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A Review on Dynamic Buffer Traffic Condition Protocol in Telemedicine

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ABSTRACT

Various MAC-protocol has been adopted over the years in Telemedicine, also known as Wireless Body Area Network system (WBANs), to enhance the proper transmission of the busy congestion of data message. However, these techniques could not coordinate traffic congestion in the receiver node, which could make the receiver nodes experience an "active mode" most of the time compared to the transmit node. This is dangerous to the network system because of uncontrollable energy usage. In this protocol, the intelligent sensor is strategically located around or implanted in the human body for the collection of human body physiological parameters. WBANs experienced some limitations such as latency and excessive consumption of energy which may hinder the lifetime maximization of the system if not taken care of properly. In this work, four elements are responsible for carrying-out only traffic data, and they are implemented by using the highest priority sensor nodes within a short period used for communicating to the Buffer Traffic Condition (BTC) discussed and the traffic measurement to mitigate active-mode interval in the receiving phase of the improved superframe structure of IEEE 802.15.6. Furthermore, meaningful information about the superframe to mitigate the busy traffic and enhance this protocol was also discussed as its possible functions with the help of an adaptive system. No article depicts the analysis of the work on the dynamic buffer traffic condition scheme, and this proposed scheme can improve on the existing one.

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1. INTRODUCTION

The WBANs technique adopts the application of intelligent sensor nodes placed on the human body accompanied by an external coordinator (Anwar et al., 2018; Fujimoto et al., 2018; Manzoor et al., 2012). The body transceiver nodes collect the patient body's vital signals, like the heartbeat and sugar level (Awan et al., 2016). Sensor nodes transmit the sensed parameters of the patient to the medical personnel for onward analysis via the Sink node (Hasan et al., 2019; Rezvani, 2012; Tachtatzis et al., 2012). This technique deploys a functioning part by offering well-being services both in the family and in the hospital by pinpointing illness associated with the sick person, thereby ensuring rapid attempts for health situation (Kirbas et al., 2013; Qureshi, Bashir, et al., 2020). This is done by continuously receiving and transmitting the vital physiological signal of the patient (Choi & Kim, 2014; Jovanov et al., 2005; Maman et al., 2013; Pegatoquet et al., 2019). A hub is usually used to transmit power, also as a storage buffer and processing power, whereas the body sensors are limited in terms of power because of their size (Ahmad et al., 2015). Various body transmitter nodes are applied for sensing various disease issues. These sensor nodes receive these body parameters in wireless form (Alam et al., 2016; Rahim et al., 2012). These body vital signals are received when the sick person is either in regular data or critical data situation where the doctor will be able to have an improved health observation on these illnesses (Iyobhebhe et al., 2022), as long as the sink node is can utilize the available communication technology such as WiFi, 4G, etc. to transverse these data to the medical service (Nguyen et al., 2014; Salayma et al., 2017) as shown below in **Figure 1**.

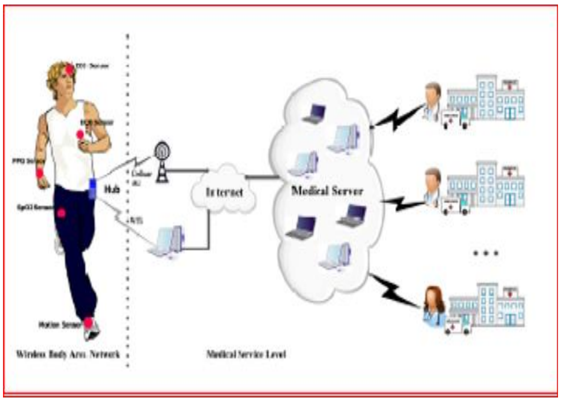

Figure 1. WBAN Architecture

There are some issues to be worked on regarding the development of the techniques (Mohamed et al., 2019; Nguyen et al., 2014; Salayma et al., 2017). Considering the connection that brings the sink and human sensor transmitter together in the Wireless Body Area Network system is characterized dynamically due to postural movement and variation (Awan et al., 2016; Kim et al., 2015; Qureshi, Idrees, et al., 2020; Venkateswari et al., 2015). That medium variation may result in attenuation of a signal with variables linking the hub, and the intelligent sensor nodes are not just organized because of distance but factors such as various body segments and postural body movement (Awan et al., 2016; Marinković et al., 2009). Any time the body posture and environment change, the link's quality may also change (Siddiqui et al., 2018; Sun et al., 2017). A dynamic link must be coordinated with the WBAN system. Secondly, because of the light weight of the body sensors (Li & Tan, 2010; Tachtatzis et al., 2012), they have a tiny size; hence, resources like transmitting power (Esteves et al., 2015) and processing power are limited as juxtaposed to standard wireless sensor (Salayma et al., 2017). Finally, the body parameters gathered through the body sensors can be transverse conveniently from humans to the Sink, and an uncontrolled latency of such body vital signs might result in a mishap (Cai et al., 2015; Tachtatzis et al., 2012).

This scheme draws the recognition of researchers to handle numerous challenges and issues which entail: delay intolerant communication, handling of traffic heterogeneity, traffic prioritization, and energy efficiency (Cai et al., 2013; Qureshi, Bashir, et al., 2020). Energy constraints characterize medical appliances used for telemedicine. Most sensor nodes operate for decades, that is, some spend up to fifteen years, twenty years, and so on. And then, energy depletion starts setting in. Due to their design, the health apparatus may likely offer some delay when used to transmit data (Ye & Au, 2018; Zhang et al., 2018). Therefore, the health apparatus is grouped into small-driven data rate, average-driven data rate, and excess-driven data rate (Qureshi, Idrees, et al., 2020). In order to have a well-organized data transmission, a "superframe structure by IEEE.802.15.6" is employed (Yessad et al., 2018), see **Figure 2**.

Considering "IEEE 802.15.6," then "the beacon-enabled mode" consist of an additional separate access state.

When working with "beacon mode," the Sink coordinates the accessed stage both in the wake-up and sleep stages. In the wake-up state, there are four states associated with it, they are:

1. Exclusive access phase (EAP): A slot that allows sinks for allotment in the most significant link for more critical users when transmitting.

2. Random access phase (RAP): Allows organizing by the Sink to distribute average data.

3. Managed access phase (MAP): MAP employs selecting state to consider regular, impromptu traffic.

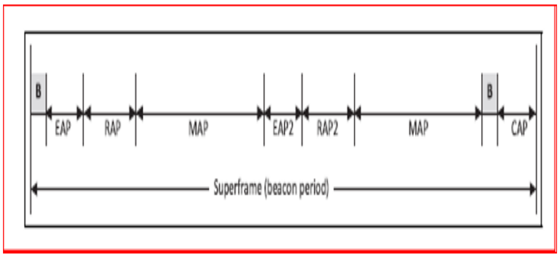

Figure.2. IEEE 802.15.6. Superframe structure.

4. Contention access phase (CAP): A slot given by a sink to a sensor node to deliver regular traffic.

There have been similar prior works on dynamic buffer condition protocol for WBAN (Jung et al., 2012). Concerning this dynamic Buffer Traffic Condition protocol, we integrated it into three MAC techniques:

- Dynamic Access Allotment-operated (DAA) MAC techniques
- Congestion Occupy Measurement-operated (COM) MAC techniques
- Dynamic Active Mode-operated (DMO) MAC techniques

Furthermore, Active–Mode–Mode (DAM) affects direct communications like energy consumption, latency, and the successful packet delivery per unit time.

2. RELATED WORKS

Allocation of resources gains essential attention in the area of dynamic buffer traffic to improve the WBAN of a dynamic buffer traffic condition protocols system characterized by a limited wireless channel resource. The power control system of the transmission coordinates energy utilization to enhance the performance of the WBAN (Awan et al., 2016; Jung et al., 2012; Qureshi, Bashir, et al., 2020; Qureshi, Idrees, et al., 2020; Yessad et al., 2018). In addition, to have a good knowledge of the utilization of power during communication of data messages in exchange for something valuable, especially as part the of compromise for reliability period in adapting wireless channels for power efficiency (Qureshi, Bashir, et al., 2020), coordinate the communication energy which allows the correct data to be received and present it for a set threshold in achieving the trade-off between energy saving and reliability. These articles have examined areas of strength and limitation.

The work (Shu et al., 2015) proposed a protocol that utilized apparatus for monitoring health employing blended MAC that coordinates interventions. In this article, a sizeable superframe was acquired to check the needless data message from the coordinator by the allotments of periodic slots of the transmitter sensor. The "Contention access phase" is solely responsible for activating when lots of data messages must be transmitted.

In the work (Dinh et al., 2018) proposed a protocol that utilized the adoption of power implementation using a technique called Low-Power Listening (LPL) in noisy environments. It was noticed that a lot of energy depletion was taking place in the network due to the sensor node's self-implementation without waiting for the coordinator's regular broadcast as an instruction.

The work by (Song & Hatzinakos, 2007) proposed Low Energy Self-Organizing techniques (LESOP) protocol. A flimsy but well-organized algorithm for administering a targeted determination and the quality-of-service projection is discovered for the trade-off between error tracking and system power.

The work (Dong & Yu, 2017) proposed a protocol named Prediction-Based Asynchronous MAC, which administered well-organized wake–up techniques to minimize energy consumption in the network. It corrects the error in the network instigated by an un-synchronization between clock drift and hardware platform.

This article reviews previous works in these technological-based protocols in the area where there is much inadequacy in terms of energy management, latency, etc. This article examines the drawing line related to proper techniques to minimize the energy that can transform the network lifetime maximization.

3. SYSTEM MODEL

WBANs get their energy via rechargeable batteries; hence a systematic energy supply method is highly needed to keep the network in a constant transmission within the specified period. The body sensor nodes transmit various physiological signs gathered from the human body, transverses them, and carry out performances to the hub depending on the techniques, either directly or indirectly routing it before it reaches the hub, depending on the classes of data it carries. In this case, a dynamic buffer traffic condition protocol has been presented for minimization of energy, latency, and throughput, which translates network system lifetime maximization and efficiency.

3.1. Classification of Data

The vital physiological signs of the body sensor nodes sensed during its transmission activities in the human body are called data. The data received by these sensor nodes are of different types depending on the data's seriousness and life-threatening vital signs.

In respect of this study, we classify these data into two groups: critical data-driven and normal data-driven as shown in **Figure 3**. Critical data-driven are abnormal in health statuses like cardio arrest diseases and high blood pressure, which are life-threatening. Whereas the normal data-driven data regularly monitor health parameters such as body temperature. If the sensor nodes sense and carry critical data, there must be an emergency in the transmission of such information by routing it directly to the hub, and then sending it to the medical personnel for urgent attention to save the patient's life on time.

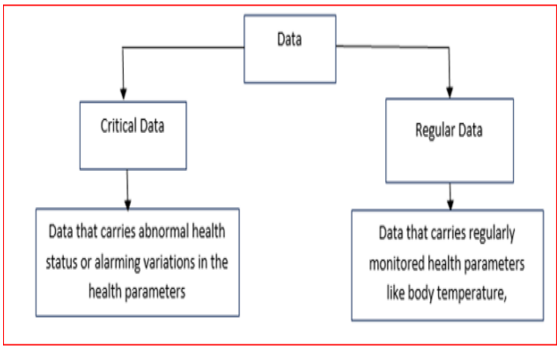

Figure 3. Classification of Data.

If most of all the sensor nodes are classified as critical data-driven, there must be traffic in the wireless channel system of the WBAN in conveying this critical data-driven to the hub. For further analysis on it by the medical personnel to save a patient's life.

3.2. Normal Data

Standard data are data sensed and transmitted by body sensor nodes that carry regularly monitored health status like body temperature, which is a vital physiological sign received from the body by the sensor nodes in attempts to monitor healthcare services; the sensor nodes look out for the first channel that it would send data to, but if find it occupied the sensor node will hold on for a stochastic back off period.

3.3. Critical Data

Critical data carry abnormal health statuses such as high blood pressure. The physiological signs are communicated with an emergency scale and little/no back-off time within a short time. Physiological signs are communicated directly from the transmitting sensor to the hub because of urgency. If body sensor nodes are transmitting critical data, there must be high traffic in the channel to deliver it to the hub, where the medical personnel will act upon further analysis due to the urgency of the data to save patients' life.

3.4. Adaptive Wake-Up Interval (AWI)

Every sensor node in the WBAN system sleeps in the network until there are activities to perform. A sensor node only wake-up when there is a packet to transmit after receiver nodes broadcast. If any data is transmitted, the time to wake up is also determined by the receiver node broadcast, which is already been installed by the receivers' node.

To avoid unnecessary power depletion without the broadcast of receiver node, the hub makes sure the message is delivered to the body sensor and also ensures that it has been set in order to conform to when it must be in the active-mode period for every sensor's subsequent period to be in active by receiver node, thereafter, the sensor could take their sleep- mode at instruction from the receiver node. The active mode transmitter node can respond to the receiver node event abruptly, which also can wake up the sensor in an inactive mode by carrying out minimal power implementation with a reduced delay (Dinh et al., 2018). This will improve network lifetime, reduce delay, energy saving, and throughput.

3.5. Traffic Transmission and Buffer Traffic

When sensor nodes are transmitting data collected from the patient's body, it is worth of note to recognize that three different types of sensor nodes communicate to the hub either directly or indirectly through the forwarder node, depending on the nature of traffic. For example, the sensor node associated with congestion load when transmitting has an urgency to be attended to, it communicates directly to the Sink without intermediary routing. Otherwise, the sensor node transmitting average data will be sent to the forwarder node before reaching the hub, thereby minimizing the networks' energy usage for network system betterment. Assuming the above, the EAP of the superframe makes use of emergency sensor node traffic and the other superframe (CAP and MAP) will use other traffic. The improvement of the "superframe structure of IEEE.802.15.6" by this work is depicted in **Figure 4**.

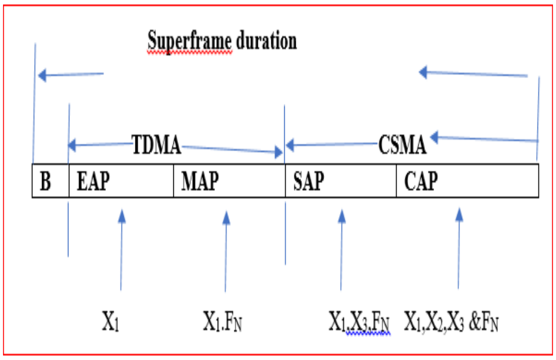

Figure 4. Improved "Superframe structure of IEEE802.15.6."

The improved superframe entails the following states: "EAP," "MAP," SAP, and "CAP" technique, which is responsible for carrying only emergency traffic (X1). "MAP" is responsible for transmitting dependent traffic buffer through forwarder node (F.N.) with (X1) "EAP and MAP" is Time Division Multiple techniques operated while SAP and "CAP" are "CSMA" based techniques. SAP is responsible for granting entry into the wireless channels when transmitting data via emergency cases, a sensor exchanging data using BTS solely for transmitting those parameters within a brief moment. BTS specified the present sensor node's packet capacity in the various sensor nodes' buffer. A particular threshold will be taken to ensure proper processing of data in the node when transmitting data by the sensor node, which culminates in improved energy in the system by not allowing the nodes to process data beyond their nodal capacity throughout reducing delay.

3.6. Mathematical Method

The dynamics behind the superframe in the allocation of slots are estimated by hub adaptive allocation of "time phases of EAP, MAP," SAP, and "CAP" periods when estimating physiological signs in the buffer considering the emergency congestion load, where all the sensor nodes display their buffer status during the network initialization phase. Calculating this technique that helps the hub manage traffic heterogeneity and allocation of adaptive time phase.

3.7. WBAN'S Time Superframe Estimation

WBAN's Time super frame (β) is estimated as,

$$\beta = \mathcal{E} \, x \, K \qquad (1)$$

where β denotes period allocation and K represents some period allocations, while,

$$\mathcal{E} = s + q \, X \, d \qquad (2)$$

In which "S" represents AllocationSlotMin, "q" represents AllocationSlotResolution, and "d" represents the length of the slot.

3.8. Phase Time Estimation

To determine EAP, we use Equation (3):

$$\text{EAP} = \text{EAP1} + \text{SAP1} \qquad (3)$$

where EAP time is given as tEAP = μ X R. In which R denotes the communication speed of congestion sensor nodes and μ is estimated as $\mu = \frac{Pb}{Prr}$. In which Pb denotes packets in the buffer and Prr denotes reception rate. Alternatively, Pb = Max. Buffer size- Packets transmitted/slot.

4. CONCLUSION

WBAN applications entail dynamic traffic and heterogeneous loads. In regular human health monitoring, little congestion data are observed, whereas statuses abnormal to humans' health status are high–load congestion. This work discusses the dynamic buffer condition techniques in WBANs. The existing IEEE 802.15.6 superframe for WBAN was examined extensively for dynamic buffer congestion. Also, flexible wake-up intervals, transmission, and buffer traffic, and the superframe's mathematical model were discussed.

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