A New Routing Protocols for Reducing Path Loss in Wireless Body Area Network (WBAN)

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***Abstract*—In view of the ever-aging society, recent developments in the field of electronics and telecommunications have witnessed the interest in developing an integrated circuit of enhanced surveillance sensors that can be worn and have an ease of movement to monitor vital signs. The main tasks of these electronic devices are collecting physiological information from the patient's body, sending the information to the medical center via a secure way and ensuring the arrival of this information in a reliable way without any loss of data. This paper proposed a protocol in Wireless Body Area Network (WBAN) to solve the problem of path loss in WBAN. For this purpose, we depend on three sets of scenario applied in OMNET++ environment. The results of proposed solution were compared with RSS path loss factor using three delay and data rate parameters.**

***Index Terms*—WBAN; Path Loss; MICS Band; CCU; Monitoring Health Care Environment; Communication System, Body Area Networks.**

I. Introduction

In the field of healthcare, the application of Wireless Body Area Networks (WBAN) includes both wearable and implantable sensor nodes that sense biological information from human body. This information is transmitted wirelessly to a control device, within short distances [1]. The main problem with WBAN is the loss or corruption of data through the transfer, and this area still needs a new protocol or algorithm to prove the efficiency of receiving full data without any loss. The loss of data is caused by free space impairments of propagating signal, such as refraction, attenuation, absorption, reflection etc. The aim of this study is to analyze and give a solution for the problems of path loss in WBAN so as to provide the requirements related to healthcare in a medical environment [2]. This research provides a clear outlook on the identification of key routing protocols and the problems related to losses and differing of data in a medical environment, thus meeting energy efficiency, low delay and reliability. This study focuses on the analysis of the identification of key algorithm protocols. The discussion includes the frame rate analysis, the algorithm utilization and throughput of the monitoring system [3]. The analysis includes the (CUU) Central Control Unit time consumed by each of the sensors of the WBAN system. The modeling is based on the newly available 402-405 MHz MICS (Medical Implant Communication Service). The study was done for Wireless Channel on-body radio channels with one Omni Antenna. The model uses four sensor nodes (5 different sensors with single collector), single Control unit and a single remote PC used to collect signals and view. The input data fitting was applied to the post-processed measurement data to identify the parameters for a path loss model. The results and analysis to identify the key protocol in the three scenarios are explained in detail. The results also show the technique for the identification of all the proposed systems to solve the problem of path loss in WBAN, and the decrease in the ratio of path loss between the sender and the receiver. The IKA protocol gives a significant result when a comparison was made with the old solution in path loss problem. The result of using receiver station outside emergency room without any path loss was considered as a support for the efficiency of IKA. Finally, we can claim that our research produces a good solution with the use of MICS ban in medical environment [4,5].

II. Path loss in WBAN

There are varieties of routing algorithms to find the shortest path between the source node and destination node for position estimation [10] in WSN, but there has been limited work on the requirement that helps path loss in WBAN. Most of the previous works do not describe PL inside the human body that allows frequency bands [11]. Further, these studies [12,13] only gave an overview of the causes of path loss in WBAN. To derive our proposed solution for path loss problem, we adopted the main idea of hash table [14] and Secure and Efficient Key Exchange WBAN [8]. Further, guided by [15], we chose the 402-405 MICS bans because they do not cause interference to other users of the electromagnetic spectrums. Another advantage is that when nodes are used as implantable, it provides small size, low-power, faster data transfer and longer communication range. The MICS is a system that can transmit vital information from an implanted antenna embedded in a human body to external equipment through the use of a wireless communication link. This system is able to reduce the time required to diagnose a patient and ease the patients' physical or mental burdens. In addition, it can communicate without a wire piercing the skin, and therefore, it does not involve any risk that causes infection [16]. It also has been introduced by FCC (Federal Communications Commission) to provide mobility and patient care. They are conducive to the transmission of radio signals within human body and do not pose a risk of interference from other radio signals[6].

A. IKA: The Proposed Solution for Path Loss Affiliation

To achieve the proposed solutions for path loss or data loss in a medical environment, we first analyzed the causes of data loss. This analysis has helped us to develop a model that takes into consideration the causes of the data loss. This model provides a guideline for other researchers. There have been very limited studies that use media transfer to solve this type of solution and prove the efficiency in transferring data for short and long distances [1,16]. The issue of transfer is clear after focusing on the types of media transfer that can provide the requirements of the proposed solution. We proposed a modeling solution by identifying key algorithm IKA and applied it in OMNET++ environment. The idea of our solution was drawn from the hash table and sink in WSN, which means giving information and putting it in station. Relating to a previous study that used a master key to identify sensor, our proposed solution focused on improving the efficiency of sending and receiving messages from sensor nodes to receiver point and solving the problem of loss data based on a transfer from the sender's point to the receiver's point. This algorithm depends on giving details about a sensor, like the type of sensor, the job of the sensor and the rate of the sensor [9].

B. The Main Structure of Identification Key Algorithm

A path loss is possible to occur when the data collected by the sensors and devices are transferred through the wireless medium to a remote destination. Figure 1 below explains the main station of our solution model.

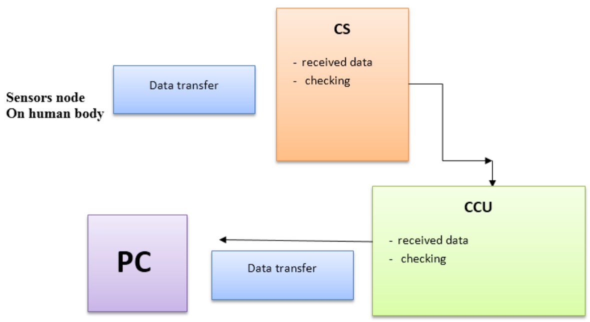

Figure 1: The main station of proposed solution

The Path loss occurs in monitoring system health because of several factors, such as the physical environment like wetness, frequency of operations as well as distance between transmitter and receiver. The methods and technologies used in this study focused on achieving the proposed identification of the key algorithm. The identification of key protocol tries to prove the efficiency of sending and receiving data in a medical environment. This method helps to solve the problem when the receiving device that receives the data does not match with the data sent by the patient's sensor. The solution can cover three types of environment and has different receiver stations to inform the monitoring side, namely the doctor or the nurse, if there is any path loss in one of receiver stations.

C. The Mechanism of MICS with CCU in Identification Key Algorithm

Previous wireless data collection systems used standards, such as Zigbee or Bluetooth that do not comply with the medical standards due to their size, power consumption and strong interference from other devices [11]. Considering hundred sensors attached to a patient's body, such systems become quite bulky to be carried by patients. Therefore, we used MICS band: An ultra-low power, unlicensed, mobile radio service for transmitting data to support diagnostic or therapeutic functions associated with implanted medical devices [7]. The MICS band permits individuals and medical practitioners to utilize ultra-low power medical implant devices, such as cardiac pacemakers and defibrillators, without causing interference to other users of the electromagnetic radio spectrum [12,13]. Several controlled units (CCU) are required in our design solution to organize the collection of medical data from the patient's body. A significant benefit of this technology is that patient using the unit can move freely at the hospital: One CCU for all sensors. The CCU will be replaced at an accessible location at a distance of 1 to 10 meters in the emergency room. After the CCU receives data, the sensors filter the data to remove unwanted signals and noise, and then amplify the signal to be stronger during the transfer. Finally, it checks the data to ensure if there is any path loss depending on the table of CCU. It is also connected to a local PC by MICS band. The CCU displays the real-time information received from the sensor nodes and records the information to a database locally, the same way that is done on the remote PC of the medical center. The stored information can be sent via internet to the database of the medical center on a periodic basis. If more than one patient is accommodated in a room as in the case of a hospital, the necessary software packages are installed in the CCU and the local PC to obtain physiological signals from sensors of each patient. Data gathering is performed at some certain time intervals assigned to patients.

D. The Scenario of Identification Key Algorithm Protocol

Before we design the scenario environment of IKA algorithm, we focused on different studies that discuss in details about the requirement of WBAN scenario to prove the efficiency of the result of study. In this case, we need to understand the main parts of efficient scenario like the type of antenna and the type of sensors. We also changed the environment in the second scenario to demonstrate a new method to extend our proposed solution.

We use three sets of scenarios to conduct our experiments, the sets focused on the patients found in an emergency room and the area outside the emergency room. The conditions of the three scenarios are at the same hospital, the patients at one place, but the receiver devices are not all at the same place. The three cases will be explained in detail in this section.

As mentioned earlier, the WBAN has a problem when data are transferred from the sender point to the receiver point. The main reason for the data loss or change is due to the type of protocol used with the WBAN or the bad physical environment or the confusion of the data sent by the receiver. The main function of the new algorithm is to give details about the sensor, like the type of sensor, job of sensors and the transition rate of sensor. In future, the development in microchip and electronic device will give a different idea in this area; hence, allowing researchers to make enhancements to the future design of WBAN routing protocols and algorithms. For this purpose, we used the memory of chip sensor so that it is possible to use the design of electric circuit and the type of memory that can save and edit data at the same time. This study used different memory for one sensor and the function of this sensor is to collect data from other sensors. We identified this sensor as a collector sensor (CS). The first step is to develop the new protocol. Taking into consideration that every sensor sends data to CS, we program the sensor table in CS memory. This helps to know if any data loss or change through the transfer data between sensor node and CS. The second step is to send data to the Central Control Unit (CCU) that transmits data to a local PC and a receiving station at a medical center. Our solution applies to special scenarios (one patient to one receiver, many patients to one receiver, and many patients to many receivers) inside the emergency room. Figure 2 shows us the diagram of the scenario to apply our solution of the new routing protocol.

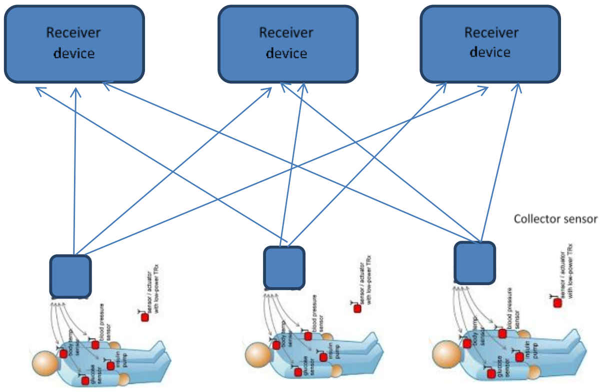

Figure 2: The general diagram of the proposed routing protocol.

We choose special cases for applying and analyzing the new algorithm to get certain data from patient sensors, as we cannot apply any algorithm on the wide area environment to get good results. Further, the simulation helps us to get a view of the enhancement relating to sending and receiving data and prove the efficiency of the protocols used in WBAN.

III. The Specification of the Sensor in Our Proposed System

The sensing elements used in the proposed system are lightweight, small in size, low power, and they are used for intelligent monitoring. These sensors continuously monitor human vital signs, physical natural processes and natural processes. The proposed solution addresses the issue of data loss, while using up less power and offering longer battery lifespan. The proposed communication can be accomplished by making body sensors compatible with the underlying technologies. The main function of the sensors is to collect vital signal from human body and send to CCU. Generally, we can consider all sensors node are communicating with the same CCU, the data are prefixed with an identifier utilized to identify sources of data that collect raw signals from a human body. The signal from a human body is normally weak or powerless, coupled with interference. Most importantly, the signal should go through amplification and filtering operation to increase the signal strength and to remove unwanted signals and interference. It will then depart through an Analog to Digital conversion (ADC) stage to be converted into digital for digital processing. The digitized signal is then processed and stored in the microprocessor. The microprocessor will then take this data and transmit over the air via a transmitter [7,14]. The pulse rate sensor node comprises Microcontroller PIC16F877 and the transceiver AMIS-5210 was selected in the project based on the following reasons: low-control utilization, size, and the suitability of working at the MICS band and preparing the physiological information. Both temperature and heartbeat rate sensor hubs were based on a typical PCB circuit. Therefore, when utilizing these gadgets, they can be exchangeable. The requirements of the CCU in our proposed system consist of a small-scale controller and a remote handset chip to organize all exercises like the sensor nodes around the human body. To get the best result, we used the same transceiver chip from AMI semiconductor (AMI52100 IC) for both the CCU and sensors nodes and the microcontroller PIC16F87. Based on a study[7] that has proven the compatibility of a system, we focus on the achieving a result that allows for the following conditions: the distance between CCU and sensors can be easily changed, the place can be in any position in the emergency room, the wireless distance using MICS band must be between 1-10 meters. Our system consists of many devices, including tiny sensors, which are placed in or around the human body in close proximity to monitor a patient. The data are first sent to the collector sensor. The data then are undergone through a simple checking table to identify any missing data before they are sent to the CCU device by the MICS band. We developed a programming of CCU memory one table, called the CCU table. This table checks if there are any loss data: If there were loss data, the program for CCU will re-ask the data from the collector sensor. The receiver station (i.e. the remote PC) is capable of displaying all the received data on a User Display Graphic (GUI), and it is also capable of storing all the data in the database system of a medical center. We modelled the human body in the programming as follows:

```
module human
{    @display("i=device/human;is=l;bgi=device/human,
s;bgb=158,211");
submodules:}
```

A. The Process of Decrease Path Loss in IKA

The path loss is the difference (in dB) between the transmitted power and the received power. It represents signal level attenuation caused by free space propagation, reflection, diffraction and scattering; hence it is necessary to calculate link budget. After we calculate the link budget, we put the first information of sensors in CS and the CCU. This step allows us to know the exact distance between the sensors and CS. The programing is as below:

The calculation of the link budget S1, S2, S3, S4 and S5, and the information put in the table with the field of position of the sensor to the calculation of link budget is as shown in the table below:

Table 1
The record field of calculation link budget to CS

Position of sensor / link budget to CS
Head /5cm
Heart /4 cm
Arm/3.5 cm
Neck / 4 cm
armpit / 3 cm

For the CCU, we can find the main configuration of idea on CS that depends on it. It first receives the data from CS, in which the data must already be checked in the CS before sending it. The CCU checks the data again to determine if there are any path loss. As mentioned previously, the programming depends on the delay and rate factor in the measurement of the path loss. The identity of sensors makes this process easier because this will be used in the CS, CCU and PC.

B. The Description of the Data on Collector Sensor (Cs)

The main idea is using a special sensor that has a memory that can be programmed. We gave the name for this sensor as the collector sensor (CS): The CS has the same job of a sink in WSN and it collects data from sensor around it. After the data collection, the table that we designed as a program on CS starts checking if there is any path loss. It asks the data from the sensors if there is any loss. Table 2 shows how we used the distribution of sensors that will be installed in the collector sensor. The sensor table installed in the collector sensor programming is as shown below:

Table 2
The distribution of collector sensor (CS)

Sensor	Sensor job	Position of sensor / link budget	The vibration	Received data
Sensor 1	Brain signal	Head /5cm	Every 2 Sec	Yes / no
Sensor 2	Heart signal	Heart /4 cm	Every 5 Sec	Yes / no
Sensor 3	Pressure	Arm/3.5 cm	Every 15 mins	Yes / no
Sensor 4	Blood flow	Neck / 4 cm	Every 10 mins	Yes / no
Sensor 5	Temperature	Armpit / 3 cm	Every 15min	Yes / no

The place of CS in the human body of our design will be as shown in Figure 3.

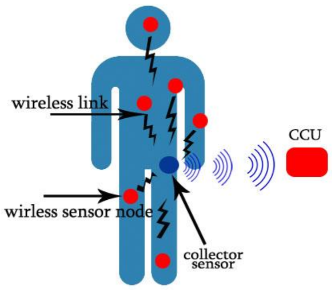

Figure 3: The location of sensors on human body with collector sensor

Figure 4 shows the first scenario, while the second scenario is shown in Figure 5 and the third scenario in Figure 6.

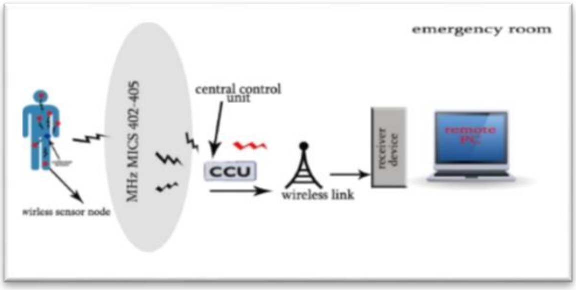

Figure 4: The first scenario in the emergency room: three patients send to one receiver

IV. Performance Analysis of Algorithms

In this section, we analyzed the result of the three scenario before and after using the IKA. The situation before using our proposed solution depends on the path loss factor estimation for RSS-based localization algorithm because the previous study depends on this path loss factor to the measurement of the path loss. Table 3, 4 and 5 show the results of the first, second and third scenario depending on the parameters of path loss, delay, and data rate before and after using the IKA.

It is clear that there is a decrease of the path loss ratio after using the IKA in the three scenarios. Table 3, 4 and 5 show the result of comparative of the first, second and third scenario depending the parameters of path loss, delay, and rate data before and after using the IKA. We can also see the decrease of the path loss ratio when using our proposed solution, the IKA. The results prove the efficiency of using our solution to decrease the path loss between sender and receiver station in the medical environment area

We can see the success of sending vital patient data to the outside emergency room at the same time sending inside the emergency room to the other receiver's station. This motivates us to add a different receiver station in any point at the hospital after making sure that the wave we depend can cover the area without any problem.

Table 3
The comparative of first scenario before and after using IKA

Parameters	First scenario								Point
	Using RSS-based localization algorithm				Using IKA The proposed solution				
	Item#	Event#	Time	Value	Item#	Event#	Time	Value	
Path loss	0	9392	5.620035856461	60.0	0	9392	35.620035856461	10.0	CS
	1	9392	15.620035856461	60.0	1	9392	35.620035856461	25.0	
	2	9392	25.620035856461	80.0	2	9392	35.620035856461	30.0	
	3	9392	30.620035856461	40.0	3	9392	35.620035856461	35.0	
Delay	100ms (milliseconds)				10ms (milliseconds)				CCU
Data rate	Mbps (bit per second)				50Mbps (bit per second)				PC

Table 4
The comparative of the second scenario before and after using IKA

Parameters	Second scenario: Using RSS-based localization algorithm				Using IKA - The proposed solution				Point
	Item#	Event#	Time	Value	Item#	Event#	Time	Value	
Path loss	0	9392	5.620035856461	60.0	0	9392	25.620035856461	10.0	CS
	1	9392	15.620035856461	60.0	1	9392	35.620035856461	25.0	
	2	9392	25.620035856461	80.0	2	9392	40.620035856461	30.0	
	3	9392	30.620035856461	35.0	3	9392	50.620035856461	40.0	
delay	100ms (milliseconds)				10ms (milliseconds)				CCU
Data rate	Mbps (bit per second)				50Mbps (bit per second)				PC

Table 5
The comparative of the third scenario before and after using IKA

Parameters	Third scenario: Using RSS-based localization algorithm				Using IKA - The proposed solution				Point
	Item#	Event#	Time	Value	Item#	Event#	Time	Value	
Path loss	0	9392	20.620035856461	15.0	0	9392	30.620035856461	5.0	CS
	1	9392	25.620035856461	20.0	1	9392	40.620035856461	15.0	
	2	9392	30.620035856461	80.0	2	9392	60.620035856461	20.0	
	3	9392	32.620035856461	40.0	3	9392	70.620035856461	20.0	
delay	100ms (milliseconds)				10ms (milliseconds)				CCU
Data rate	Mbps (bit per second)				50Mbps (bit per second)				PC

Table 6
The final compare between the result of the three scenario and the old solution

Using RSS-based localization algorithm				Using IKA - The proposed solution			
Item#	Event#	Time	Value	Item#	Event#	Time	Value
0	9392	11.620035856461	80.0	0	9392	30.620035856461	70.0
1	9392	16.620035856461	64.0	1	9392	40.620035856461	55.0
2	9392	23.620035856461	55.0	2	9392	60.620035856461	40.0
3	9392	30.620035856461	45.0	3	9392	70.620035856461	30.0

V. CONCLUSION

In this paper, the literature gap found that the current solution of path loss in WBAN cannot cover the full requirements of the health monitoring system and there is still a problem in path loss. Considering that there is a missing data at the receiver station, we proposed a solution that focuses on giving identity for all sensors base on MICS band. The radio communication from the implanted medical devices is opening new horizons for the understanding and preventing diseases in humans. This research provides a solution that is applied in three scenario covering different cases for the position of the receiver station. The result of the simulation in OMNET++ proves that there is a decrease in the path ratio in WBAN. The use of the OMNET++ supports the communication in our design because we used the INT frame inside it.

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