they can rest however much as could be expected to spare vitality and henceforth increment battery life. The transmission of ZigBee is inside a scope of 10–100 m, contingent upon the yield control and the ecological attributes.

To put it plainly, ZigBee is an ease, low-fueled, low-rate, and short-went WPAN innovation. With respect to the ZigBee radio, it works in the ISM recurrence band. This recurrence band ranges at 686 MHz, 915 MHz, and 2.4 GHz, and supports information paces of 20 kbps, 40 kbps, and 250 kbps individually. Security at Link and Network layers are being upheld as well. Systems administration topologies that incorporate star, bunch tree, and work up to 64K (65536) hubs are permitted in a solitary system. ZigBee depends on IEEE 802.11.4 MAC and PHY norms. Despite the fact that they are exceptionally upgraded for control utilization, low information rate is a significant disadvantage of ZigBee [14].

WiFi-IEEE 802.11

WiFi (or Wi-Fi) is a Wi-Fi Alliance controlled by wireless local area network (WLAN), a radio technology that is high in power and speed. Wireless products certified by WiFi are of IEEE 802.11 standards. Even though WiFi covers most of the IEEE 802.11 standards that includes 802.11a, 802.11b, 802.11g, and 802.11n, as for comparison purpose, we will only talk about IEEE 802.11b-based WiFi, which is in the 2.4 GHz ISM band.

Two types of networking topologies are supported by WiFi as follows:

- Access point-based topology: An Access Point (AP) enables client devices to communicate with each other as depicted in Figure a-2.9.
- Peer-to-Peer (ad-hoc) topology: Communication between the devices (peers) is done directly with each other known as ad hoc network as illustrated in Figure b-2.9.

WiFi makes use of Direct Sequence Spread Spectrum (DSSS) radio technology. This is to prevent interference from other wireless technologies like the 2.4GHz ZigBee and Bluetooth which are co-located on the 2.4 GHz ISM frequency band [4].

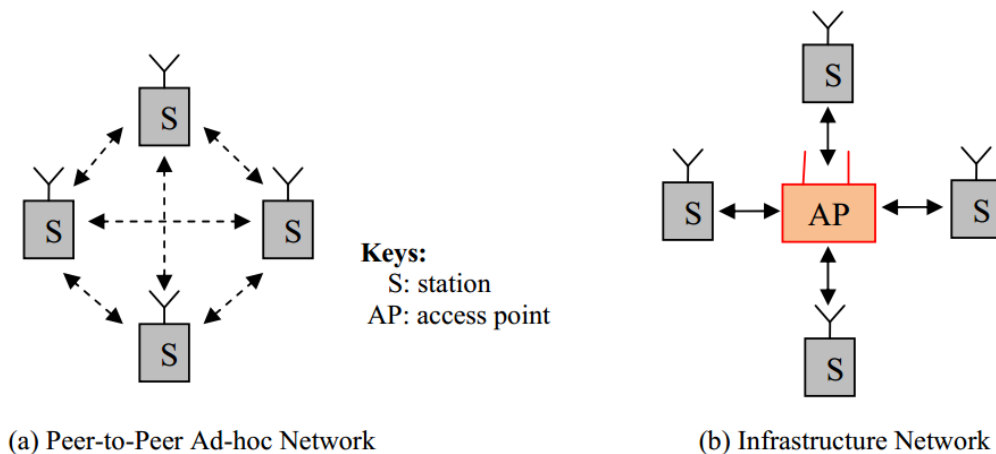


Figure 3. Examples of two possible types of Wi-Fi [11]

WLAN networks are protected as WiFi gives priority to authentication and encryptions. “Suppressing SSID” and “Mac Address Filtering” are some of the techniques usually used to prevent unauthorized access, eavesdropping, and snooping to the WLAN networks. Wire Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA) are two major encryption algorithms supported by WiFi compatible product. IEEE 802.11b uses the CSMA/CA media access method as in the original 802.11 standard with the highest data rate of 11 Mbit/s. In reality, the 802.11b application can achieve a maximum of 5.9 Mbit/s using TC band 7.1 Mbit/s using UDP. WiFi consumes more power and energy compared to WPAN technologies like ZigBee and Bluetooth. Weeks of battery life are not feasible for WBAN sensor devices as the WiFi consumes five times more power than Bluetooth. Another setback of WiFi is the heavyweight and complex protocol stack that needs extra resources in the form of memory and processing speed. This may not be available in a normal WBAN sensor node [12]. In short, WiFi, which is a high-powered, high-speed WLAN technology operates in the unlicensed ISM frequency band and have a theoretical maximum throughput based on IEEE 802.11bps. The data rate of 11 Mbps also supports the ad hoc and infrastructure-based network besides the Link-layer security (encryption and authentication). The two setbacks faced by WiFi from the BAN point of view are the high power consumption and heavy protocol stacks [13].

Medical implant communication service

Medical implant communication service (MICS) is a short distance standard used to obtain signals from

different sensors on the body in a multi-hop structure. It is specially designed for communication in WBAN. It has very low power radiation, thus, making it the most appropriate sensors used in the human care monitoring system [14]. Studies by [15] show that used standards like ZigBee or Bluetooth do not comply with medical standards because of their size, power consumption, and strong interference from other devices. The systems become quite bulky, as patients need to carry with them about hundred sensors attached to their body.

As a result, Federal Communications Commission (FCC) and European Telecommunications Standards Institute (ETSI) from the USA and other countries have come up with a new MICS. The MICS, at 402–405 MHz with 300 KHz channels, enables wireless communication of medical devices delivering high level comfort, mobility, and better care for the patient. The frequencies have propagation characteristics that are suitable for the transmission of radio signals within the human body. At the same time, they do not pose significant risk of interference to other radio operations using the same band. The MICS is an ultra-low powered, unlicensed, mobile radio service that transmits data to support diagnostic or therapeutic functions related to implanted medical devices. The MICS band allows individuals and medical practitioners to make use of ultra-low power medical implant devices like the cardiac pacemakers and defibrillators, without interfering with other electromagnetic radio spectrum users [16].

2.2. Comparison of the candidate short-range wireless technologies

This section provides an overview of the candidate's wireless technologies. This excludes the UWB and MICS, which have been discussed earlier. Table 3 shows that the IEEE 802.11b WLAN technology has higher power consumption and require higher system resources, like memory etc., to implement the protocol stack. Therefore, it is not a suitable choice for BAN applications. In this aspect, the WPAN technologies, namely, Bluetooth and ZigBee are better suited for battery-powered body sensor networks. However, ZigBee's faster, flexible, and scalable networking features enable it to score better than Bluetooth. To add, it consumes less energy, processing, and system resources besides supporting standard-based security.

Table 3. Overview of the standard wireless options for intra-BAN communications [11]

	WiFi IEEE 802.11b	Bluetooth IEEE 802.15.1	IEEE 802.15.4			
						ZigBee
Application Focus	Web, E-mail, Video	Cable Replacement	Monitoring and Control			
Frequency band	2.4GHz	2.4GHz	2.4GHz (Global)	915MHz (US)	868MHz (EU)	
Spectrum Spreading (SS)	DSSS	Frequency Hopping (FHSS)	Direct Sequence Spread Spectrum (DSSS)			
#channels/schemes	11(US), 13(EU)	10	16	10	1	
Max Data Rate	11Mbit/s	1Mbit/s	250kbit/s	40kbit/s	20kbit/s	
Range (meters)	1 - 100	1 – 10+	1 – 100+			
Network Topology	Star, peer-to-peer	Star	Star, peer-to-peer			+ mesh
Network Size	32	8	64K			
Network join time	<3s	<10s	<<1s			
Real-time support	No	No	Guaranteed time slots			No
Protocol complexity	Medium	High	Simple			Low
System resources	1MB+	250KB+	4KB – 32 KB			
Security	Authentication, encryption	Authentication, encryption	Authentication, encryption			
Power consumption	400-700mW	200mW	60-70mW			
Battery life (days)	0.5 - 5	1 - 7	100 – 1000+			
Success metrics	Speed, Flexibility	Cost, Convenience	Reliability, Power, Cost			

It is noticeable that with ZigBee, battery life is feasible for weeks, months and even years, primarily since ZigBee is based on the physical and MAC protocols of IEEE 802.15.4, which are highly optimized for low power. In addition, ZigBee devices spend most of their time in sleep mode or power-down mode and this reduces power consumption and consequently yields a longer battery life [17]. As a summary, can conclude

that among the options shown in Table 2.5, ZigBee is the best choice for WBAN application.

2.3. Long-range WBAN communications

This type of Wireless Technologies used for Extra-BAN like Cellular mobile communication systems that are widely used worldwide, and devices like cellular phones, smart box and laptops have already utilized their services. Many standard technologies have been developed and already in use, namely, Global System for Mobile communications (GSM), the General Radio Packet Service (GPRS), EDGE, CDMA-2000, WCDMA, and 3G UMTS. These systems are commonly known as Wide Area Networks (WANs) as they usually cover a large geographical space and offer valuable services that include voice, data and multimedia, to many subscribers within their geographical coverage. They also represent backbone networks for other types of smaller networks like WSN, PAN, and WBAN. The WBAN systems can provide a range of useful services like real-time monitoring of body parameters (such as heart rates, glucose levels, and blood oxygen saturation) and provide direct feedbacks to their users via graphical user interface (display or LCD), or vocal user interface (e.g. speaker). By interconnecting WBAN with other existing public networks like cellular mobile networks and the Internet, the possibilities and applications of WBAN systems will become almost endless [18]. Examples of such applications include remote monitoring of patients, elderly people, athletes, or soldiers via the Internet. Another similar example is a situation where a patient suffering from chronic disease such as heart attack and diabetes using medical sensors of WBAN systems (like ECG and glucose sensor). The system can alert hospitals or caregiver if abnormality (e.g. heart rate exceeded a predefined threshold or insulin level declined) is detected via SMS if it is connected to mobile phone networks. The most popular standard long-range wireless communication technology that popular use currently are: GSM, GPRS, EDGE, and UMTS [19]. The next section explains in detail the different between them.

2.4. Comparison of the long-range wireless technologies

Table 4 provides an overview of the standard wireless mobile communication technologies that came into consideration for WBAN-based remote monitoring applications.

Table 4. Overview of different standard wireless options for extra-BAN communications [11]

Technology	GSM	GPRS	EDGE	UMTS
Properties				
Generation	2G	2.5G	2.75G	3G
Frequency band	850 900 1800 1900 MHz			1885-2200 MHz
Radio access technique	TDMA			CDMA
Modulation	GMSK		GMSK and 8PSK	QPSK
Type of data service	Circuit-based (CSD and HCSD)		Packet-based	
Theoretical max data rate	CSD: 9.6kbps HCSD: 57.6kbps	160kbps (with 8 time slots and CS-4)	384kbps	14.4Mbps (with HSPDA)
Effective max data rate	CSD: 9.6kps HCSD: 57.6kbps	56kbps	180kbps	2Mbps (with HSPDA handset)
Power consumption	Low	Low	Low	High
Battery Life	Very good due to simple protocol, good coverage and mature, power-efficient chipsets.			Lower due to high demands of WCDMA power control and young chipsets.
Latency	Very low and nearly fixed	Very high and dynamic	High and dynamic	Low but dynamic
Connection setup	Costly (up to a minute)	Nearly instantaneous		

Table 5 shows the comparison of a brief overview of the communication technology in WBAN, this study covers almost type of communication waves used in the WBAN system. However, many challenging tasks should be further addressed to make this technology affordable, robust, secure, and easy to use.

Table 5. Wireless technologies used in medical monitoring [11]

	MICS	WMTS	UWB (802.15.6)	IEEE 802.15.4 (ZigBee)	IEEE 802.15.1 (Bluetooth)	WLANs (802.11b/g)
Frequency band	402-405 MHz	608-614, 1395-1400, 1429-1432MHz	3-10 GHz	1.4 GHz (868/915MHz Eur./US)	2.4 GHz	2.4 GHz > 11 Mbps
Bandwidth	3 MHz	6MHz	>500 MHz	5 MHz	1 MHz	20 MHz
Data rate	19 or 76 kbps	76 kbps	850 kbps to 20Mbps	250 kbps (2.4 GHz)	721 kbps	
Multiple access	CSMA / CA, Polling	CSMA / CA, Polling	Not defined	CSMA / CA	FHSS/GFSK	OFDMA,CS MA/CA
Trans power	-16dbm (25 μ W)	\geq 10dbm and <1.8 db	-41 dBm	0 dBm	4,20 dBm	250mW
Range	0-10	> 100 m	1,2 m	0-10 m	10,100 m	0-100 m

3. Analysis communication technology in WBAN

In WBAN communications, the human body is an important part of transfer process, for that must choose the suitable wave band in communication. Wireless networks can serve as a communication medium with in-body nodes, e.g., pacemakers. Because of the very specific channel inside the human body and the very high demands with respect to energy efficiency. Generally, there are two main types of communication technologies use in WBAN system known as short-range and long-range communication waves. The main different between short-range and long-range communication waves are speed transfer data, data rate, power consumption, require system resources, supporting or not support standard-based security, networking topologies, geographical coverage, cost, bandwidth, throughput, latency and frequency band. Short-range communication standard within approximately 10 m and a data rate of 3 Mbps. Its high bandwidth and low latency features have promoted its use in health care. Besides, it is evident that it supports many mobile platforms. However, due to its high-power consumption, it is avoided in health care monitoring applications. Additionally, it is found to be suitable for latent and bandwidth-sensitive scenarios. The recommended Short-range WBAN Communication that recently used in WBAN system are IEEE 802.15.1 (Bluetooth), Ultra-Wideband– IEEE 802.15.3, ZigBee – IEEE 802.15.4, WiFi – IEEE 802.11 and Medical Implant Communication Service (MICS) band.

IEEE 802.15.1 (Bluetooth) is short-range communication standard within approximately 10 m and a data rate of 3 Mbps, its high bandwidth and low latency features have promoted its use in health care. Besides, it is evident that it supports many mobile platforms. However, due to its high-power consumption, it is avoided in health care monitoring applications. Additionally, it is found to be suitable for latent and bandwidth-sensitive scenarios. Additionally, it is found to be suitable for latent and bandwidth-sensitive scenarios. Bluetooth devices are divided into three different categories. This is dependent on their ability to transfer a maximum range of power, which at the same time determines the maximum transmission range of the Bluetooth radio.

IEEE 802.15.3, the standard name given to UWB technology for PAN applications, operates in 2.4GHz ISM band and aims at an RF front-end and baseband processor optimized for short-range transmission. It exhibits a current drain of less than 100 mA and a small form factor for integrating into consumer devices. In comparison to WLAN (IEEE 802.11) and Bluetooth (IEEE 802.15.1), single-carrier PHY is used in UWB (IEEE P802.15.3). This is to reduce complexity and power consumption.

Built on top of the IEEE 802.15.4, based on WPAN as a standard ZigBee – IEEE 802.15.4 is a low-cost, low-powered, low-rate, and short-ranged WPAN technology. As for the ZigBee radio, it operates in the ISM frequency band. This frequency band ranges at 686 MHz, 915 MHz, and 2.4 GHz, and supports data rates of 20 kbps, 40 kbps, and 250 kbps respectively. The Network Layer of ZigBee supports star, tree and mesh topologies. Three types of devices are being defined by ZigBee based on their networking capabilities. Although they are highly optimized for power consumption, low data rate is a major drawback of ZigBee.

WiFi covers most of the IEEE 802.11 standards that includes 802.11a, 802.11b, 802.11g, and 802.11n, as for comparison purpose, two types of networking topologies are supported by WiFi. WiFi consumes more power and energy compared to WPAN technologies like ZigBee and Bluetooth. Weeks of battery life are not feasible for WBAN sensor devices as the WiFi consumes five times more power than Bluetooth. Another setback of WiFi is the heavyweight and complex protocol stack that needs extra resources in the form of memory and processing speed. This may not be available in a normal WBAN sensor node. In short, WiFi, which is a high-powered, high-speed WLAN technology operates in the unlicensed ISM frequency band and have a theoretical maximum throughput based on IEEE 802.11bps.

The last type of Short-range WBAN Communication is Medical Implant Communication Service (MICS), use for short distance and standard used to obtain signals from different sensors on the body in a multi-hop structure. MICS band specially designed for communication in WBAN, for that has very low power radiation, thus, making it the most appropriate sensors used in the human care monitoring system. The compare between MICS band and other Short-range WBAN Communication waves show that used standards like ZigBee or Bluetooth do not comply with medical standards because of their size, power consumption, and strong interference from other devices. The systems become quite bulky, as patients need to carry with them about hundred sensors attached to their body.

The design of the proposed scheme in this thesis uses the MICS band because the most recent studies , Federal Communications Commission (FCC), European Telecommunications Standards Institute (ETSI) and the support of this range in many countries in their working environment to ensure that they do not mix with another wavelength. MICS band work with 402-405 MHz MICS range and 300 kHz channels in wireless communication of medical devices that provide high-level comfort, mobility with better patient care. These frequencies have suitable propagation characteristics within the human body, and they do not cause any significant problems or risks when interfering with the radio signals of the same range.

In other words, the wave of MICS was compared with other waves and was preferred after comparing several research results in selecting the best vector range of data. MICS is a very low, unlicensed mobile radio service that transmits data to support the diagnostic or therapeutic functions of transplanted medical devices. The MICS allows individuals and medical practitioners to take advantage of extremely low-energy medical implant devices such as pacemakers and pacemakers, without interfering with users of the electromagnetic band.

Long-Range Wireless Technologies used for Extra-BAN Communications, these types of communication band are commonly known as Wide Area Networks (WANs) as they usually cover a large geographical space and offer valuable services that include voice, data and multimedia, to many subscribers within their geographical coverage. The most popular standard long-range wireless communication technology that popular use currently like GSM, GPRS, EDGE, and UMTS.

Finally, the analysis part focused on short range communication because the proposed scheme uses this kind, the proposed scheme work in emergency room (in hospital), the future work will be send the patient data outside hospital, that's mean need to use long range communication band.

4. Approach of network performance in WBAN

Network performance can be defined as the measurement Quality of Service (QoS) in transmitting data from the point of transmission to the receiving point. There are several methods use performance analysis metric to measure the performance of the network. These methods vary depending on the nature and design of the network and the area in which it is used [20]. A simulation model can also be designed to test how to efficiently control the transmission of data in a network. the efficiency of network performance in health care applications is one of the most important prerequisites for designing an effective surveillance system [21]. The purpose of any study in network performance of WAN systems to verify the transfer of patient data from sensors on the body to receivers with the least value of possible packet loss, by developing a solution that can reduce the value of packet loss, End to end delay and increase the value of throughput. Recently, most systems focused on the development of solutions to address the problem of slow network and find out what is the main cause of this slow, which may be due to the transmission wave is not suitable for the carrier medium, inefficient devices, the end of the battery device, packet loss during transport or delay, etc. The network response is the main indicator for determining packet loss, End to end delay and throughput and how it affects

network traffic. The throughput that represents the amount of data being sent and received in a time unit determines the amount of packet loss during transport. None of the previous studies have succeeded in proposing an effective scheme that could cover the requirements for effective network performance or the development of the WBAN system capable of sending and receiving vital patient data efficiently [22].

Therefore, there is a need to improve the effectiveness of network performance in addition to improve schemes and waves transfer of WBAN. Need to enhance the performance of the network in WBAN to verify the transfer of patient data from sensors on the body to receivers with the least value of possible packet loss, by developing a solution that can reduce the value of packet loss and increase the value of throughput, relying on confirmation and matching data between the sender and receiver. In this research the approach for measure the network performance is called scheme.

5. Wave propagation of WBAN

One of the considerations in the development of WBAN is the characterization of the electromagnetic wave propagation from devices embedded inside the human body or close to it. A simple packet loss model for WBAN is difficult to be driven into view due to the complex nature of human tissue structure and body shape. Frequency band for implant devices (i.e. MICS) shall be between 402–405 MHz as specified the maximum power limitation for MICS is as bellow [23]:

- European Telecommunications Standards Institute (ETSI): The output power is set to a maximum of 25 uW ERP.
- FCC & ITU-R: The output power is set to a maximum of 25 uW EIRP, which is ≈ 2.2 dB lower than the ERP level.
- The 25 uW limit applies to the signal level outside of the body (total radiating system), which allows for implant power levels to be increased to compensate for body losses.

The radio channel depends on many parameters: body condition and movements, tissue properties, frequency, antenna localization and polarization, surrounding environment, etc. All these parameters will have a different impact on the channel when the human body is moving; antenna orientation and separation changes, direct transmissions and/or multi paths appear or vanish. Subsequently, the WBAN channel exhibits large time-variations superimposing both shadowing and interference effects [24]. Table 2.8 shows the Channel Characterization on-body.

Table 6. Channel characterization on-body [25]

Description	Frequency Band
Implant to implant	402-405 MHz
Implant to body surface	402-405 MHz
Implant to external	402-405 MHz
Body surface to body surface (LOS)	13.5,50,400,600,900MHz 2.4,3.1-10.6 GHz
Body surface to body surface (NLOS)	13.5,50,400,600,900MHz 2.4,3.1-10.6 GHz
Body surface to External (LOS)	13.5,50,400,600,900MHz 2.4,3.1-10.6 GHz
Body surface to External (NLOS)	13.5,50,400,600,900MHz 2.4,3.1-10.6 GHz

6. Conclusion

The antenna is an essential element of WBAN applications for off-body, in-body and on-body communication system. The antenna must be of small size for human body application and must also be put at three layers of

body tissues (skin, fat, and muscle), with relative permittivity and different thickness. In case of antennas placed on the surface or inside the body, it is influenced by its surroundings. It is, therefore, essential to understand the changes in the antenna patterns and other characteristics must also be considered in the scenarios requiring propagation measurements. It is noticed that the form factor of antenna is dependent on the requirements of applications. Different types of antennas are suitable for different applications, e.g. for MICS, a circular antenna is used for pacemaker implant, while a helix antenna is most appropriate for a heart stent or urinary implant [26]. Performance of antennas is greatly influenced by the form factor, which in turn affects the overall system performance. Antennas considered suitable to characterize the human body (i.e. change in body tissues) are designed for measurements of channel model. Antennas used in WBAN communication are categorized into the following type. Electrical antennas are generally used for on-body communications. They are avoided for in-body communications, because, electromagnetic radiations of these antennas are harmful to the tissues and muscles of the body. On-body communications through these antennas do not make any direct contact with the body tissues and muscles, thus it does not result in the heating of tissues. Magnetic antennas are mostly used for in-body and implant communications. These antennas do not overheat the body tissues and is not dangerous to human body unlike electrical antennas. A loop of magnetic field is formed in magnetic antennas, which is within the defined range of the antenna, thus, these can communicate within this range that do not interfere with the body. For wireless communication in WBAN, the human body is not considered an ideal medium for the propagation of signal. Human body consists of materials that contain different dielectric constants, thickness, and impedance, which may not be ideal for communication. Depending on the frequency of operations, the human body may encounter many impairments and losses such as absorption, attenuation, diffraction, etc. [27].

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