

# Adaptive Load Control For Zigbee-Based Wbans With Coexisting Wi-Fi Networks

**M Gunasekaran**

*PG Scholar, ECE Dept.  
Bannari Amman Inst. of Tech  
Sathyamangalam,  
gunasekaran.co15@bitsathy.ac.in*

**M.G. Sumithra**

*Professor, ECE Dept.  
Bannari Amman Inst. of Tech  
Sathyamangalam,  
sumithramg@bitsathy.ac.in*

**Abstract**— The development of health tele monitoring through wireless body area networks (WBANs) is an evolving direction in personalized medicine and home-based mobile health care. In a health tele monitoring system, a WBAN consists of a number of lightweight miniature sensors. The sensors measure physiological parameters such as electrocardiography (ECG), electroencephalogram (EEG), body temperature, and blood pressure. These measurements are transmitted to an external data aggregation device called a coordinator via wireless communication networks, and are then sent to a health tele monitoring center (e.g., a hospital) via the Internet. One of the most widely used wireless technologies in WBANs is ZigBee because it is targeted at applications that require a low data rate and long battery life. However, ZigBee-based WBANs face severe interference problems in the presence of Wi-Fi networks. This problem is caused by the fact that most ZigBee channels overlap with Wi-Fi channels, severely affecting the ability of healthcare monitoring systems to guarantee reliable delivery of physiological signals. To solve this problem, adaptive load control algorithm that controls the load in Wi-Fi networks to guarantee the delay requirement for physiological signals, especially for emergency messages, in environments with coexistence of ZigBee-based WBAN and Wi-Fi. Since Wi-Fi applications generate traffic with different delay requirements, the focus is mainly on Wi-Fi traffic that does not have stringent timing requirements. A adaptive load control algorithm for ZigBee based WBAN/Wi-Fi coexistence environments has been proposed, with the aim of guaranteeing that the delay experienced by ZigBee sensors does not exceed a maximally tolerable period of time. Simulation results show that the proposed algorithm guarantees the delay performance of ZigBee-based WBANs by mitigating the effects of Wi-Fi interference in various scenarios.

**Index Terms**— Adaptive load control, delay, health tele monitoring, wireless body area network, Wi-Fi and ZigBee. .

## 1 INTRODUCTION

The development of health tele monitoring via wireless body area networks (WBANs) is an evolving direction in personalized medicine and home-based mobile health. In a health tele monitoring system, a WBAN consists of a number of lightweight miniature sensors. The sensors measure physiological parameters such as electrocardiography (ECG), electroencephalogram (EEG), body temperature, and blood pressure. These measurements are transmitted to an external data aggregation device called a coordinator via wireless communication networks, and are then sent to a health tele monitoring center (e.g., a hospital) via the Internet. At the hospital, medical professionals monitor their patients' physiological parameters continuously, so that there is no need for them to visit the hospital in person.

The physiological signals in the system can be categorized into two types: regularly collected information and emergency messages. Regularly collected information is stored and transmitted after a given period of time, while emergency messages must be transmitted immediately since they alert the hospital to emergency situations such as excessively high or low blood pressure or body temperature, or heart beat stoppage. According to the TG6 technical requirement document, emergency messages must be transmitted in less than 1 s. Hence, guaranteed delay requirement is of utmost importance to the proper operation of health tele monitoring systems.

One of the most widely used wireless technologies in WBANs is ZigBee (IEEE 802.15.4) because "it is targeted at applications that require a low data rate and long battery life". However, operating on the unlicensed 2.4-GHz industrial scientific

and medical (ISM) band, ZigBee is subject to interference from coexisting Wi-Fi (IEEE 802.11) devices which share this band. This is because the transmit power of Wi-Fi is 5–20 dB stronger than that of ZigBee, which "easily forces ZigBee sensors to back off and dominate the ZigBee interference". In the presence of Wi-Fi devices, therefore, it is difficult to guarantee reliable delivery of vital signs, especially for emergency messages. Furthermore, "with the proliferation of Wi-Fi devices (e.g., smartphones) and high-rate applications (e.g., HD video streaming)," recent studies have shown that "moderate to high Wi-Fi traffic" increases the delivery delay of each ZigBee packet.

## 2 RELATED STUDY

Mashood Anwar et al(2015) GTS size adaption algorithm for IEEE 802.15.4 wireless Networks IEEE802.15.4 standard specifies the Medium Access Control(MAC) and Physical(PHY)layer for wireless sensor networks(WSN) applications with limited power and low data rate. This standard supports time critical applications by allowing TDMA based access in beacon enabled networks. In these networks, the PAN coordinator exchanges data with the end devices through guaranteed time slots (GTS). The PAN coordinator an allocate GTS on a first come first serve (FCFS) basis in response to there quests by end devices. In original standard, the coordinator can assign up to the maximum seven GTSS. This fixed number of GTS allocation may result in inefficient utilization of channel bandwidth. In this paper a new GTS allocation scheme that will

set the GTS size adaptively in accordance with the data size of the end device.

Mohammad N. Deylami et al(2014) A Distributed Scheme to Manage The Dynamic Coexistence of IEEE 802.15.4-Based Health-Monitoring WBANs. The dynamic coexistence management (DCM) mechanism to make IEEE 802.15.4-based WBANs able to detect and mitigate the harmful effects of coexistence. DCM improves the successful transmission rates of dynamically coexisting WBANs by 20%–25% for typical medical monitoring applications.

Dynamic coexistence of WBANs may result in the loss of critical health monitoring data. The criticality of such information in addition to the high probability of coexistence in healthcare environments necessitates the development of mechanisms that enable the WBANs to detect and mitigate the harmful effects of coexistence. In this paper introduced the DCM mechanism as an extension to the IEEE 802.15.4 standard which enables the WBANs to independently manage the coexistence situation in a distributed manner.

Essafi Sarra et al(2014) Coexistence Improvement of Wearable Body Area Network (WBAN) In Medical Environment. To improve coexistence between WBAN based IEEE 802.15.4 protocol and WIFI. It is adopted with multi-hop routing to ensure reliability, connectivity and battery life. The investigation of different effects of transmit power, transmission frequency and packet size on WBAN performances under heavy and real interferences circumstances. A well suited model is provided with simple adaptive algorithm which adjust dynamically its parameters with received performances indicators. Considering the harmful effect of interference in medical WBAN. in this work to minimize their impacts taking into account mobility, resources constraint and application requirements. Cho et al(2014) Contention window adaption for coexistence of WPAN and WLAN Medical Environments the coexistence problem of WBAN and wireless LAN (WLAN) in medical environments. In order to resolve the unfairness issue caused by coexistence, the novel is provided with contention window adaptation scheme for achieving efficient channel sharing by considering network performance and fairness at the same time. The coexistence problem for medical environments of WBAN (IEEE 802.15.4) and WLAN (IEEE 802.11) in the 2.4GHz ISM band. Under coexistence, the performance degradation of conventional WBAN is inevitable because of asymmetry of the transmission power and the response time. In order to resolve the asymmetric performance and to guarantee the required medical QoS, The proposed method adaptively tunes the contention window size of WLAN by observing the delay of WBAN so that the performance of WBAN is maintained at a certain pre-specified level.

Gayatri Pawar et al(2014) Tele monitoring in Healthcare System Using Sensor Nodes. A Wireless medium is widely used application in numerous field and so it is also applicable to medical and healthcare systems in wide proportions. Tele monitoring thus provides the collection of critical information to its required destination in various fields such as medical ,military etc. This paper represents a day-to-day application in medical fields using most acceptable based android system using smart-phones and sensor nodes. Xinyu Zhang et al(2013) Cooperative Carrier Signaling: Harmonizing Coexisting WPAN and WLAN Devices .The unlicensed ISM spectrum is getting crowded by

wireless local area network (WLAN) and wireless personal area network (WPAN) users and devices. Spectrum sharing within the same network of devices can be arbitrated by existing MAC protocols, but the coexistence between WPAN and WLAN (e.g., ZigBee and Wi-Fi) remains a challenging problem. The traditional MAC protocols are ineffective in dealing with the disparate transmit-power levels, asynchronous time-slots, and incompatible PHY layers of such heterogeneous networks. Recent measurement studies have shown moderate-to-high Wi-Fi traffic to severely impair the performance of coexisting ZigBee. CCS employs a separate ZigBee node to emit a carrier signal (busy tone) concurrently with the desired ZigBee's data transmission, thereby enhancing the ZigBee's visibility to Wi-Fi. It employs an innovative way to concurrently schedule a busy tone and a data transmission without causing interference between them. The implemented and evaluated CCS on the Tiny OS/MICAz and GNU Radio/USRP platforms. Our extensive experimental evaluation has shown that CCS reduces collision between ZigBee and Wi-Fi by 50% for most cases, and by up to 90% in the presence of a high-level interference, all at negligible Wi-Fi performance loss. Zenghua Zhao et al (2013) ZigBee vs Wi-Fi: Understanding Issues and Measuring Performances of IEEE 802.11n and IEEE 802.15.4 Coexistence. A Wireless coexistence is crucial with the explosive development of wireless technologies in recent years. The coexistence issues of IEEE 802.11 b/g and IEEE 802.15.4 have been well studied, however few work focused on 802.11n new features including MIMO, channel bonding and frame aggregation. This paper with conducted extensive experiments to understand how 802.11n impact on 802.15.4 and vice versa in a systematic way. The primary features of 802.11n is used in both symmetric and asymmetric scenarios. The goal of work is to gain more insights into the coexistence issues of 802.11n and 802.15.4 and thus to help protocol design and co-located network deployments. Saeed Rashwand et al (2012) Two-Tier WBAN/WLAN Healthcare Networks; Priority Considerations the IEEE 802.15.6-based WBANs and the IEEE 802.11e EDCA-based WLAN to develop a wireless healthcare network. To consider eight WBAN User Priorities (UPs) to the WBAN nodes. By mapping the UPs into four WLAN Access Categories (ACs) and convey the medical data to the WLAN access point. The investigate network performance under varying priority differentiation and number of nodes in the WLAN. The results of this work indicate that differentiation by AIFS is more appropriate to preserve relative order of frame response times established in WBAN.

Jelena misic et al (2010) bridge performance in a multitier wireless network for healthcare monitoring. Advances in computer and communication technology have enabled online healthcare monitoring using miniature sensing devices attached to a patient's body. Data collected in this manner is then delivered in real time, through one or more wireless hops, to the hospital network. This article discuss some design of alternatives for the wireless portion of an integrated healthcare monitoring system, in particular issues related to its topology, the choice of wireless communication technology for tiers with well-defined function, and the bridging between tiers and also present some performance results for a two-tier topology with isolation of high-data-rate traffic from low-data-

rate traffic, in which the patient's body area network is implemented using 802.15.4 low-data-rate WPAN technology, while connection in the next higher tier (i.e., from the body area network to a hospital ward network or home network) uses the ubiquitous 802.11 WLAN technology. Vojislav B. et al (2009) Bridging Between IEEE 802.15.4 and IEEE 802.11b Networks for Multi parameter Healthcare Sensing. The interconnection of an IEEE 802.15.4 body area network (BAN) in which nodes sense physiological variables such as electrocardiography (ECG), electroencephalography (EEG), pulse oximeter data, blood pressure and cardiac output, with an IEEE 802.11b room/ward WLAN. This model of operation done with two-tier network assuming that 802.15.4 BAN operates in CSMA-CA mode and that the BAN coordinator acts as the bridge which conveys BAN packets to the 802.11b access point. To analyze the two-hop network delay and discuss the mutual interaction of different data streams as well as impact of the number of bridges on packet delay.

### 3 ADAPTIVE LOAD CONTROL FOR ZIGBEE BASED WBANS WITH COEXISTING WIFI NETWORKS

#### 3.1 ZIGBEE-BASED WBAN/WIFI COEXISTENCE ARCHITECTURE

The goal of the health tele monitoring system is to provide automatic and reliable data transmission between the medical sensors and the health tele monitoring system. In the presence of Wi-Fi traffic on the shared channel, however, ZigBee-based WBANs can suffer significant degradation in delay performance due to Wi-Fi interference. In such cases, it is difficult to guarantee fast transmission of an emergency message when an emergency condition (e.g., heart attack) has been detected.

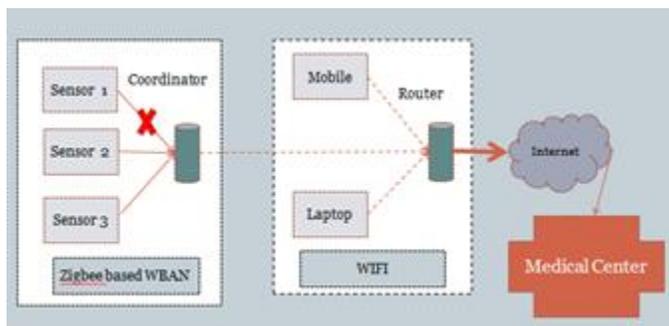


Fig 1. ZigBee-based WBAN architecture coexisting with Wi-Fi

The ZigBee-based WBAN/Wi-Fi architecture is shown in Fig.1. Once interference is detected, the coordinator sends the Wi-Fi node information to alert the AP to the presence of Wi-Fi interference. The AP identifies the Wi-Fi node that has the highest received signal strength and is generating traffic that does not have any time-based sensitivity requirements. With the use of traffic classification, the traffic has already been determined. The AP then sends a message to the identified Wi-Fi node, and upon its receipt, the node reduces its transmission rate.

The ZigBee-based WBAN coexists with a Wi-Fi network at home. This is because Wi-Fi networks are becoming increasingly

popular as the number of mobile users who install small-size APs rises. Medical sensors, attached onto or implanted in the body, are connected to a coordinator via ZigBee communication. The coordinator, implemented on a personal digital assistant, cell phone, or personal computer, aggregates medical information from ZigBee sensors and forwards the collected information to a health tele monitoring system through an AP, which is connected to the Internet.

#### 3.2 PACKET ERROR RATE ANALYSIS IN ZIGBEE BASED WBAN/WIFI COEXISTENCE NETWORKS

For Wi-Fi networks, let  $P_{cca}$  be the clear channel assessment (CCA) power threshold in watts. This is the minimum power required for correct receipt of transmitted packets. A define  $A_c^{(w)}$  as a set of Wi-Fi nodes whose signal strength observed at a coordinator  $c$  is greater than  $P_{cca}$

$$A_c^{(w)} = \{ \text{Wi-Fi node } j \mid P_{c_j}^{(w)} \geq P_{cca} \} \quad (1)$$

where  $P_{c_j}^{(w)}$  is the received signal power of Wi-Fi node  $j$  observed at coordinator  $c$ . Let  $P_{c,m}$  be the power of the signal sent from ZigBee sensor  $m$  at ZigBee coordinator  $c$ 's receiver, and let  $P_{noise}$  be the received noise power level at coordinator  $c$ . The signal-to-interference-plus-noise ratio (SINR) at coordinator  $c$  from ZigBee sensor  $m$  with Wi-Fi interference,  $S_{c,m}^{(I)}$  and without Wi-Fi interference,  $S_{c,m}$ , are given as

$$S_{c,m}^{(I)} = P_{c,m} / P_{noise} + P_c^{(w)} \quad (2)$$

and

$$S_{c,m} = P_{c,m} / P_{noise} \quad (3)$$

where  $P_c^{(w)}$  is the average received signal power of Wi-Fi nodes observed at coordinator  $c$ . Assuming an additive white Gaussian noise channel, It can express the bit error rate (BER) as a function of the SINR as

$$BER(S) = Q(\sqrt{2\gamma S}) \quad (4)$$

Using (2)–(4), the PER for a packet sent from ZigBee sensor  $m$  when coordinator  $c$  receives a packet is determined as follows:

$$\epsilon_{c,m} = 1 - (1 - BER(S_{c,m})) \times (1 - BER(S_{c,m}^{(I)})) \quad (5)$$

where  $L$  is the average length of a ZigBee packet and  $u_c^{(w)}$  is the Wi-Fi channel utilization observed at coordinator  $c$ .

#### 3.3 DELAY ANALYSIS IN ZIGBEE-BASED WBANS

Let  $T_{bi}$  and  $T_{sf}$  denote the beacon interval and the superframe duration in the ZigBee network, respectively. Noting that each packet is generated in a slot, the average waiting time before sensing the channel condition (i.e., CCA).

$$D_{wt} = (T_{bi} - T_{sf})^2 / 2 T_{bi} \quad (6)$$

The ZigBee node waits for a random number of back off periods and senses the channel condition. The random number for back off is uniformly distributed in the range of  $[0, W_0 - 1]$ , where  $W_0$  is the size of the initial contention window. If the channel is busy, channel access fails and the ZigBee sensor waits again for a random number of back off periods with the new contention window  $W_1 = 2 \times W_0$ . Subsequent channel access failure causes further doublings of the contention window until the window size reaches a maximum value of  $W_X$ . Thus, the average back off time for the contention window size  $W_x$  ( $0 \leq x \leq X$ ) can be expressed

$$D_{c,m}^{(b)} = D_{wt} + \sum_{x=0}^{X-1} (u_c^{(z)})^x D_x^{(b)} + 1(u_c^{(z)})^X / 1 - u_c^{(w)} \times D_X^{(b)} \quad (7)$$

Let  $T_s$  and  $T_f$  be the duration of successful and unsuccessful ZigBee frame transmissions, respectively. For IEEE 802.15.4,  $T_s = bL + T_{CCA} + T_{SIFS} + T_{ACK}$  and  $T_f = bL + T_{CCA} + T_{ACK,TO}$ , where  $b$  is the duration of a bit transmission,  $T_{CCA}$  is the duration of CCA in ZigBee,  $T_{SIFS}$  is the duration of a short ZigBee inter frame space,  $T_{ACK}$  is the duration of a ZigBee ACK packet, and  $T_{ACK,TO}$  is the duration of ZigBee ACK timeout [6]. Using (5) and (7), It can obtain the transmission delay  $D_{c,m}$  for a ZigBee packet sent from ZigBee sensor  $m$  to coordinator  $c$ , as follows

$$D_{c,m} = T_s + (1 - e_{c,m})^{-1} (D_{c,m}^{(b)} + e_{c,m} T_f). \quad (8)$$

### 3.4 WI-FI TRAFFIC CLASSIFICATION

To improve the delay performance of the ZigBee network by controlling only the Wi-Fi traffic generated from delay-tolerant applications so that delay-sensitive Wi-Fi traffic remains uninterrupted. In this section introduce a mechanism that classifies Wi-Fi traffic into the two classes of real-time (RT) (e.g., PPLive, Google Hangouts) and non real-time (NRT) (e.g., Bit Torrent, Web browsing, YouTube) and identifies the traffic class for an application.

Our classification mechanism works in two phases: offline training and online classification phases. In the offline training phase, The extract the characteristic features of the traffic generated by each application. The features of the traffic to consider in this study are frame size (FS) and frame inter arrival time (FIT). 50% of the dataset is chosen randomly as the training dataset, and the remaining 50% is used for testing. The training phase calculates the statistical features of a set of training data (i.e., FS and FIT) and outputs a set of traffic descriptors  $\{(FS_i, FIT_i)\}$  for the two classes. Then, when Wi-Fi traffic arrives at the AP, it is identified online as one of the traffic classes using the statistical features obtained from the offline training phase.

### 3.5 ALGORITHM FOR GUARANTEEING DELAY REQUIREMENTS IN ZIGBEE-BASED WBANS

An adaptive load control algorithm to guarantee that the delay between a ZigBee sensor and a coordinator is no longer than the maximally tolerable delay  $D_{max}$  by using the analyses and traffic classification presented previously. To detect Wi-Fi interference, and compute the PER of a packet sent from ZigBee sensor  $m$  to coordinator  $c$  to satisfy  $D_{max}$ . The constraint for the maximum ZigBee delay,  $D_{max}$ , is

$$D_{max} \geq D_{c,m} \quad (9)$$

Where  $A_c^{(z)}$  is a set of ZigBee nodes connected to coordinator  $c$ . (8)–(9) give us the maximum allowable channel utilization in the Wi-Fi network for ZigBee node  $m$  (denoted as  $u_{c,m}$ ) such that the ZigBee delay does not exceed  $D_{max}$ . Therefore, the maximum allowable Wi-Fi channel utilization at coordinator  $c$  is given as

$$\tilde{u}_c = \min \{ u_{c,m} \} \quad \forall j \in A_c^{(w)} \quad (10)$$

**Algorithm 1** Guarantee of the Delay Requirement in a ZigBee Coordinator

$$N_c = 1, u_c^{(w)} = 0, \text{BUSY} = \text{false}, t_D = 0$$

while (BUSY is false) or (Current\_time() <  $t_D$ ) do  
The coordinator monitors the channel to get  $u_c^{(w)}$

```

if BUSY is false then
if  $u_c^{(w)} > \tilde{u}_c$  then
    BUSY = true
     $t_D = \text{Current\_time}() + D_z^{\max}$ 
     $\text{sum} = u_c^{(w)}$ 
     $N_c = 1$ 
end if
else
     $N_c = N_c + 1$ 
     $\text{sum} = \text{sum} + u_c^{(w)}$ 
if  $(\text{sum}/N_c) < \tilde{u}_c$  then
    BUSY = false
end if
end if
end while

```

Send  $\tilde{u}_c$  and the MAC address list of the Wi-Fi nodes  $\in A_c^{(w)}$  sorted in descending order of their  $P_{c,j}^{(w)}$  to the AP

As shown in Algorithm 1, the coordinator monitors  $u_c^{(w)}$  so as not to exceed  $\tilde{u}_c$  according to the following procedure:

- The related parameters are initialized as follows:  $u_c^{(w)} = 0$  and  $\tilde{u}_c$  is set by . Then introduce two new parameters: A BUSY flag to indicate whether the channel is busy and  $t_D$  to guarantee  $D_{max}$ . set BUSY = false and  $t_D = 0$ .
- Coordinator  $c$  monitors the channel to observe the current channel utilization and the received signal strength from each Wi-Fi node. If it is BUSY = false.
- If  $u_c^{(w)} > \tilde{u}_c$ , the coordinator sets BUSY = true and  $t_D = \text{Current\_time}() + D_{max}$ , and the total utilization to  $\text{sum} = u_c^{(w)}$ .
- Otherwise, the coordinator increments the number of observations,  $N_c$ , and computes  $\text{sum} = \text{sum} + u_c^{(w)}$ . Then, if the average channel utilization  $\text{sum}/N_c$  is smaller than the maximum allowable utilization  $\tilde{u}_c$ , the coordinator sets BUSY = false.
- If BUSY = true and  $\text{Current\_time}() \geq t_D$ , the coordinator sorts the MAC address list of the Wi-fi nodes in descending order of received signal strength observed at coordinator  $c$ ,  $P_{c,j}^{(w)}$ . Then, the coordinator sends the list and  $\tilde{u}_c$  to the AP.

**Algorithm 2** Adaptive Load Control in an AP

Receive  $\tilde{u}_c$  and the MAC address list from coordinator  $c$

```

 $u_a^{(w)} = 0$ 
for  $\forall j \in A_c^{(w)}$  do
     $u_a^{(w)} = u_a^{(w)} + u_j^{(w)}$ 
end for
while  $u_a^{(w)} > \tilde{u}_c$  do
     $u_a^{(w)} = u_a^{(w)} - u_j^{(w)}$ 
end while

```

Upon receiving a message including  $\tilde{u}_c$  and the MAC addresses from coordinator  $c$ , the AP performs the following procedure (see Algorithm2)

- The AP sums the channel utilization of Wi-Fi node  $j \in A_c^{(w)}$ ,  $u_j^{(w)}$  (denoted as  $u_a^{(w)}$ ), the type of Wi-Fi traffic being determined with the use of traffic classification.
- If  $u_a^{(w)} > \tilde{u}_c$ , the AP conducts a search to identify the node generating NRT traffic from the top of the MAC address list. The AP then sends a control message to the identified node and removes it from the list, and the AP updates  $u_a^{(w)}$  by subtracting the utilization of the throttled node. If, after the update,  $u_a^{(w)} > \tilde{u}_c$ , the AP finds the next node from the list and sends a control message to make it delay its transmissions. This process continues until  $u_a^{(w)} \leq \tilde{u}_c$ .
- Every node that receives a control message from the AP starts a timer that expires after  $T_c$  seconds and delays NRT data transmission until the timer expires

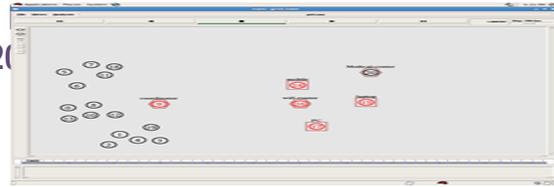


Fig.2 simulation scenario of node placement in WBAN

In figure 3 the coordinator node 9 will send the packets to all cluster sensor nodes and also it will send packets to Wi-Fi router and the Wi-Fi router is connected to mobile, PC and laptop.



Fig.3 Normal data transmission in WBAN

#### 4.SIMULATION RESULTS AND DISCUSSION

##### 4.1 SIMULATION SETUP

In this project use NS-2 (v-2.35), a network simulation tool to simulate Wireless Body Area Network. NS2 is discrete event simulator and which is developed by the University of California in Berkeley. Table 1 shows the simulation parameter and its value.

Table 1. Simulation parameter and its value

Simulation parameter	Parameter value
Network range	1600x*900y
MAC layer	802.11
Topology	Mesh Topology
Protocol	DSDV
Number of nodes	21
Application type	Constant Bit Error Rate
Simulation time	50sec
Number of nodes in human body	15
Initial energy	100J

##### 4.2 SIMULATION ENVIRONMENT

Equations Fig.2 represents the stimulation scenario, which has 21 nodes and it is randomly placed and the coordinator colour is red with hexagonal of node 9 will send the root discovery packet to cluster sensor nodes 2,3,4 and 19 then cluster sensor nodes 0,8,10,12 and 13 after that cluster sensor nodes 3 5,6,7,11 and 18 these 3 clusters sensor nodes are mesh topology. The node 14 represents the mobile node 16 refers to Wi-Fi router and node 15 and 17 are laptop and PC. Node 20 is medical canter These are user nodes.



Fig.4 Generation of packet loss in this node14

##### 4.3 PACKET DELIVERY RATIO (PDR)

It is defined as the ratio between numbers of packet received to the number of packets send. PDR is measured in percentage.

$$PDR = \frac{\text{Number of packet receive}}{\text{Number of packet send}}$$

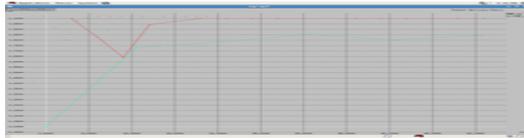


Fig.5 Packet Delivery Ratio

Figure 5 shows the PDR value in WBAN. The value of PDR is very high when compared with existing method. Figure 5 indicates the ratio of packet delivery is not same at all the time. In based packet delivery ratio is maximum (above 95%) at 50s, 40s and minimum value (64%).

#### 4.3 END TO END DELAY

End-to-end delay or one-way delay refers to the time taken for a packet to be transmitted across a network from source to destination

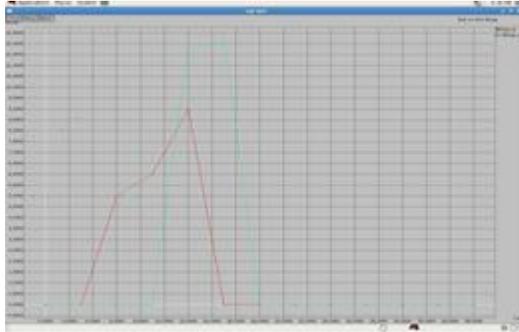


Fig 6. End to End Delay

Aim to improve the delay performance of the ZigBee network by controlling only the Wi-Fi traffic generated from delay-tolerant applications so that delay-sensitive Wi-Fi traffic remains uninterrupted. The delay induced in existing method for 60 and 70ms for cluster sensor nodes and then proposing method for delay decrease in 25 to 35ms.

## 5 CONCLUSION

The performance of adaptive load control algorithm in ZigBee based WBAN/Wi-Fi coexistence environments in terms of the transmission delay of ZigBee packets from a ZigBee sensor to a coordinator. Most ZigBee channels overlap with IEEE 802.11 Wi-Fi channels, resulting in increased delays for ZigBee packets due to interference. To solve this problem, proposed an adaptive load control algorithm that controls only the Wi-Fi traffic generated from delay-tolerant applications dynamically with the aim of guaranteeing that the delays experienced by ZigBee sensors do not exceed the maximally tolerable delay period. Also analyzed the PER in ZigBee-based WBAN/Wi-Fi coexistence networks and the delay from a ZigBee sensor to the coordinator while considering the effects of interference from the ZigBee network and other Wi-Fi networks. In addition, the traffic classification is presented to classify applications. The simulation results that the proposed algorithm guarantees the delay requirement for ZigBee sensors.

## References

[1] Yufeng Zhan, Yuanqing Xia, Mashood Anwar, "GTS size adaptation algorithm for IEEE 802.15.4 wireless networks" journal homepage: [www.elsevier.com/locate/adhoc](http://www.elsevier.com/locate/adhoc) September 2015.

[2] M. N. Deylami and E. Jovanov, "A distributed scheme to manage the dynamic coexistence of IEEE 802.15.4-based health-monitoring WBANs," IEEE J. Biomed. Health Informat., vol. 18, no. 1, pp. 327–334, Jan. 2014.

[3] Essafi Sarra, Hassine Mouncla, "Coexistence Improvement of Wearable Body Area Network (WBAN) In Medical Environment," IEEE ICC- Wireless Communications Symposium, 2014.

[4] Byeong-Moon Cho and Kyung-Joon Park, "Contention Window Adaptation for Coexistence of WBAN and WLAN in Medical Environments."- ICTC 2014.

[5] Gayatri Pawar, Shradha Pawar, "Telemonitoring in Healthcare System Using Sensor Nodes," International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae., Volume 4, Issue 9, September 2014.

[6] X. Zhang and K. G. Shin, "Cooperative carrier signaling: Harmonizing coexisting WPAN and WLAN devices," IEEE Trans. Netw., vol. 21, no. 2, pp. 426–439, Apr. 2013.

[7] Zenghua Zhao, Xuanxuan Wu, Xinyu Lai, Jing Zhao, Xiang-Yang Li, "ZigBee vs WiFi: Understanding Issues and Measuring Performances of IEEE 802.11n and IEEE 802.15.4 Coexistence," NSFC (National Natural Science Foundation of China) under Grant No. 61172063- 2014 IEEE.

[8] S. Rashwand and J. Mistic, "Two-tier WBAN/WLAN healthcare networks; priority considerations," in Proc. IEEE Global Telecommun. Conf., 2012.

[9] J. Mistic and V. B. Mistic, "Bridge performance in a multitier wireless network for healthcare monitoring," IEEE Wireless Commun., vol. 17, no. 1, pp. 90–95, Feb. 2010.

[10] J. Mistic and V. B. Mistic, "Bridging between IEEE 802.15.4 and IEEE 802.11b networks for multiparameter healthcare sensing," IEEE J. Sel. Areas Commun., vol. 27, no. 4, pp. 435–449, May 2009.