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A Comparative Study of Wban Performance Using 802.15.6 and 802.15.4 Standards

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ABSTRACT—WBAN (WIRELESS BODY AREA NETWORK) is a wireless personal area network consisting of a hub (data concentrator) and small sensor nodes that are placed on, in or around the human body. The sensor nodes take measurements of important physiological parameters like temperature, pressure, oxygen saturation etc and relay to the hub from where it can be transferred remotely to doctors for evaluation or to nurses for monitoring the patients. The important requirements of WBAN are 1) need for low consumption of energy since battery powerfor sensor nodes is limited 2) low delay since life threatening scenarios can occur. Various media access methods can be used so that the requirements of WBAN for particular scenarios can be met. One such media access is based on 802.15.6 standard where a superframe is compartmentalized to produce different types of access such as contention access, scheduled access and polling. Another standard that can be used for media accessis 802.15.4 which has contention access and scheduled accessusing guaranteed time slots. In this project we will taking some scenarios which will simulate real life applications and make a comparative study on the performance of the network with respect to energy and delay using these two standards.

Index Terms—Body Area Network, Carrier sense multiple access, Personal area network, Time Division Multiple Access, Wireless Body Area Network.

I. INTRODUCTION

Wireless Body Area Networks (WBANs) are a type of wireless network that has been designed to monitor the physiological and physical conditions of the human body. WBANs are becoming increasingly popular due to their abilityto provide remote health monitoring, personalized healthcare, and improved quality of life for patients. There are several wireless communication standards available for WBANs, in- cluding the IEEE 802.15.4 and IEEE 802.15.6. These two standards have gained significant attention due to their low- power consumption, reliability, and low data rates. The aim ofthis project is to conduct a comparative study of the IEEE 802.15.4 and IEEE 802.15.6 standards over WBANs. The study will compare the two standards based on their features, capabilities, and limitations. It will also investigate the factors that affect the performance of these standards over WBANs, such as transmission range, data rate, and power consumption. Figure 1 represent the position of sensors on the WBAN model.

The findings of this project will be beneficial to researchers, engineers, and healthcare professionals who are interested in using WBANs for remote health monitoring and personalized healthcare. The results of this study will provide insights into the strengths and weaknesses of these standards and will help in selecting the most suitable standard for a given application. Ultimately, this project aims to contribute to the development of better healthcare systems that leverage wireless technologies to improve patient outcomes.

This paper Evaluate and compare the two IEEE standards 802.15.4 and 802.15.6 over a WBAN with a given configura- tion and to select the standard that is suitable for a particular configuration.

In this work, first section is the introduction section which explains the general background of the thesis. Literature survey along is described in the second section. Third section gives the ideas on the problems identified. Methodology of the proposed system including the requirements and design, is discussed in the fourth section . Implementation along with the advantages of the proposed system is explained in the fifthsection. After the conclusion is discussed.

II. LITERATURE SURVEY

A. WBAN

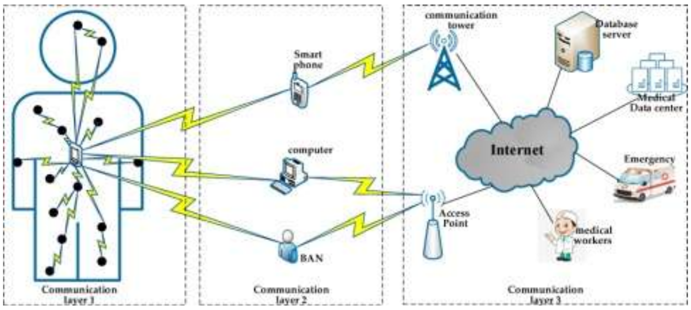

Fig. 1. WBAN model

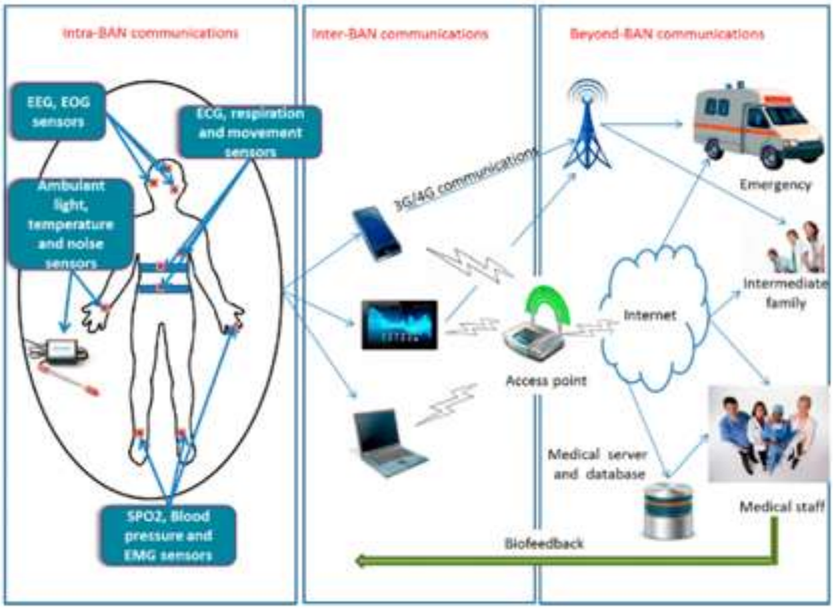

Fig. 2. WBAN architecture for medical applicatons

A Wireless Body Area Network (WBAN) connects inde- pendent nodes (e.g. sensors and actuators) that are situated in the clothes, on the body or under the skin of a person. The network typically expands over the whole human body and the nodes are connected through a wireless communication channel. According to the implementation, these nodes are placed in a star or multihop topology. A WBAN offers many promising new applications in the area of remote health mon- itoring, home/health care, medicine, multimedia, sports and many other, all of which make advantage of the unconstrained freedom of movement a WBAN offers. [1] In the medical field, for example, a patient can be equipped with a wireless body area network consisting of sensors that constantly measure specific biological functions, such as temperature, blood pres- sure, heart rate, electrocardiogram (ECG), respiration, etc. Theadvantage is that the patient doesn't have to stay in bed, but can move freely across the room and even leave the hospital for a while. This improves the quality of life for the patient and reduces hospital costs. In addition, data collected over a longer period and in the natural environment of the patient, offers more useful information, allowing for a more accurate and sometimes even faster diagnosis. . Medical Application diagram of WBAN is presented in Fig. 2.

B. WBAN communication protocols

WBANs (Wireless Body Area Networks) are a type of wireless network that allows the connection of multiple sen- sors and devices on and around the human body. There are several communication protocols that can be used in WBANs,including:

- IEEE 802.15.4: This protocol is commonly used in low- power, low-data-rate applications such as home automa- tion and industrial control. It operates in the 2.4 GHz frequency band and supports a star and peer-to-peer topology. It has low power consumption, making it suitable forWBAN applications.

- IEEE 802.15.6: This protocol is specifically designedfor WBANs and is optimized for low-power, short-range communication between medical devices and sensors. It operates in the 2.4 GHz and medical implant commu- nication service (MICS) frequency bands and supports multiple network topologies. It also has several security features that are essential for medical applications.
- Bluetooth Low Energy (BLE): This protocol is commonly used in short-range wireless communication between de- vices. It operates in the 2.4 GHz frequency band and has low power consumption, making it suitable for WBAN applications. It supports both star and mesh topologies.
- Zigbee: This protocol is used in wireless sensor networks and is based on IEEE 802.15.4. It operates in the 2.4 GHz frequency band and supports star, peer-to-peer, and mesh topologies. It has low power consumption, making it suitable for WBAN applications.
- Ultra-Wideband (UWB): This protocol is used in short- range wireless communication and operates in the 3.1 to 10.6 GHz frequency band. It has a very high data rate and supports peer-to-peer and mesh topologies. However, it has higher power consumption than other protocols

Wireless body area networks are a type of wireless network used for monitoring and communicating physiological data from sensors attached to the body. The IEEE 802.15.4 standardis often used for WBANs due to its low-power and low-data- rate capabilities.

C. IEEE 802.15.4 MAC Specifications

The IEEE 802.15.4 is a wireless standard introduced for low power, low cost wireless communication with moderate data rates. In the next few years, it is expected that Low Rate Wireless Personal Area Networks (LR-WPAN) will be used in a wide variety of embedded applications, including home automation, industrial sensing and control, environmen- tal monitoring and sensing. In these applications, numerous embedded devices running on batteries are distributed in an area communicating via wireless radios. This work presents a method which can be used for comparing current consump- tion of wireless data transfer embedded systems. This paper implements a small subset of the IEEE 802.15.4 protocol to achieve a point to point communication. The implemented protocol uses 802.15.4 MAC compliant data and acknowledgment packets. Current consumption is measured while doing one data packet transmission. Measurements are compared with existing work. IEEE 802.15.4 protocol implementation is done using Verilog language. Code implementation is done in such a manner so that it can be ported to any platform with minimal changes. It can also be modified to suit any special experimental setup requirements. [5]

In the IEEE 802.15.4 standard, two different operational modes are distinguished: the non-beacon enabled mode, and beacon enabled mode. According to [**?**], the first mode is suitable for sensors that usually like to sleep for most of the time and it does not provide any guarantees for data trans- missions. Hence, it is not suitable for the medical applications of WBAN. In the second mode, The IEEE 802.15.4 defines a superframe structure, which consists of two basic periods including active and inactive periods. The active period can be further divided into a contention-access period (CAP) and an optional contention-free period (CFP). In the CAP, nodes deliver content for the channel using the slotted CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance), while CFP mode works in TDMA (Time Division Multiple Access) manner where the coordinator node can assign up to seven guaranteed time slots (GTS) to a request node.As shown in figure 2.

D. Frame Structure

The frame structures have been designed to keep the com- plexity to a minimum while at the same time making them sufficiently robust for transmission on a noisy channel. Each successive protocol layer adds to the structure with layer-specific headers and footers. [4] This standard defines four frame structures:

- Beacon Frame, used by a coordinator to transmit beacons.
- Data Frame, used for all transfers of data.
- Acknowledgment Frame, used for confirming successful frame reception.
- MAC Command Frame, used for handling all MAC peer entity control transfers.

IEEE 802.15.4 is a wireless communication standard that provides several advantages, including:

- Low power consumption: It is designed for low power devices and has a low data rate, making it ideal for battery-powered IoT devices.
- Low cost: The standard uses low-cost radio transceivers, making it accessible for budget-conscious applications.
- Simple implementation: The standard provides a simple and reliable communication layer, making it easy to implement and deploy.
- Robust security: The standard includes features such as encryption and authentication, ensuring secure communi- cation between devices.
- Wide area coverage: The standard supports both personal and mesh networks, providing coverage over large areas.
- Interoperability: The standard is widely used and provides compatibility with many different devices, making it possible to build large-scale networks.

E. IEEE 802.15.6 MAC Specifications

In the IEEE 802.15.6 standard, three different operational modes are specified: beaconed mode with superframe, non- beaconed mode with superframe and nonbeaconed mode with- out superframe. The first mode is the most used in medical applications as it makes the network more reliable and more energy efficiency. As shown in Fig.2.3, the superframe used in this mode is delimited by two beacons. At the beginning of each superframe we find a beacon followed by two successive periods. Each period contains three sub-periods: Exclusive

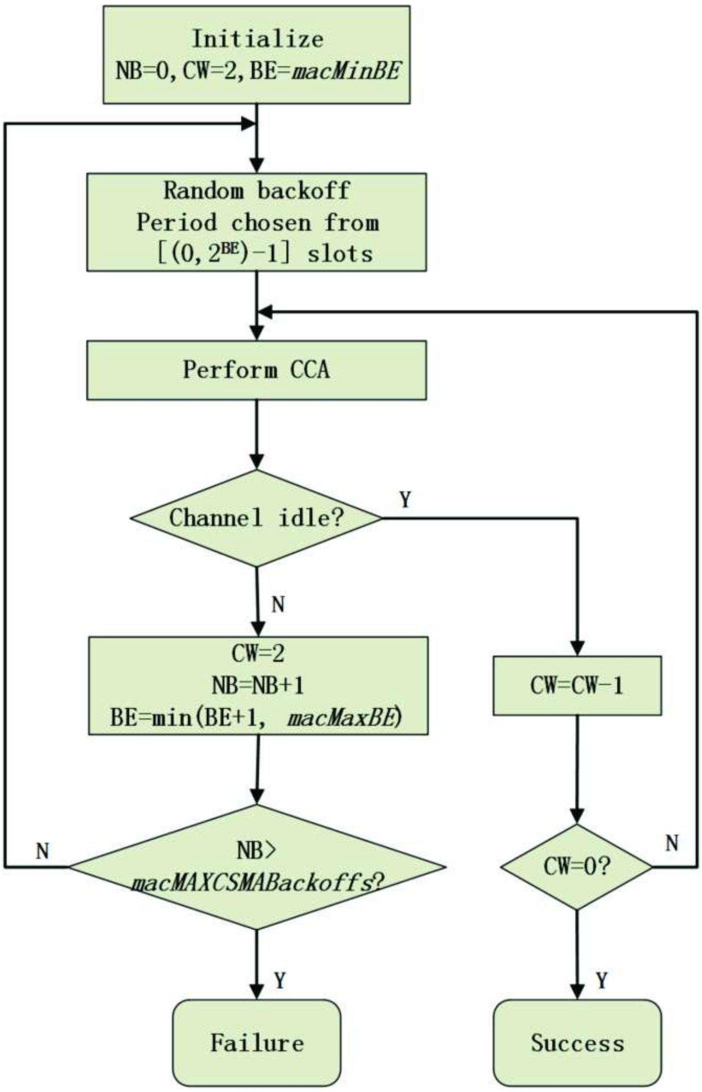

Fig. 3. CSMA/CA algorithm

(EAP), Random (RAP) and Managed Access Phases (MAP, also called Type I / II) consecutively. After these two periods, we can have an optional beacon B2 before the start of theCAP EAP periods are reserved for high priority traffic such as emergency messages. The RAP and CAP periods are reserved for regular traffic, whilst the Type I / II periods are provided for reservation of transmission periods or transmission of unplanned traffic. [7]

F. CSMA/CA algorithm

The CSMA/CA (Carrier Sense Multiple Access with Col- lision Avoidance) algorithm is a protocol used to access the wireless medium in wireless communication networks. The standard defines two types of CSMA-CA algorithms: slotted and unslotted. Slotted CSMA-CA is used when a superframe structure is used in the PAN, whereas unslotted CSMA-CA is used when beacons are not being used or cannot be located in a beacon-enabled network. The algorithm is implemented using units of time called backoff periods, which is equal to aUnitBackoffPeriod symbols. [8]

Each device in the network has 3 variables: NB, CW, and BE, which determine the number of times the device backs off before attempting to transmit data frames. The contention window length (CW) defines the number of backoff periods that need to be clear of activity before transmission can start. In slotted CSMA-CA, the backoff periods of each device are synchronized with the superframe slot boundaries of the PAN coordinator. On the other hand, unslotted CSMA-CA allows for asynchronous backoff periods. The CSMA-CA algorithm involves steps to initialize variables and locate the boundary ofthe next backoff period. The algorithm also involves assessing the channel to determine if it is idle or busy. If the channel is busy, the device increments NB and BE and waits for a random number of complete backoff periods before requesting a clear channel assessment (CCA). If the channel is idle, the device decrements CW and starts transmission on the boundary of the next backoff period (in slotted CSMA-CA) or immediately (in unslotted CSMA-CA). Figure 3 represent CSMA/CA algorithm.

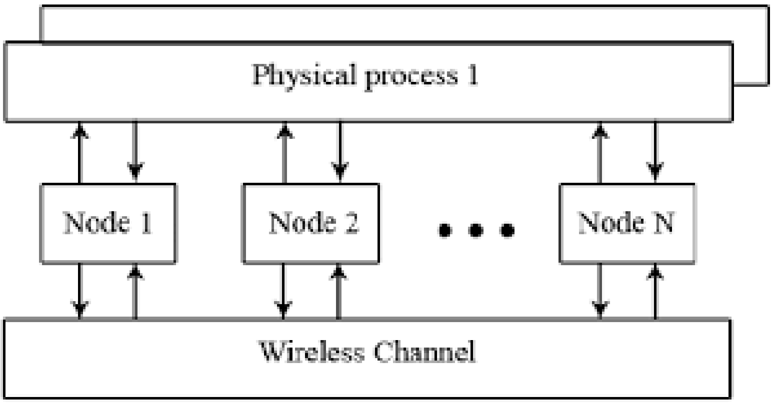

Fig. 4. Castalia-node-architecture

G. Castalia

Castalia is a simulator for Wireless Sensor Networks (WSN), Body Area Networks (BAN) and generally networks of low-power embedded devices. It is based on the OMNeT++platform [4]. Castalia can be used to evaluate different plat- form characteristics for specific applications, since it is highly parametric, and can simulate a wide range of platforms.

Figure 3 represents the node architecture for Castalia. Castalia incorporates an advanced channel model based on empirically measured data collected on real body movements (simulates real like environment).It has a complex model for path loss that varies with time known as the Temporal Variations of Path Loss or Temporal Model. Temporal model bridges the gap between simulations in an ideal and real environment. It consists of a path loss model for various activities such as walking and running. Without this temporal model, the nodes will behave ideally i.e. the nodes are static as they won't have any temporal variations. Temporal Variations help to test a protocol in real scenarios where the nodes arenot static. Due to this temporal behavior the availability of nodes varies with time. If the packet rate is low this temporal behavior will not affect the performance of overall system due to re transmission mechanisms but however if the packet rate is high, the re transmission mechanism might not be able to compensate for the loss incurred by the temporal behavior in the same time frame. Layered Architecture in Castalia ensures that all functionalities are at least divided in basic layers i.e. Application Layer, Routing Layer and MAC Layer. Now whena packet has to be sent out to the wireless channels in Castalia,the packets flow from the upper layers to the lower layers and finally sit in the MAC buffers. When a node gets its turn to transmit in the media, the packets from the buffers are released into the media and only after its successful transmission tothe intended destination and reception of acknowledgment by the intended destination, the transmitted packets are removed from the MAC buffers and MAC buffers are filled with newer packets. In case if the packets are not transmitted successfully, the same packets from MAC buffers are re transmitted toensure reliability.

H. Wireless Body Area Network with Castalia

- The simulation methods were used to validate and design a Wireless Body Area Network device.
- For monitoring symptoms in human blood using body sensors in WBAN.
- Wearable devices (Smart Watches) transmit the sensing data to the hub node and it passes the data to the coordinator of the body. Using communication standards are,
- Baseline MAC(IEEE 802.15.6)
- ZigBee MAC (IEEE 802.15.4)

III. PROPOSED METHOD FEATURES CONSIDERED FOR EVALUATION

A. Life time of the nodes

Wireless Sensor Networks are composed of thousands of tiny sensor nodes, where each sensor node is equipped with limited storage, power and processing capabilities. Sensor nodes are densely deployed in unattended environment. Nodes"sense" the environmental phenomenon and send the signalsto the data collection center known as "base station". Since recharging of batteries of these nodes is not possible so it highly recommended to design energy efficient protocols for these networks. Additionally to send the data to the sink multihop communication is also needed. If base station and sensor nodes are not in the range of each other than they need some intermediate nodes to relay their message to the base station. [8] For normal nodes active or idle, lifetime is only 2.5 daysfor battery capacity of 560 mAh.

B. Average application latency

Latency can be a critical issue in Wireless Body Area Networks (WBANs) in the health sector, particularly in ap- plications that require real-time monitoring or control. High latency can cause delays in transmitting data, which can result in inaccurate or delayed diagnosis and treatment, and can even lead to serious medical consequences.

For example, in a WBAN-based cardiac monitoring system, high latency can result in delayed detection of arrhythmia or other cardiac events, which can lead to delayed treatment and potentially life-threatening consequences. In a WBAN-based insulin delivery system, high latency can result in delayed or inaccurate insulin dosing, which can lead to hypoglycemia or hyperglycemia. Several factors can contribute to latency in WBANs, including network topology, channel interference, transmission range, and the MAC protocol used. Therefore, it is essential to design and optimize WBANs for low latency in the health sector.
This section presents the performance and comparison of the two protocols such as IEEE802.154 and IEEE802.156.

TABLE I
LIFETIME AND PRIORITY OF NODES

PRIORITY OF NODES	LIFETIME
5	69.89
6	69.89
7	69.89

$$\text{PathLoss} = 10\log(d) + 10\log(f) + A \qquad (1)$$

C. Pathloss

Path loss is a phenomenon that occurs in wireless com- munication, which results in the attenuation of signal power as it propagates through the wireless medium. The path loss is influenced by several factors such as distance, frequency, terrain, obstacles, and environmental conditions. In the case of wireless networks like

802.15.4 and 802.15.6, path loss isa crucial factor that needs to be considered in designing and deploying the network. Pathloss can be calculated using the equation given in 3.2. where d is the distance between the transmitter and the receiver, f is the frequency of the signal, and A is the path loss exponent.

Assuming that the nodes are using carrier sense multiple access with collision avoidance for medium access. Castalia simulator is based on IEEE 802.15.6 standard with super- frames separated by beacons transmitted by the sink.

IV. ASSUMING THE FOLLOWING PARAMETERS FORSIMULATION;

A. 802.15.6 WBAN No path loss

1) Simulation results, Lifetime and Average applicationlatency:

- Node 0 - hub
- EAP = 42 slots , RAP = 78 slots
- Nodes 1, 2, 3, 4, 5, 6, 7 priority 7 nodes
- EAP and RAP using CSMA.
- Data rate = Bernoulli with average rate of 2 packets/sec.
- Nodes 8, 9, 10, 11, 12, (priority 6 nodes) RAP using CSMA, Data rate = constant bit rate of 5 packets/sec.
- Nodes 13, 14, 15 (priority 5 nodes) RAP only usingCSMA
- Data rate = Bernoulli with average rate of 2 packets/sec.

Table 3.1 represents the Lifetime of IEEE802.156 with respect to priority of nodes and figure 3.1 represents the corresponding lifetime configuration. Table 3.2 represents the average application latency of IEEE802.156 with respect to priority based nodes and figure 3.2 is the corresponding latency configuration.

B. 802.15.6 WBAN with path loss

C. Node 0 - hub

D. EAP = 42 slots , RAP = 78 slots

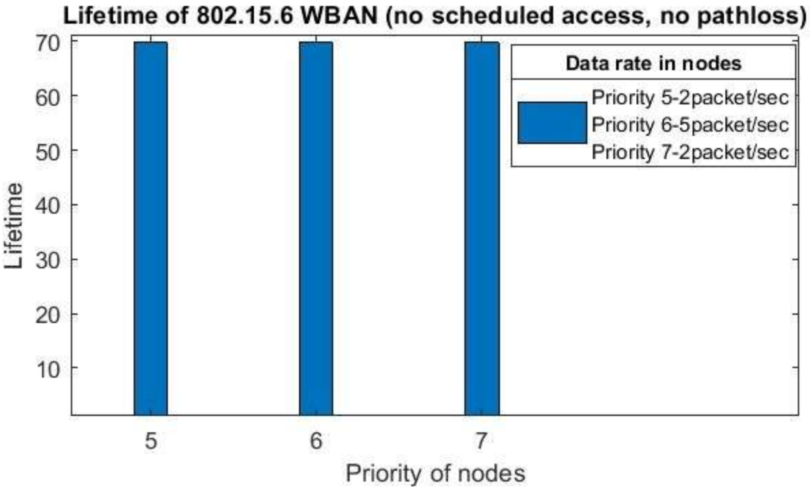

Fig. 5. Lifetime configuration of 802.15.6 WBAN (no scheduled access, nopathloss)

TABLE II
AVERAGE APPLICATION LATENCY OF802.156 WBAN (NO SCHEDULED ACCESS, NO PTHLOSS)

PRIORITY OF NODES	AVERAGE APPLICATION LATENCY
5	1.071
6	1.070
7	1.075

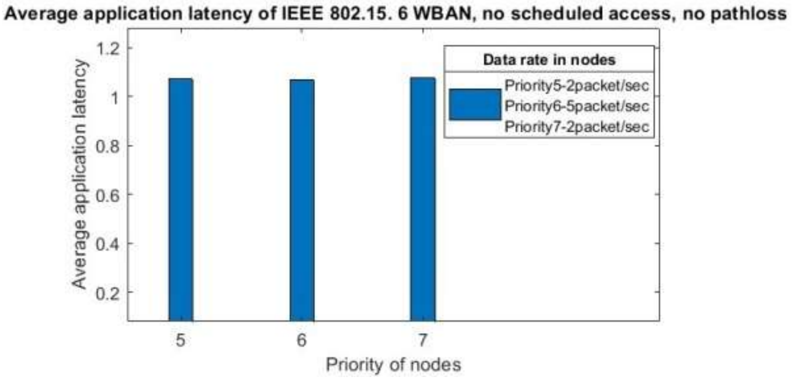

Fig. 6. Average application latency of 802.156 WBAN, no pathloss

TABLE III
LIFETIME OF 802.156, WITH PATHLOSS, NO SCHEDULED ACESS

PRIORITY OF NODES	LIFETIME
5	52.88
6	66.36
7	65.35

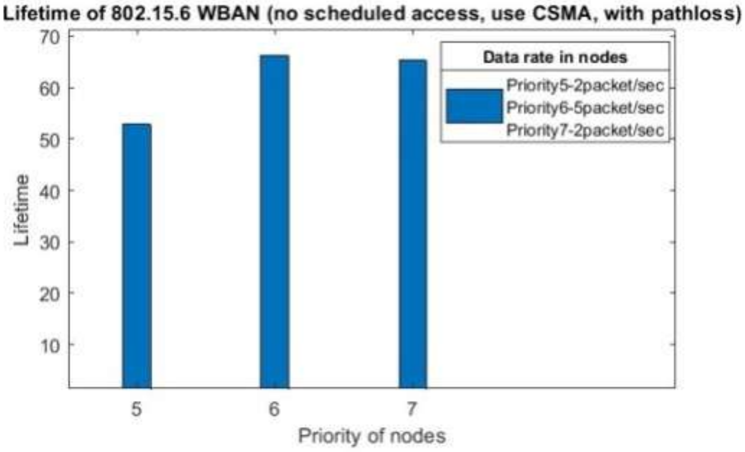

Fig. 7. Lifetime of 802.156, with pathloss,no scheduled access

TABLE IV
VERAGE APPLICATION LATENCY IEEE802.156, WITH PATHLOSS,NO SCHEDULED ACCESS

PRIORITY BASED NODES	AVERAGE APPLICATION LATENCY
5	51.75
6	4.90
7	6.67

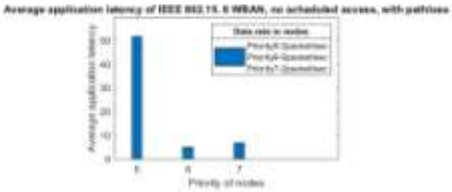

Fig. 8. Average application latency IEEE802.156,with pathloss,no scheduledaccess

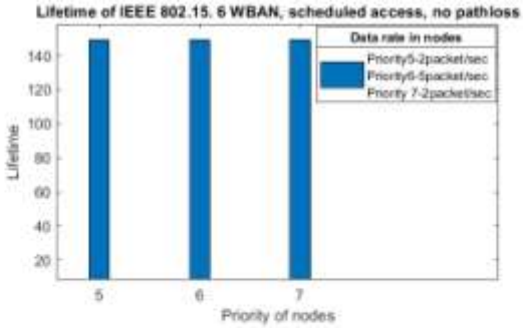

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Fig. 9. Lifetime configuration IEEE02.156, no pathloss, sheduled access

- Nodes 1, 2, 3, 4, 5, 6, 7 (priority 7 nodes) EAP and RAPusing CSMA.
- Data rate = Bernoulli with average rate of 2 packets/sec.
- Nodes 8, 9, 10, 11, 12, (priority 6 nodes) RAP usingCSMA.
- Data rate = constant bit rate of 5 packets/sec.
- Nodes 13, 14, 15 (priority 5 nodes) RAP only usingCSMA.
- Data rate = Bernoulli with average rate of 2 packets/sec

C. 802.15.6 WBAN, No path loss

- Node 0 - hub
- EAP = 42 slots , RAP = 13 slots
- Nodes 1, 2, 3, 4, 5, 6, 7 (priority 7 nodes) EAP and RAPusing CSMA.
- Data rate = Bernoulli with average rate of 2 packets/sec.

TABLE V

LIFETIME OF 802.156 WBAN,NO PATHLOSS,SCHEDULED ACCESS

PRIORITY OF NODES	LIFETIME
5	148.84
6	148.83
7	148.83

TABLE VI

AVERAGE APPLICATION LATENCY IEEE802.156 WBAN,NO PATHLOSS,SCHEDULED ACCESS

PRIORITY BASED NODES	AVERAGE APPLICATION LATENCY
5	20.04
6	19.75
7	19.63

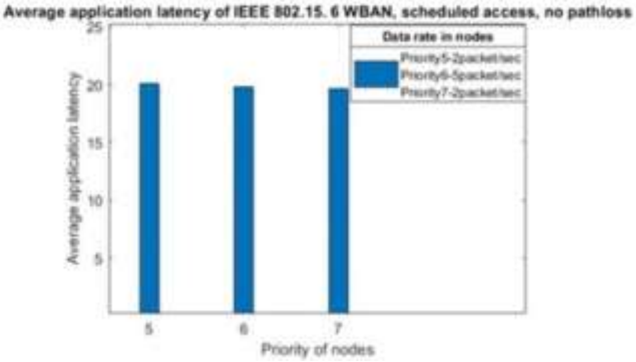

Fig. 10. Average application latency of IEEE80.156 WBAN,no pathloss,scheduled access

TABLE VII
LIFETIME,ZIGBEE(IEEE802.154),WITHOUT PATHLOSS

PRIORITY BASED NODES	LIFETIME
5	386.89
6	383.12
7	383.22

- Nodes 8, 9, 10, 11, 12, (priority 6 nodes) scheduledaccess, 13 slots per node.
- Data rate = constant bit rate of 5 packets/sec
- Nodes 13, 14, 15 (priority 5 nodes) RAP only usingCSMA.
- Data rate = Bernoulli with average rate of 2 packets/sec

D. ZigBee without path loss
- Node 0 - pan coordinator
- Nodes 1, 2, 3, 4, 5, 6, 7 (priority 7 nodes) GTS slots onefor each node.
- Data rate = Bernoulli with average rate of 2 packets/sec.
- Nodes 8, 9, 10, 11, 12, (priority 6 nodes) Slotted CSMA.

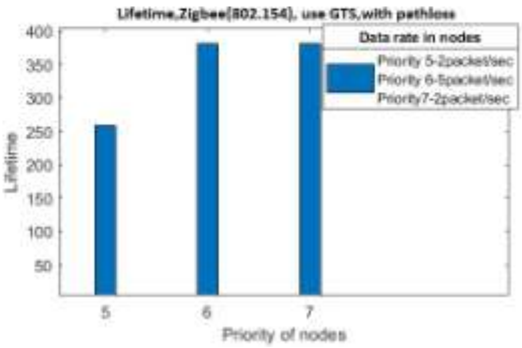

Fig. 11. Lifetime,Zigbee(IEEE802.154),without pathloss

TABLE VIII
AVERAGE APPLICATION LATENCY (ZIGBEE)IEEE802.154,USE GTS,NO PATHLOSS

PRIORITY BASED NODES	AVERAGE APPLICATION LATENCY
5	43.96
6	46.26
7	57.45

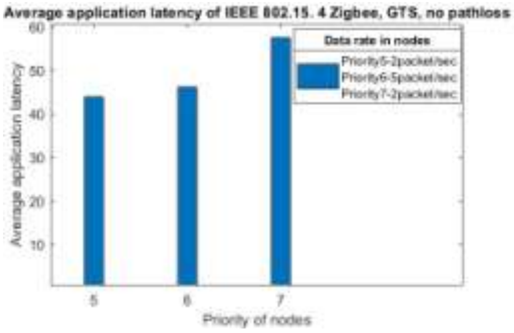

Fig. 12. Average application latency (Zigbee)IEEE802.154,use GTS,nopathloss

TABLE IX
LIFETIME, ZIGBEE(802.154),NO GTS,NO PATHLOSS

PRIORITY BASED NODES	LIFETIME
5	257.43
6	257.39
7	257.39

- Data rate = constant bit rate of 5 packets/sec.
- Nodes 13, 14, 15 (priority 5 nodes), Slotted CSMA.
- Data rate = Bernoulli with average rate of 2 packets/sec.
- No of CSMA slots = 9
- No of GTS slots = 7

E. ZigBee - no path loss and no GTS

- Node 0 - pan coordinator

Nodes 1, 2, 3, 4, 5, 6, 7 (priority 7 nodes), slotted CSMA.

- Data rate = Bernoulli with average rate of 2 packets/sec.
- Nodes 8, 9, 10, 11, 12 (priority 6 nodes) Slotted CSMA

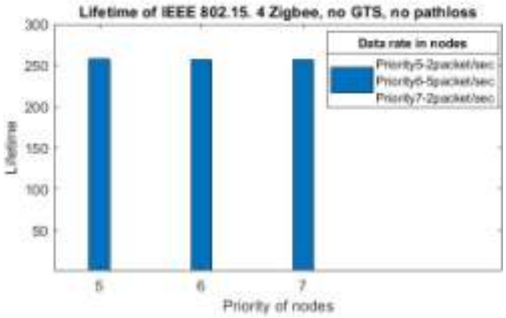

Fig. 13. Lifetime, Zigbee(802.154),no GTS,no pathloss

TABLE X
AVERAGE APPLICATION LATENCY, ZIGBEE(802.154),NO GTS, NO PATHLOSS

PRIORITY BASED NODES	AVERAGE APPLICATION LATENCY
5	44.30
6	44.36
7	44.16

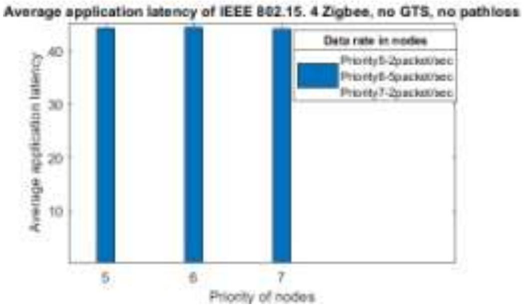

Fig. 14. Average application latency, Zigbee(802.154),no GTS, no pathloss

TABLE XI
LIFETIME ,ZIGBEE(802.154),USE GTS, NO PATHLOSS

PRIORITY BASED NODES	LIFETIME
5	258.45
6	381.22
7	381.46

Data rate = constant bit rate of 5 packets/sec

- Nodes 13, 14, 15 (priority 5 nodes) Slotted CSMA. rate = Bernoulli with average rate of 2 packets/sec.

F. ZigBee with Path loss

- Node 0 - pan coordinator
- Nodes 1, 2, 3, 4, 5, 6, 7 (priority 7 nodes) GTS slots onefor each node.
- Data rate = Bernoulli with average rate of 2 packets/sec
- Nodes 8, 9, 10, 11, 12, (priority 6 nodes) Slotted CSMA.
- Data rate = constant bit rate of 5 packets/sec.
- Nodes 13, 14, 15 (priority 5 nodes) Slotted CSMA.

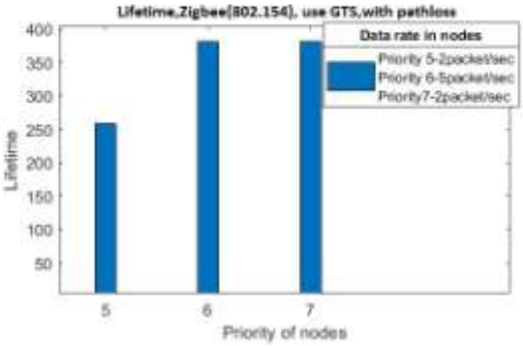

Fig. 15. Lifetime ,Zigbee(802.154),use GTS, no pathloss

TABLE XII
AVERAGE APPLICATION LATENCY,ZIGBEE(802.154),USE GTS, WITH PATHLOSS

PRIORITY BASED NODES	AVERAGE APPLICATION LATENCY
5	99.44
6	48.61
7	57.73

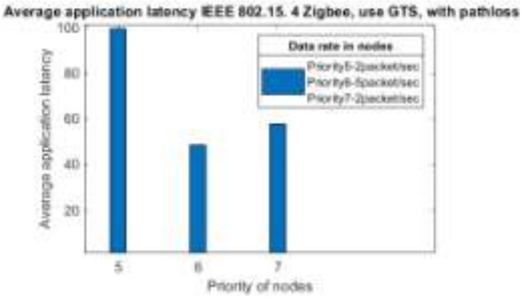

Fig. 16. Average application latency,Zigbee(802.154),use GTS, with pathloss

TABLE XIII
LIFETIME ZIGBEE(802.154),NO GTS, WITH PATHLOSS

PRIORITY BASED NODES	LIFETIME
5	197.96
6	256.52
7	255.14

- Data rate = Bernoulli with average rate of 2 packets/sec.
- No of CSMA slots = 9
- No of GTS slots = 7

V. ZIGBEE WITH PATH LOSS NO GTS

- Node 0 - pan coordinator
- No GTS, full CSMA

- Nodes 1, 2, 3, 4, 5, 6, 7 (priority 7 nodes),slotted CSMA
- Data rate = Bernoulli with average rate of 2 packets/sec
- Nodes 8, 9, 10, 11, 12, (priority 6 nodes) Slotted CSMA.
- Data rate = constant bit rate of 5 packets/sec.
- Nodes 13, 14, 15 (priority 5 nodes) Slotted CSMA.
- Data rate = Bernoulli with average rate of 2 packets/sec.
-

VI. IMPLEMENTATION AND EVALUATION

LIFETIME

IEEE 802.15.4 have a longer lifetime for sensor nodes compared to IEEE 802.15.6, and there are several reasons for this:

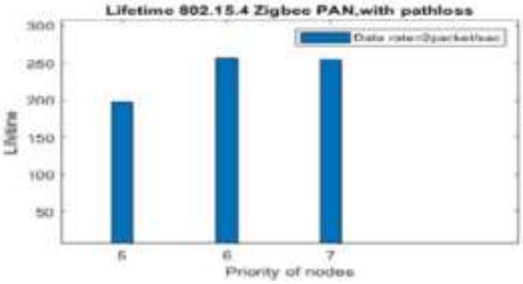

Fig. 17. Lifetime Zigbee(802.154),no GTS, with pathloss

TABLE XIV
AVERAGE APPLICATION LATENCY, ZIGBEE(802.154),NO GTS, WITH PATHLOSS

PRIORITY BASED NODES	AVERAGE APPLICATION LATENCY
5	91.58
6	47.72
7	47..06

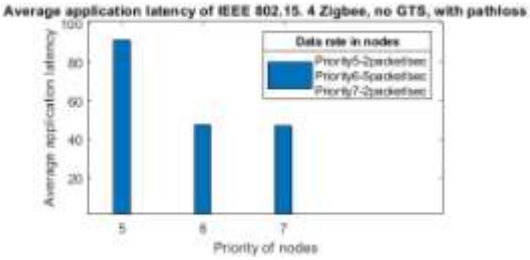

Fig. 18. Average application latency, Zigbee(802.154),no GTS, with pathloss

- Power Consumption: IEEE 802.15.4 is designed to oper- ate at a lower power consumption level compared to IEEE 802.15.6. Sensor nodes using IEEE 802.15.4 can operate for longer periods on a single battery charge, leading to a longer overall lifetime for the node.
- Transmission Range: IEEE 802.15.4 operates at a lower frequency band (2.4 GHz) compared to IEEE 802.15.6 (around 400 MHz). IEEE 802.15.4 has a longer transmis- sion range, which allows sensor nodes to communicate over longer distances, reducing the need for additional nodes, and leading to a longer overall lifetime for the network.

VII. AVERAGE APPLICATION LATENCY

In the case of average application latency in medical appli- cations, IEEE 802.15.6 is better than IEEE 802.15.4. Thereare several reasons for this are:

- Higher Data Rate: IEEE 802.15.6 has a higher data rate than IEEE 802.15.4, which allows for faster transmission of data. This can result in reduced latency for medical applications, where timely delivery of data is critical.
- Low Latency Channel: IEEE 802.15.6 includes

a low latency channel that can be used for critical data trans- mission. This channel is designed to provide low latency and high reliability for time-critical applications, such as medical applications.

VIII. CONCLUSION

The comparative study of IEEE802.15.4 and IEEE802.15.6 over WBAN, in terms of average application latency and lifetime, has revealed that both protocols have their unique advantages and limitations.The project is implemented using Castalia simulator. IEEE802.15.4 has a lower data rate and simpler network topology, which makes it consume less power and results in longer battery life of devices. However, the lower data rate and less optimized protocol structure result in longer average application latency.

On the other hand, IEEE802.15.6 has a higher data rate and more optimized protocol structure, which results in lower aver- age application latency. However, it requires more power and results in shorter battery life of devices. Therefore, the choice of protocol for a particular application depends on the specific requirements of the application. For applications that require low latency, IEEE802.15.6 may be a better choice, while for applications that require longer battery life, IEEE802.15.4 may be more suitable. The study has provided insights into the trade-offs between average application latency and battery life when choosing between IEEE802.15.4 and IEEE802.15.6 protocols for WBAN applications. By considering the specific requirements of the application, researchers and developers can make informed decisions on the appropriate protocol to use in order to optimize the performance of the WBAN.

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