Energy Efficiency Enhancement in Body Area Network Using IEEE 802.15.6 Standard

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Abstract – *Wireless Body Area Network is an interdisciplinary field that monitors the health parameter of an individual along with the real time updation of the parameter values to the medical personnel. As most of the energy is consumed by the transceivers for the purpose of transmission and reception of the data, it becomes necessary to analyze the energy consumed by various transceivers in their receive, transmit and sleep mode and to choose the one that consumes lesser amount of energy. An algorithm has been proposed in which all the nodes will transmit the data to the coordinator node when there is an abnormal situation with the patient. Under normal conditions, only ECG and temperature sensors will be sending the data to coordinator node so as to achieve energy conservation. Simulation is carried out using OMNeT++ simulation tool. Also proposed algorithm is compared with the existing IEEE 802.15.4 algorithm and better percentage of packet reception is obtained.*

Key Words: Wireless Body Area Network, Wireless Body Sensor Network, Carrier Sensor Multiple Access with Collision Avoidance, Time Division Multiple Access, OMNeT++, IEEE 802.15.6.

1. INTRODUCTION

Aged group of population requires continuous monitoring of their health conditions. Body Area Network (BAN) is one of the techniques which has been developed to provide continuous health monitoring. BAN is a network of wearable computing devices. BAN consists of various miniaturized sensors connected to one central unit.

Sensors can be placed as an implant within the body or placed only on the surface of the human body. Normally, BAN can be defined as networks, which are used for monitoring and detection of the human body parameters. This area relies on the placement of small biosensors inside the human body. The information will be transmitted by using wireless communication to an external processing unit [1].

BAN is an area which could provide constant health monitoring with the help of internet and sensors. These sensors will gather the data in order to observe the health status of an individual.

WBAN consists of sensors, actuators, transceivers and processors for processing the information obtained from the sensors through transceivers and instruct the actuators to act accordingly.

The international standard for WBAN is IEEE 802.15.6 that aims in providing low power, short range and reliable wireless communication.

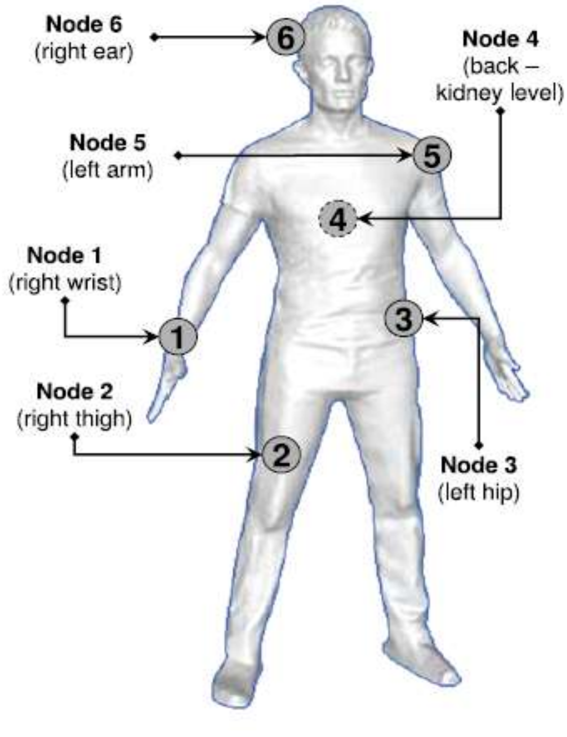

Fig -1: Overview of WBAN [1]

Figure 1 shows the Overview of a Body Area Network, wherein various nodes or sensors are placed on the surface of the human body.

Rest of the paper is structured as follows. Section 2 discusses about the review of the related works that has been carried out. In section 3 proposed methodology has been described. Section 4 details about the obtained results and discussion on it. Section 5 concludes the paper.

2. RELATED WORKS

S.G Valenzuela et al. 2011 [2], presented different types of sensors that can be implemented in WBAN.

1. Wearable sensors: Wearable sensors have different shapes and dimensions. These sensors consist of electrodes which are made up of silver chloride. These electrodes can be implemented on the patient's cloth's surface or worn on the body as implants. Hence this alternative method can provide better comfort to the patient.

2. Implantable Sensors: Implantable sensors are generally injected into the human body. This is considered to be risky because the human body may reject this sensor or it may cause damages to the tissues present in the human body.

Sana ullah et al. 2012 [3], have discussed the architecture of WBAN. WBAN system consists of in-body and on-body sensors. These sensors are connected to the personal devices by means of star or point to point topology. In star topology there is a central hub or personal device. Each of the devices are connected to the central device.

Samaneh Movassaghi et al. 2014 [4], have discussed about different types of node that can be implemented in and around the human body based on roles, functionality and implementation.

Personal Device (PD): Collects the information from all sensors and forwards it to the medical personnel.

Sensors: Sensors are used to collect the information based on the physical stimuli. The sensors used may be ECG, Temperature, Humidity etc.

Actuators: Actuators receive the signal from the sensors and act accordingly to the received signals. Example is the pumping of the correct dosage of the medicine into the human body.

Implant node: These are present under the skin of the human body or injected into the human tissue.

Body surface node: These are the nodes that are touching the human skin.

External node: These are the nodes which will not be in touch with the human body.

Coordinator node: Coordinate node coordinates all the nodes that are present in the WBAN architecture. Various other nodes present in WBAN architecture can communicate with each other only through coordinator nodes.

Behrouz A Forouzan 2006 [5], have discussed about data communication and networking in which CSMA/CA has been discussed.

In wireless networks collisions are to be avoided since they cannot be detected in wireless networks. In CSMA/CA even though the channel is found to be idle, it will wait for a period known as Inter Frame Space (IFS). After IFS, node will choose a random amount of time slot as its wait time. Node will sense the channel in each time slot. If the channel is found to be busy it restarts the timer when the channel becomes idle.

Another important protocol discussed by Behrouz A Forouzan is the TDMA protocol where node will sense the channel before transmitting the Data.

N Javaid et al. 2013 [6] have presented energy efficient MAC protocols in WBAN which describes different mechanisms for saving the energy.

Rezvani et al. 2013 [7], have proposed a protocol that differentiates the medical traffic as normal and emergency traffic. Separation between these traffics are according to the user's medical condition.

N.K Ray et al. 2009 [8], have discussed about causes of energy waste and consumption. Major causes for the wastage of energy at MAC layer are collision, idle-listening, over-hearing etc.

Kiran et al. 2015 [9], have discussed about the necessary transmission of the data to the base station. The data extracted is subjected to various decision algorithms and then decided whether it should be transmitted or not.

3. METHODOLOGY

1) Energy consumed by various transceivers in their Sleep, Transmit and Receive states are determined.

2) An algorithm is designed to transmit the data from all the nodes only in the abnormal condition which results in the conservation of energy.

3) Percentage of packets that are received and lost at the coordinator node is tabulated.

4) Comparison of the proposed algorithm in terms of packets lost is done with existing IEEE 802.15.4 algorithm.

Notations used in Algorithm

Temp: Temperature.

ECG: ECG Signal.

S_1: Normal state.

S_2: Abnormal state.

□r: Comparison co-efficient.

□$_1$: Comparison co-efficient upper limit.

□$_2$: Comparison co-efficient lower limit.

E_r: Reserve energy.

E: Energy.

Input: Temp, ECG, E_r=0.02.

Output: State (S_1 or S_2)

Algorithm

begin process

compare (Temp, ECG)

if($⍰r \le ⍰_1$ && $⍰r \ge ⍰_2$)

{

state→ S_1; //Normal condition

Wait for 10 seconds before transmitting the data;// For the purpose of energy conservation.

if($E>E_r$)

{

Transmit data to the access point; //Transmission of packets using CAP of CSMA/CA

}

else

{

Transmit "I am alive packet"; //Transmission of packets using CAP of CSMA/CA

}

}

else

{

State→ S_2; //Abnormal condition

Awake all nodes;

Transmit data to the access point; //Transmission of packets using CFP of CSMA/CA

}

end process;

Figure 2 shows the flowchart for the proposed system.

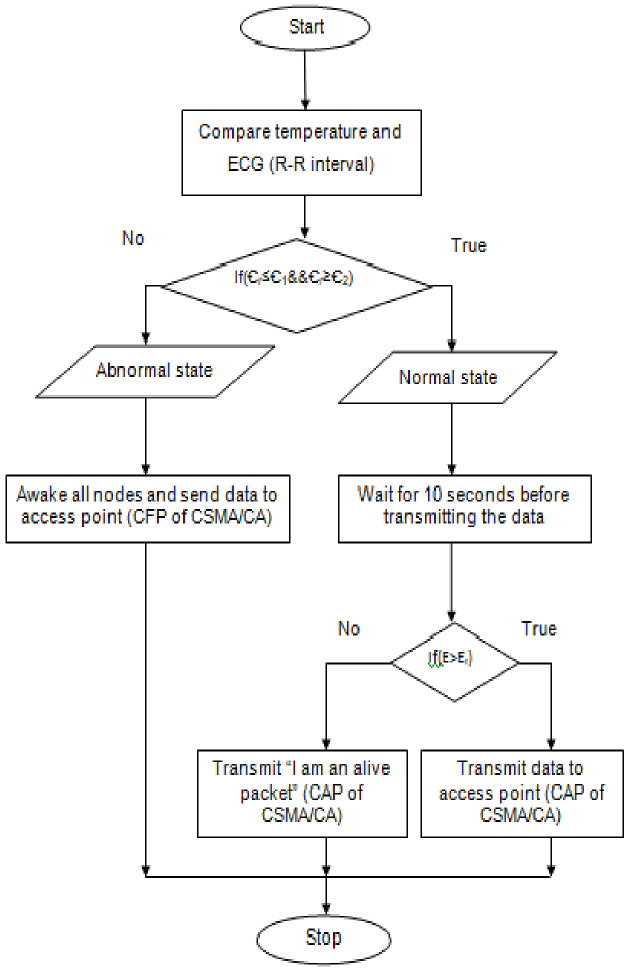

Fig -2: Flowchart of the Proposed System

4. SIMULATION AND RESULTS

Initially energy consumed by various transceivers in their Sleep, Transmit and Receive states are calculated and is tabulated as shown in the Table 1

Table -1: Energy consumption in various transceivers

Transceiver	States		
	Sleep	Transmit	Receive
CC2420	6 μJ	15.9 mJ	22.2 mJ
CC1000	1.4 mJ	29.04 mJ	62 mJ
CC1101	2.932 pJ	15.83 mJ	18.76 mJ
BAN Radio	0.05 mJ	2.9 mJ	3.1 mJ

Figure 3 shows the description of the network that is implemented on the surface of the human body using OMNeT++ simulation tool.

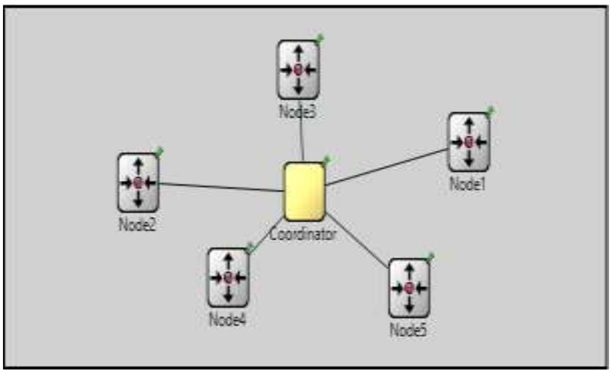

Fig -3: Network description

Each node consists of BAN Radio, as its transceiver which consumes lesser energy in comparison with CC1000, CC1101 and CC2420. Considering that BAN Radio consists of a total energy of 1J, simulation is carried out.

In the simulation of algorithm, R-R interval of the ECG signal is set to 0.8060 second and body temperature is set to 98.5°F. In this scenario normal condition of the patient is found and transmissions of the packets are carried out using CSMA/CA protocol by only temperature and ECG sensors. Figure 4 shows the transmission of the packets using CSMA/CA protocol.

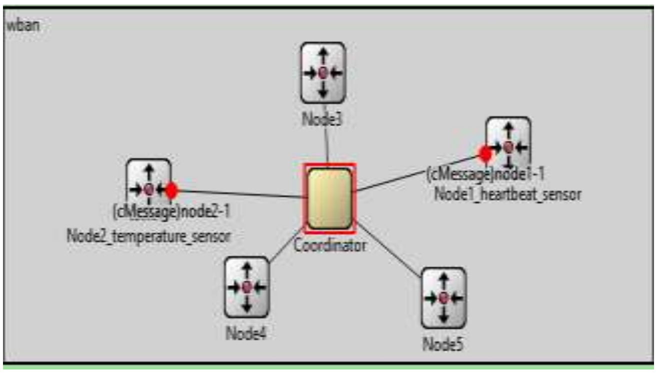

Fig -4: Data from temperature and ECG sensor in normal state

Next is to consider the case when either of the temperature or R-R interval of ECG signal or both are out of the acceptable value. In the simulation temperature is set to 102°F and R-R interval is set to 1.2655 seconds. This is the abnormal condition and all the sensors will send the data to the coordinator node using TDMA protocol and is as shown in Figure 5.

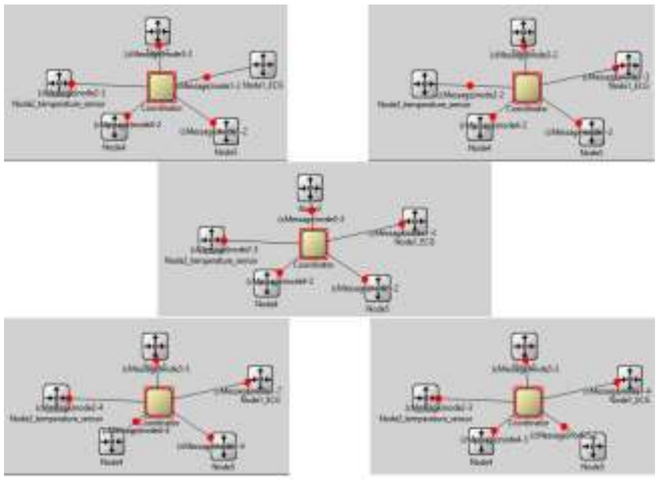

Fig -5: All nodes sending data in abnormal condition using TDMA protocol

Table 2 shows the percentage of packets received and lost at the coordinator node for abnormal and normal condition.

Table -2: Percentage of packets received and lost

Condition	Average percentage of packets received	Average percentage of packets lost
Normal	93.1%	6.6%
Abnormal	95.22%	4.76%

Figure 6 shows the plot of number of packets received and lost at the coordinator node for normal condition for the simulation being carried out 2061 seconds.

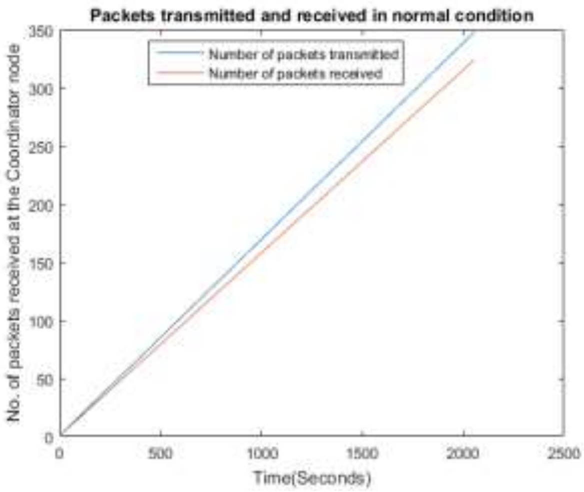

Fig -6: Number of packets transmitted and received at coordinator node in normal condition

Figure 7 shows the plot of number of packets received and lost at the coordinator node for abnormal condition for the simulation being carried out for 319 seconds.

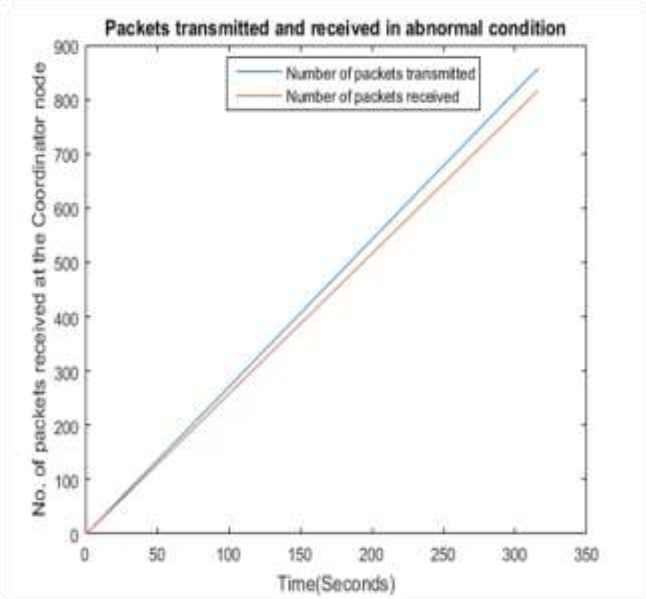

Fig -7: Number of packets transmitted and received at coordinator node in abnormal condition

Joseph Jeon et al. [10] has presented Duty Cycle Adaptation algorithm for IEEE 802.15.4 beacon-enabled networks in which percentage of packets lost at the coordinator is determined. Figure 9.31 shows the comparison of number of packets that are received at the coordinator node for DCA algorithm for IEEE 802.15.4 beacon-enabled networks and the proposed algorithm in both normal and abnormal conditions of the input parameters of the patient.

From Figure 8 it has been inferred that percentage of packet of packet loss at the coordinator node in normal condition is 4.4% less then DCA algorithm and 6.24% less in abnormal condition and hence energy enhancement is achieved.

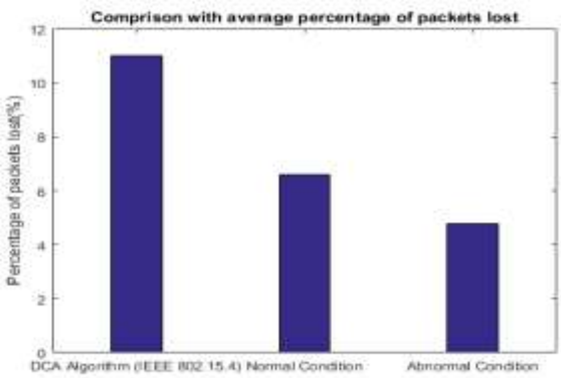

Fig -8: Comparison with existing work

5. CONCLUSION

Wireless Body Area Network is essential to monitor the health condition of patients suffering from chronic diseases or elderly people. A WBAN system has been created for the same, where five body sensor nodes will transmit the packets to the coordinator node. The simulation initiates the transmission of packets between the body sensor nodes and the coordinator. After analyzing the energy consumption during 'active' and 'sleep' states, BAN Radio has been utilized in the system. In the setup CSMA/CA and TDMA have been incorporated for channel access phase. An algorithm is developed that handles normal as well as abnormal condition of health parameters of the patient. The algorithm has been successfully coded in OMNeT++ simulation environment. As proposed in the algorithm, during normal operation ECG sensor and temperature sensor's data are being sent to the coordinator using CSMA/CA mechanism. The abnormal situation is sensed by the algorithm based on the input health parameters and the transmission of the data is carried out using TDMA mechanism. Thus the algorithm had handled normal as well as abnormal conditions of the patients and lead to a better health management system. Proposed algorithm is compared with DCA algorithm using IEEE 802.15.4 in which percentage of packet loss was 4.4% less in normal condition and 6.24% less in abnormal condition.

ACKNOWLEDGEMENT

Authors are grateful towards the institution for providing all the necessary facilities required for carrying out the work in a more successful way. We acknowledge our sincere thanks to the HOD of ECE department. We are also thankful for the support given by the entire department of the institution.

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