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Delay Reduced MAC Protocol for Bio Signal Monitoring in the WBSN Environment

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Abstract. Due to the recent development of medical and wireless communication technology, the application range of the WBSN is gradually increased. We measure various biometric data signals directly from the body surface and then to transmit them to the various monitoring devices according to the deifferent application environment. In this paper, we examine TDMA based MAC Protocol in a conventional CSMA/CA networks . The proposed MAC protocol applies the maximum delay restriction in addition to the priority based transmission in order to avoid the occurence of many invaild data due to the long packet delay. Simulation resuts show that proposed scheme provide the reduction of average delay of packet transmission over conventional Bio-MAC protocol. for several biometric signal transmission.

Keywords: WBSN, CSMA/CA, TDMA, GTS, PET, MAC, PSAP,

1 Introduction

The WBSN(Wireless Body Sensor Network) environment performs the patient health monitoring by collecting bio-signal data from the sensor nodes. In the near future, WBSN environment presents that wired transmission significantly may cause the limitation in medical personnel's performing for medical care actions. Accordingly, the research on the wireless medical monitoring solution for the WBSN environment is required[1]. CSMA/CA(Carrier Sensed Multiple Access/Collision Avoidance)[2] may cause higher energy consumption due to the frequent idle listening and packet collision. Accordingly, TDMA(Time Division Multiple Access) schemes are known to be more beneficial for battery saving and the reduction of node transmission delay[3][4]. The organization of this paper is composed of Chapter 1 (Introduction), Chapter 2 (related-research; Bio-MAC Protocol), Chapter 3 (The proposed MAC Protocol), Chapter 4 (Comparative Analysis) and Chapter 5 (Conclusion).

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2 Bio-MAC Protocol

Figure 1 illustrates a structure of the Bio-MAC Super-Frame.

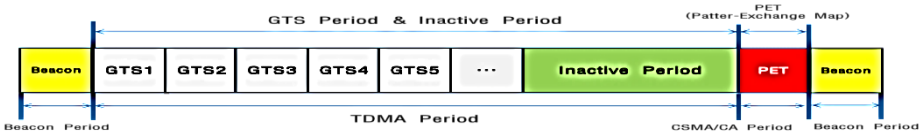

Fig. 1. Super-Frame of Bio-MAC [6]

A Super-Frame structure can convert his structure for WBSN through the modification of existing IEEE 802.15.4 MAC protocol [5]. Each GTS (Guaranteed Time Slot) is a period for transmitting the different bio-signal data without competition. PET (Pattern Exchange Time Slot) is an interval that performs the scheduling for GTS allocation in the next period. The unallocated Time-Slots enter to Inactive mode for power reduction.

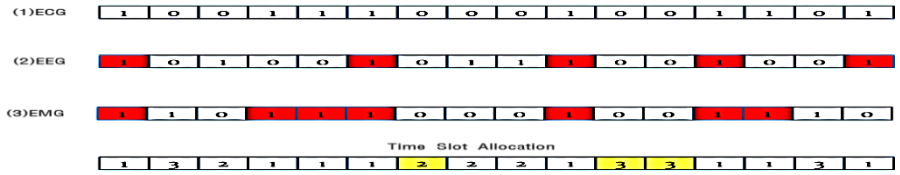

Fig. 2. Example of Bio-MAC Pattern Scheduling

Figure 2 shows the pattern-scheduling of Bio-MAC. Each node competes with others for channel allocation to transmit data to the coordinator. At this time, only the priority of each Node is considered as the standard in carrying out allocation. Lower Priority nodes that fail to assign the time slots allocation move the corresponding packet to the buffer queue and then assigns in the next possible time slot. The Lower-priority nodes may suffer a very long transmission delay compared to the higher priority nodes if the packet collision is occurred very often.

3 The Proposed MAC Protocol

Figure 3 shows the structure of super-frame of the proposed DTD (Decrease of Transmission Delay)-MAC Protocol. The basic structure and its performance of each time-slot are very similar. The DTD MAC has a new PBM(Pattern Bit Map) configurations in PSAP(Pre-Slot Assignment Period) slot corresponding to the PET slot of the Bio-MAC, which are only different feature over conventional Bio-MAC.

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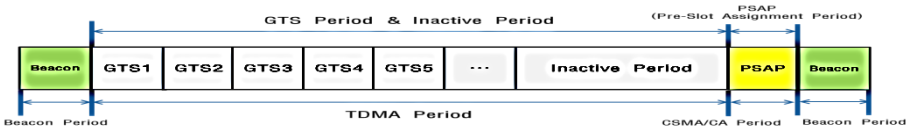

Fig. 3. Super Frame of DTD-MAC Protocol

The proposed MAC protocol directly considers the basic WBAN requirements as shown in Table 1. If the data for WBSN do not satisfy the QoS requirements presented in the BAN environment, we can take these WBSN data is not vaild in the real environment.

Table 1. Requirements of WBAN Application

Application	Bit Rate	Delay	BER
Deep Brain Stimulation	< 320Kbps	< 250ms	10^{-10}
Drug Delivery	< 16Kbps	< 250ms	10^{-10}
Capsule Endoscope	1Mbps	< 250ms	10^{-10}
ECG	192Kbps	< 250ms	10^{-10}
EEG	86.4Kbps	< 250ms	10^{-10}
EMG	1.536Mbps	< 250ms	10^{-10}
Glucose Level Monitor	< 1Kbps	< 250ms	10^{-10}
Audio Streaming	1Mbps	< 20ms	10^{-5}
Video Streaming	< 10Mbps	< 100ms	10^{-3}
Voice	50~100Kbps	< 100ms	10^{-3}

The proposed scheme preferentially transmits the relevant data with first priority when it reaches the maximum delay time to prevent excess delay and loss of the validity of packet for the data of the lower priority nodes. When each node attempts to transmit data for the channel allocation, and reached the maximum delay 250ms, the proposed scheme assigns the channel preferentially by ignoring conventional his priority of each node. In case of the time slot with no assigned transmission, the data in the buffer node can be transmitted based on the priority of existing nodes, but any node first transmission attempt has reached the maximum transmission delay (250ms) in the sequential transmission. On the other hand, even, packets of the failed node in the data transmission are considered as packet loss after the maximum delay. When each node and the buffer for the current period to transfer data, in the existing Bio-MAC environment, at this time, only the priority of each node is considered for determining the channel allocation. DTD-MAC Protocol is a way to consider for reducing the critical packet delay. In addition, by excluding the invalid data with excessive transmission delay, we can expect the reduction of overall average transmission delay. Consequently, in the real-time data processing environment, the proposed MAC Protocol is to offer guarantees a QoS of fair transmission.

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4 Performance Comparison

In this paper, WBSN simulation is configured with no change in the number of devices under star topology environment. One time-slot length was composed of 50ms, the time-slot of one cycle consisted of 100 time-slot, for 100 cycles of the 5 simulation, we calculate the data of average value. The number of transmission packets of each biological signal is assumed to be the different value by reference to table 1. In addition, if each node can't transmit the data every 250ms, is calculated by the packet loss data (DTD-MAC) and invalid data(Bio-MAC). Figure 4 shows the average transmission delay per packet for each MAC Protocol.

Through Figure 4, it can be confirmed that the DTD-MAC Protocol significantly reduces the average transmission delay compared to Bio-MAC Protocol. The Bio-MAC performs the channel allocation based on the standard of each node's priority, and always the allocation is carried out for the node of high priority. Hence the lower priority node may not receive the channel allocation in very long time duration. However, since the channel allocation in the proposed MAC Protocol is performed based on not only the priority of each node but also its maximum allowable delay requirement. The overall average transmission delay of the proposed scheme may have significantly reduced compared to the existing Bio-MAC Protocol, by ensuring the transmission of low priority biological signal in his maximum valid time duration.

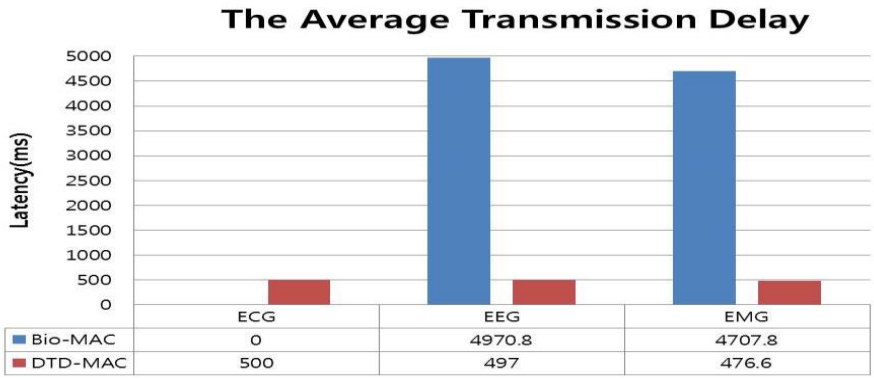

Fig. 4. Comparison of the average transmission delay on the transmission of various biological signal

5 Conclusion

The Bio-MAC, allocates channel allocation based on the standard of each node's priority, and the allocation is always carried out based on the priority of the node. Hence the lower priority node may have the possibility of no channel allocation in very long time duration. Generally, the possible invalid data, which is occurred in the preceding period, may result in a risk of malfunction in an environment that requires a

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real-time data processing. On the other hand, the proposed DTD-MAC Protocol performs the channel allocation by applying the delay requirements of the WBAN application environment. Hence, the proposed scheme guarantees channel allocation and transmission priority of each node. In addition, the data of the node that is not transmitted in the reference period were summed to packet loss in accordance with validity judgement. As a further studies to enhance in this work, the improved approach of dynamic channel allocation for data transmission fairness in the environment in which the number of node is continuously fluctuating.

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