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An Emergency MAC Protocol in WBAN

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Abstract*— A wearable Wireless Body Area Network (WBANs) is an upcoming technology which has widely accepted for variety of healthcare applications for healthcare monitoring. This allows the researchers to exploit the different research problems and its related solutions. The typical requirement of Medium Access Control (MAC) which handles an emergency situation is the key requirement. MAC protocol used in WBANs must satisfy the need of every service, especially when one needs reliable and immediate service in case of emergency. This paper presents efficient MAC protocol for emergency handling in WBANs based on existing MAC protocols such as 802.15.4. Our proposed MAC scheme uses priority mechanism where a channel will be allocated immediately by the coordinator as early as possible. The proposed MAC protocol has been simulated with various test cases. The obtained results are analysed and compared using NS-2 Simulator. The result shows that the delay in getting prioritised events channelized thru' the improved MAC has been increased by 60% in comparison with existing system.

***Keywords*— Wireless, WBAN, MAC**

I. INTRODUCTION

The concept of WBAN is an extension of the wireless sensor network consisting of various networks as well as miniature wireless devices enabling the remote monitoring of person body functionalities and corresponding environment. Technological advancements in wireless communications, sensors, low-power integrated circuits have enabled the design of economically viable miniaturized sensor nodes that can measure vital physiological parameters. For remote health monitoring, these sensor nodes can be seamlessly integrated into wireless body networks WBANs. By providing inexpensive, non-invasive, continuous, ambulatory health monitoring WBAN can transform health care, and with almost real time updates of medical records via the Internet. Figure 1 shows the example of health monitoring system using the concepts of WBANs. The system spans a network comprised of individual health monitoring systems in WBAN. First tier is of sensor nodes that connect with a Personal Server (second tier) which in turn communicates to the top of this hierarchy i.e. a medical server tier.

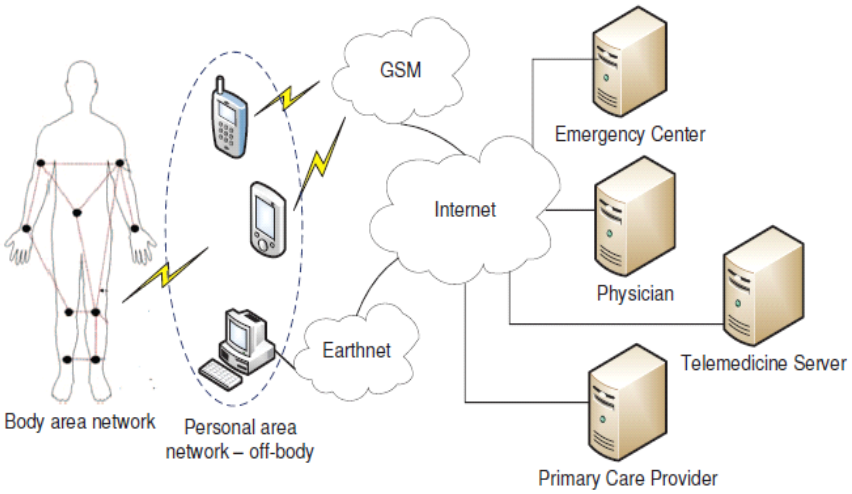

Fig 1: Healthcare System Example of WBAN [1]

To regularly generate the medical data at low data rate is the characteristics of medical applications. For network configuration of medical sensor devices, MAC protocol i.e. IEEE 802.15.4 is preferred. Protocol suitable for WBAN is required to monitor patient condition in real time sending emergency data of patient rapidly, and thus must ensure reliability of medical data and be able to send diversified data including CE application data.

The rest of the paper is organized as follows: The requirements of WBANs and related MAC protocols are discussed in Section II. Section III describes IEEE 802.15.4 MAC protocol. In Section IV, we describe the proposed emergency handling scheme and its performance is evaluated in Section IV. Finally, Section V highlights our conclusion and future work.

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II. RELATED WORK

The WBAN technology has been inherited from the wireless sensor network. However there will be an urgent attention required to handle the emergency situations in terms of allocating channel without any wait. Also energy efficiency is the most important attribute of MAC protocol for WBAN. Other important factors are delay, throughput, and network adaptability according to changes in topology, bandwidth utilization. For WBAN a good MAC protocol must ensure Quality of Service (QoS). For emergency situation, the MAC protocol must quickly access the channel to send the critical data to the coordinator. Therefore implementation of a diversified MAC in power –efficient traffic is required. Several studies have been conducted to solve the issues of IEEE 802.15.4.

Smita et. al. has suggested a WBAN MAC [1] Protocol based on Aloha protocol which differentiates and preferred various types of traffic based on emergency case.

To enhance the GTS mechanisms, the authors in [5],[6],[7] have proposed additional GTS allocation schemes on CFP (Contention free period). CFP increases with increase in GTS slots. The immediately delivery of emergent data cannot be achieved under CFP. The authors in [8] proposed special slots within the intervals of GTSs called 'Preemptive slots allocation' which provide fast and premptive data transmission slot (DTS) and non-preemptive emergency transmission slot (ETS) transmission. The authors in [9] proposes a traffic load aware MAC protocol ATLAS where the superframe structure varies based on the estimated traffic load and accordingly it uses a multihop communication pattern. But it also does not take the priority of different applications into account.

To ensure packet delivery with the least possible delay and the highest reliability, authors in [10] have proposed McMAC, emergency packet handling mechanism. Apart from the emergency handling schemes in WBAN[11][12][13], we introduce an emergency handling MAC scheme that strengthens the IEEE 802.15.4 MAC by reducing the emergency reporting delay in WBAN thereby providing the reliable data transmission method for emergency events.

III. IEEE 802.15.4 MAC PROTOCOL

The IEEE 802.15.4 MAC architecture provides three network topologies; star, peer-to-peer and cluster tree. For the healthcare services around the human body, star topology will be the most applicable topology considering the network coverage within the several meters. WBAN coordinator and sensor devices are usually attached on the human body and configure single network.

In beacon-enabled mode, the Superframe of IEEE 802.15.4 is consists of beacon, contention access period (CAP), guaranteed time slot (GTS), and Inactive interval as shown in figure 2.

CAP will be used for management and data frame transmissions which utilize contention avoid mechanism of Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). GTS is a useful mechanism for the periodic data transmission during dedicated time slot without loss of packets caused by collision. The PAN coordinator receives GTS request message during the CAP and allocates the time slots in GTS period. After the GTS for devices is allocated for specific time slots, the device or coordinator send data without using contention access mechanism. Since the transmission direction should be assigned during GTS request period, only one-way communication is allowed with acknowledgement. GTS allocation may occupy several time slots according to the request of device. IEEE 802.15.4 standard defines four frame structures: Command frame, Beacon frame, data frame and ack frame.

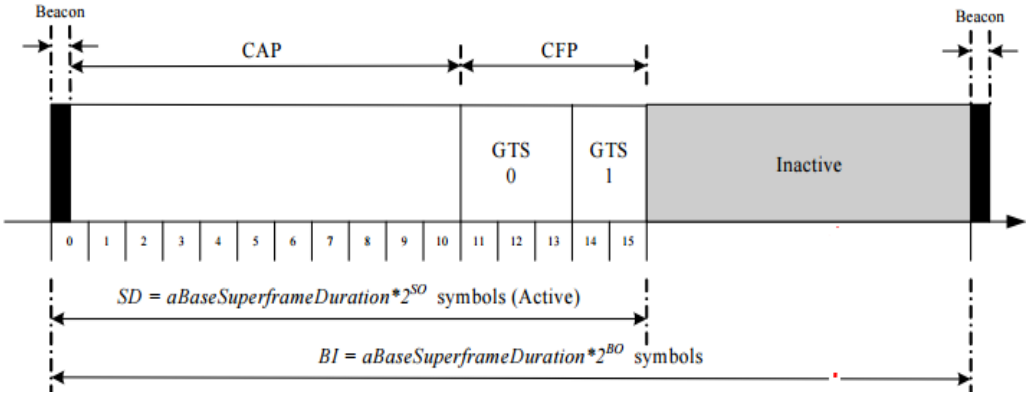

Fig.2. Superframe structure in IEEE 802.15.4 [3].

IV. THE PROPOSED MECHANISM

In existing IEEE 802.15.4, nodes that failed in the CAP section contention were passed to the next cycle and a section in which emergency data is transmitted separately is not provided. In a situation where urgent and general data compete for channel allocation, the emergency data should be transmitted within the maximum transmission delay of 125ms by principle and non critical data within 250ms.

To implement the priority based data transmission procedures, we change the way the frame formats are filled at respective emergency data sending nodes.

Beacon frame is responsible to keep non transmitting stations in waiting state, depending on which sleep scheduling at respective nodes are configured. Following steps are performed for our mechanism:

Step 1: To achieve emergency data handling, priority bit in beacon frame is modified accordingly. If the data is critical then this bit is 1 else set to 0 for non critical data. Figure3 shows modified Beacon Frame format.

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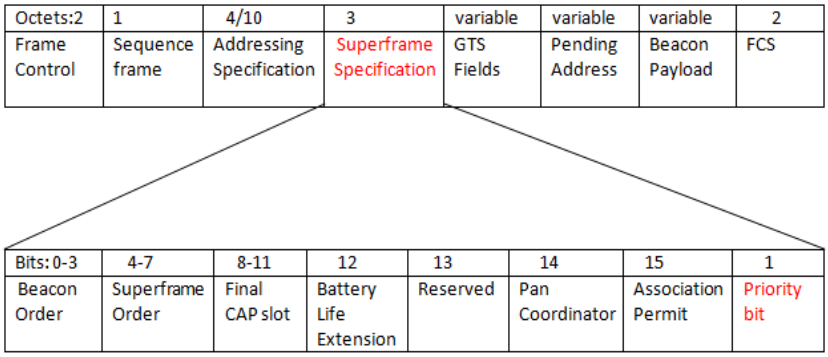

Fig 3. Modified Beacon Frame

Step 2: On Receiving Beacon frame, several nodes transmit their data by setting their priority bit to 0 or 1. If the data is more critical then priority bit set as 1 otherwise less critical data is coming, priority bit set as 0.

Step 3: According to the priority bit of the beacon frame, coordinator performs following steps:

1) If get higher priority data then send this data over the channel.
2) Apply first in first out (FIFO) algorithm if received the number of nodes with priority bit 1.

V. PERFORMANCE ANALYSIS

The below table shows the topology where 20 nodes are considered including the coordinator. Every node will be sending a beacon which will indicate an event or casual data taken and the coordinator has to pass on the data. Our outcome shows that there is a significant improvement in event reporting time.

Table 1 Prioritised events

No of nodes	No. of events coming to coordinator	Prioritized event reporting delay(ms)	Non-prioritized event reporting delay (ms)	Improvement in event reporting delay(ms)	Improvement in event reporting delay (%)
20	3	345	743	398	46.43
	8	489	899	410	54.93
	12	566	1230	664	46.01
	15	590	1340	750	44.02

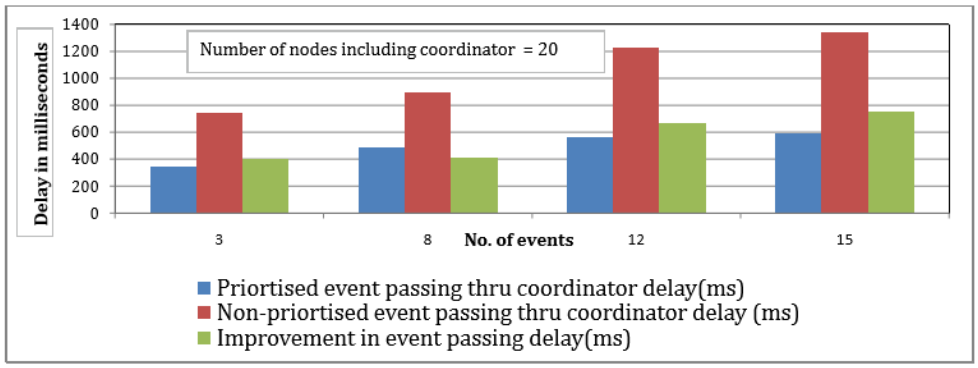

Fig 4. Improvement in event reporting delay

The graph shows a relation between prioritised event passing/reporting delay and non-prioritised passing / reporting delay.

VI. CONCLUSION

In this paper, we have proposed emergency handling scheme for WBAN using the concept of modification in Beacon Frame.It can be applied to Superframe structure of IEEE 802.15.4**.** Our result shows a significant improvement in event passing delay. The delay has been increased by average 50 % which will be help the healthcare applications to take emergency actions and many times may save even a patient's life.

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