IEEE 802.15.6 Superframe Adjustment By Using Drop Packet Estimation Technique

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***Abstract*—Wireless Body Area Network (WBAN) is a low power sensor network that operates in a close vicinity of human body. The network typically expands over the entire human body in which bio sensors are connected with a central controller (Hub) through a wireless communication channel with the purpose to monitor healthcare application in particular. IEEE 802.15.6 is specifically released for WBAN to support the wireless communication for human proximity. IEEE 802.15.6 MAC has well defined superframe structure for communication of hub and biosensors. It assigns a fixed duty cycle at the start of the superframe. In this paper, we propose a novel scheme for dynamic adjustment of superframe for IEEE 802.15.6 called drop packet estimation technique. The scheme adjusts the duty cycle based on packet drops to reduce the wastage of communication channel. The simulation results show that by increasing the EAP phase time on the basis of emergency traffic, packets reception rate is increased by 10%.**

Keywords— IEEE 802.15.6, Superframe, duty cycle, and drop packets;

I. INTRODUCTION

A wireless body area network (WBAN) is a special type of network mainly designed to monitor physiological states of patient. It comprises of sensors (on-body and in-body) to monitor physiological states such as heartbeat, glucose level, blood pressure and body temperature [9]. The history of WBAN is traced back to 1995 when Personal Area Network (PAN) was used to execute communications on or / and around human body. The rapid growth in development of technology brought the wireless communication entirely within, on and in a human body range [9]. Now days, A BAN uses PAN technologies as gateways to provide access to physician over internet. The physician observes patient's data online and responds accordingly.

The IEEE community released a separate standard IEEE 802.15.6 that support prioritized traffics and very reliable wireless communications within the proximity of human body. As a body centered network, the energy of nodes is strictly restrained since they are battery powered. The communication range of sensor nodes is 3 m having various data rates from 10 kbps to 10 Mbps depending upon the application's requirement [10].

IEEE 802.15.6 defines a fixed superframe structure of 0-255 allocation slots numbered as 0,1…. as time axis. This time axis has beacon periods of same length. A hub is responsible to provide access to phases in each active superframe. It also maintains I inactive superframe after each active superframe. Typically, a hub is uses three modes for accessing to specified phases. These are beacon mode with superframe, non-beacon mode with superframe and Non-beacon mode without superframe. This paper focuses on beacon mode with beacon period as it has three well defined access phases. i.e. Random Access Phase (RAP), Exclusive Access Phase (EAP) and Managed Access Phase (MAP) followed by B2 and CAP as illustrated in Figure 1 [11]. EAP is used to deliver emergency traffics of highest user priority and RAP is used to deliver normal / regular as well as emergency traffic whereas MAP is reserved for control / management frame transmission.

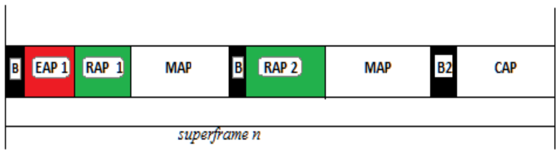

Figure 1:Superframe Structure

The allocated slots in a beacon period result in wastage of communication channels especially in EAP1 and EAP2 when there are no emergency traffics. The channel is always idle for pSIFS within the RAP, CAP and UP<7 (for not an emergency), or within phases and UP=7 (for an emergency). Time duration between the start and end is sufficient to deliver a frame [12].

This paper presents a novel scheme called drop packet estimation technique with the aim to avoid the wastage of communication channels if there is no emergency traffic by using dynamic allocation of slots in superframe structure. The paper is organized into four sections. In Section I, introduction of WBAN and its standard is given. Section II provides an overview of drop packet estimation technique and section III presents the related work whereas in section IV simulation results are presented in detail.

I. OVERVIEW OF IEEE 802.15.6

IEEE 802.15.6 Designed a network for human body area which works in a close vicinity. It monitors human body via sensors placed on it. A star topology network is formed which ha centrally communicating device known as HUB. The IEEE 802.15.6, defines PHY layers, i.e., NB, UWB, and HBC layers. On above physical layer the IEEE 802.15.6 defines a MAC protocol that controls access to the channel. In WBAN nodes are connected inside/outside the human body. The basic architecture of WBAN is shown in figure 1:

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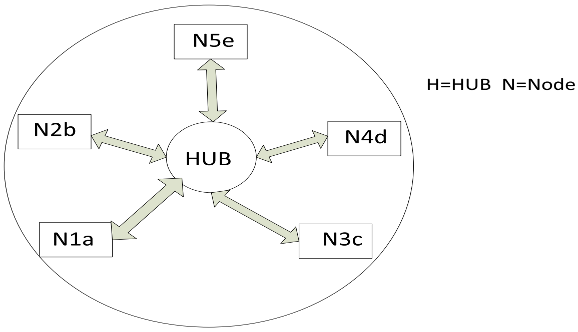

Figure 2: Architecture of WBAN

In WBAN all nodes and hub establish a time reference base model and their medium access is scheduled in time where time axis is divided into beacon periods of equal length and each superframe is composed of allocation slots of equal length Communication in WBAN is possible by the use of superframe structure [6]. Superframe structure can be between 0 – 255.

A Hub shall operate in one of the following three access modes [6].

1. Beacon mode with beacon period
2. Non-beacon mode with superframe
3. Non-beacon mode without superframe

A superframe operates in one of the three modes. Work of this research is focus on one mode that is beacon mode with beacon period.

II. RELAED WORK

In [1], hybrid and secure MAC protocol for WBAN is introduced in which beacons are transmitted at the end of superframe using beacon enabled mode. In this scheme, nodes are also prioritized by priority-guaranteed CSMA/CA procedure CAP period. In [2], presents the low power MAC protocol for communication of master and slave nodes. Master node plays a very important role in IEEE 802.15.6, acquires and controls data from slave nodes. The number of nodes are increased accordingly to improve MAC protocol and energy consumption rate and to solve the addressed problem. It uses superframe structure and Type-I/II period for large data transmission. The energy wasting problem is solved by minimizing the frequency / use of type-I/II phase and to changing state of node. In [4], focus on emergency data services delivery it is an important issue in medical environment. Emergency message require minimum channel access delay. IEEE 802.15.6 proposed an adjustable superframe structure that consist on CFP and CAP in short superframe to satisfy the channel access delay. The use of long superframe may result in increase of channel access delay. Medical Emergency Body (MEB) is introduced to solve the channel access delay in long superframe by dynamic insertion of listening window to minimize delay of channel access by emergency traffic. In [5], proposes IEEE 802.15.4 MAC scheme for handling of emergency events. It handles by modifying the inactive part of superframe structure. For this purpose, the inactive part is divided into three new periods in such a manner to provide exchanging state of new and inactive periods. In [6], IEEE 802.15.4 Beacon enabled mode is enhanced in which active period is dynamically adjusted using prior traffic information. Clear Channel Assessment (CCA) in IEEE 802.15.4 is used to determine the network traffic and to improve energy efficiency and data throughput.

III. DROP PACKET ESTIMATION TECHNIQUE

The adjustment of three phases (EAP, RAP and MAP) in beacon-enabled mode is a challenging task for researchers as their adjustments always based on the application requirements. In this paper we present a novel scheme for dynamic adjustments of time of access phases in superframe structure by drop packet estimation technique. In this scheme, sender calculates the time for packets sent and decides how much time they acquire based on drop packet estimation. Upon receiving this time Hub adds this time to its existing phase time that results in increasing packets reception ratio.

In this scheme, each individual node is responsible for time estimation of packets generated and dropped through which they calculate the amount of time required for the completion. The equations for time calculations and packet drop estimations are given as under:

A. Equations

Eq (i) calculates superframe length in seconds:

$$T_{SF} = nSlot \times T_{slot} \quad \text{(i)}$$

Eq (ii) calculates the requested allocation slot length i.e.

$$T_{slot} = (pAllocationSlotMin + L \times pAllocationSlotResolution) \quad \text{(ii)}$$

These below mentioned Eqs calculates single packet time, required time, roundoff time which are used to calculate the New phase time:

$$single_{pkt_{time}} = \frac{(Current_{time} - Superframe_{boundary})}{Generated_{pkts}} \quad \text{(iii)}$$

$$Required\ time \ = \ single_{pkt_{time}} * drop\ pkts \quad \text{(iv)}$$

$$Roundoff = roundNo\ (Required\ time) \quad \text{(v)}$$

$$New_{phaseTime} = Exsisting_{phaseTime} + Recieved_{Time} \quad \text{(vi)}$$

The required time calculated by above mentioned equations is transmitted to the HUB after EAP period. Upon Reception of this packet HUB compares its current phase time with its existing phase time and make decission either to increase its phase time or not. If the received time is greator than 5 we make it 5. The reason we make 5 our threshold value is the maximum length of a superframe. According to IEEE 802.15.6 the maximum length of any superframe can no more than 32.64 seconds. To achieve this much of duration we have to take 255 slots while keeping the value of L to 255.

Now HUB updates its phase time and send it to the network via beacon frame in next beacon period. This is the same beacon which is broadcasted to the BAN in the start of each superframe, so that WBAN nodes can get the information regarding their transmission time in respective phases. When we are increasing EAP1 phase timing in the same time we are decreasing RAP1 phase timing by using equation below:

$$Deducted_{Slots} = Recieved_{Time} \div T_{slot} \quad \text{(vii)}$$

This same procedure applies on the EAP2 and RAP2 phases.

IV. RESULTS AND DISCUSSION

This section presents simulation results of the proposed scheme. The simulation is performed on OPNET simulator by using parameters listed in Table 1. The analysis is compared with IEEE 802.15.6:

Table 1. Simulation parameters

S. No.	Parameter	Details
1.	Network Topology	Star
2.	No. of source nodes	10
3.	No. of sink nodes	01
4.	Node Placement	Fixed
5.	Area of Simulation	3m x 3m
6.	Simulation time	450 seconds
7.	Emergency Traffic Packet Size	1600 bits
8.	Regular Traffic Packet Size	800 bits
9.	Traffic Load (Packets/Second)	250
10.	Buffer occupancy	25
11.	No of retries	03
12.	pAllocationSlotMin	500µs
13.	pAllocationSlotResolution	500µs
14.	nSlots	1-256
15.	Slot Length (L)	0-255

Two parameters: Packet Delivery Ratio (PDR) and Throughput are used as network performance metric. Star topology network model is formed which has 10 nodes centrally connected through the HUB as shown in below Fig 3

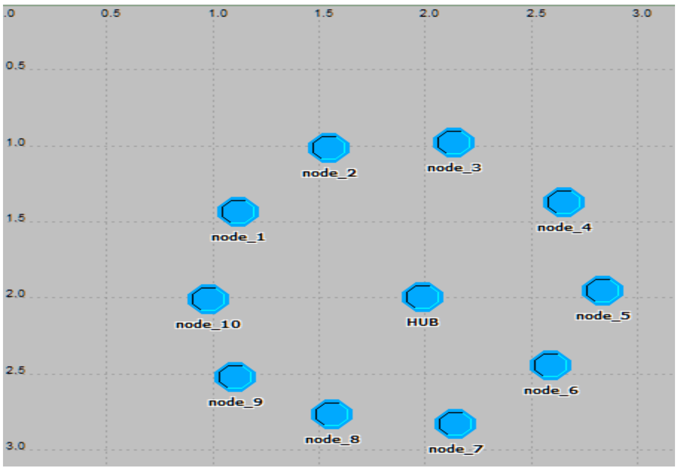

Figure 3: Network Topology

IEEE 802.15.6 superframe is designed in such a way that each phase has some implications attached to it. As non-emergency traffic cannot flow in EAP phase whereas emergency traffic can flow in RAP phase if the current duration of superframe is in RAP phase and emergency traffic arrives. At the start of WBAN network its phase duration is fixed by the network which we can't change during the coarse of transmission. This shows static behaviour in all the concurrent superframes in a BAN and it lacks in to entertain the crictical traffic events which are generated randomly by the nodes. In our proposed scheme we try to address this behaviour and make it dynamic by using drop packet estimation technique. The following graph shows phases time with reference to each superframe. IEEE 802.15.6 shows static behaviour interms of phases timing whereas our proposed scheme shows dynamic behavioural change in phases time by using estimation calculation of drop packets. It calculates the network requirement of the emergency traffic being sent by the sender nodes of the WBAN in restricted star tree topology where all the BAN nodes are connected to centered device known as HUB.

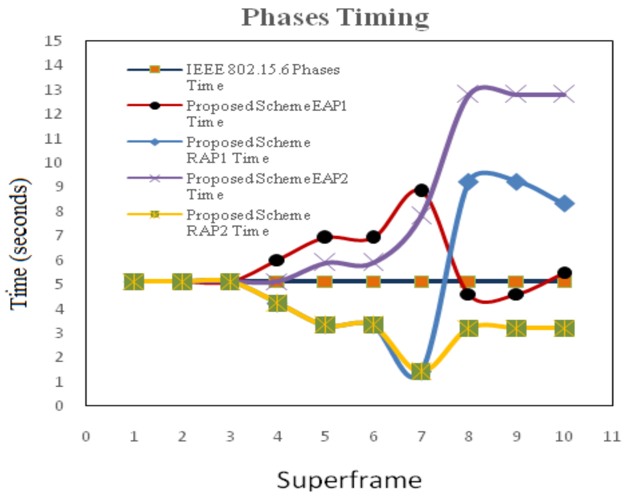

Figure 4: Superframe Phase Timing

In Fig 4 EAP1, RAP1, EAP2 and RAP2 phase timing is shown. Comparison is shown between the IEEE 802.15.6 implementation and our proposed scheme. As in IEEE 802.15.6 once the timing is communicated to the nodes in the beginning of the WBAN establishment it can't be changed during the course of the communication whereas, in our proposed scheme we can change its time by the estimation calculation of the drop packet. By using the scheme, we can see that its PDR is increased and more emergency traffic is entertained by the network which was wasted earlier.

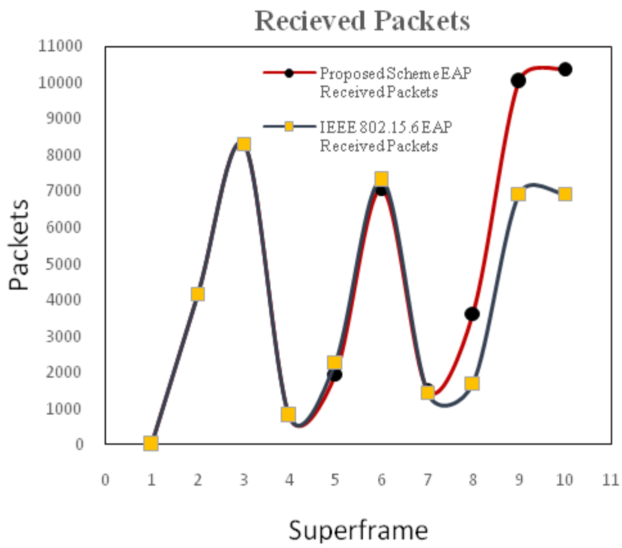

Figure 5: Packet Reception of Proposed Scheme and IEEE 802.15.6

In above figure packet reception is shown during the course of transmission.Comparison is shown between the IEEE 802.15.6 and proposed scheme. Our scheme reflects the decrease and increase in packet delivery ratio based on the adjustment of phase time using drop packet estimation.

We ran 350 seconds simulation and observed that as the communication goes on our proposed scheme shows better results in terms of received packets.PDR is increased which eventually improve network performance.

Table 2:Data Generation Schedule Parameters

	UP7		UP5		UP3	
MSDU Interval Time (seconds)	0.004		0.004		0.004	
MSDU Size (bits)	1600		800		400	
NODE 01	50 sec	150 sec			350 sec	400 sec
NODE 02			150 sec	200 sec		
NODE 03	50 sec	150 sec				
NODE 04			150 sec	200 sec		
NODE 05	150 sec	200 sec				
NODE 06	350 sec	400 sec			200 sec	250 sec
NODE 07	150 sec	200 sec				
NODE 08			200 sec	250 sec		
NODE 09	250 sec	350 sec				
NODE 10					250 sec	350 sec

Figure 5 shows the average throughput of proposed drop packet scheme and IEEE 802.15.6.As it is seen that after 150 seconds of simulation throughput increases gradually with respect to data generation.The only reason its not increasing during first 150 second is that only two nodes are generating traffic of same user priority which in this scenario is 7.So when the traffic fluctuates interms of different priorities throughput is increased.

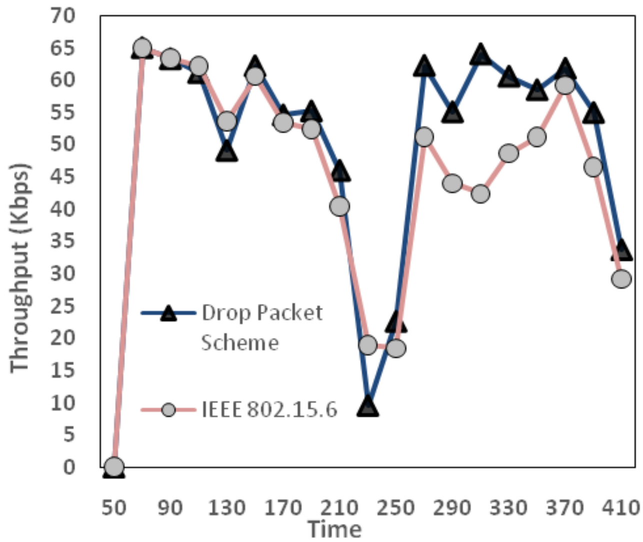

Figure 6: Average Throughput of Proposed Scheme and IEEE 802.15.6

CONCLUSION

IEEE 802.15.6 MAC layer has well defined superframe structure. The superframe structure is consists of fixed time slot in three different access phases. The access phases are designed in such a way to handle WBANs traffic of different priority. However, the fixed phase time for each traffic results in wastage of communication channel. For example, if there is no emergency traffic then the allocated slots in EAP is wastage of channel. In this paper, we presented a novel scheme which dynamically adjusts the time of access phase based on the drop packets by the sender. We have done simulations in Opnet and compared our scheme with the standard IEEE 802.15.6. It is concluded that our scheme provides better results for packet delivery ratio and throughput than IEEE standard 802.15.6.

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