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Fast and Reliable Packet Transmission MAC Protocol for Wireless Body Sensor Networks

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ABSTRACT: Medical monitoring wireless body sensor networks (WBSNs) monitor the occurrence of medical abnormal conditions so that medical staff can diagnose and treat patients quickly and accurately. In this case, not only abnormal data but also related data may be needed for better judgment by medical staff. In this paper, we propose a MAC protocol that can quickly and reliably transmit not only abnormal data but also related data. The proposed FR-MAC protocol reduces the packet transmission delay and prolongs the network lifetime compared to existing similar MAC protocol.

KEYWORDS: Wireless Body Sensor Networks (WBSN), Multiple Access Control (MAC) Protocol, Energy Efficiency, Quality of Service (QoS), Transmission Delay

I. INTRODUCTION

In recent decades, with the spread of MEMS (Micro-Electro-Mechanical Systems) technology that motivated the development of smart sensors [1, 2], the field of wireless communication has exploded and attracted great attention worldwide. A wireless access network provides various connections to the network and provides various functions according to the requirements of clients and applications, and a typical example is a wireless sensor network (WSN). In recent years, numerous studies [1,2,4]. on WBSN have been published, and many have concluded that the standard protocol used by WBAN and the protocol proposed for a long time are still insufficient to meet the dynamic needs of Quality of Service (QoS), energy efficiency, reliability [5,8]. In general, WBSN consists of several sensor nodes and one hub node, that is, a coordinator node. That is, WBSN consists of a one-hop network in which data packets transmitted from sensor nodes are directly transmitted to coordinator nodes. In general, the coordinator node serves as a sink node in the WSN network.

The contributions of this paper are as follows. First, a new fast abnormal packet transmission MAC protocol is developed for WBSNs. By using the frame variable extension mechanism, abnormal data is quickly delivered to the coordinator node within the limited time in case of a critical event occurrence. Upon receiving the abnormal data from sensor, the coordinator node decides whether to extend the entire operational frame size or not and notifies this information to all nodes. Second, when certain critical events are monitored and these values exceed the predefined levels, the coordinator node requests to send the relevant data so that medical staffs can make quick decisions.

The structure of this paper is as follows. Section 2 describes the design of the proposed protocol. Performance analysis is made in Section 3, and conclusions are made in Section 4.

II. DESIGN OF MR-MAC PROTOCOL

The MAC protocol proposed in this paper is a synchronous protocol in duty cycle networks. That is, all nodes forming a virtual cluster with neighboring nodes transmit packets through time-synchronization. In addition, each node alternately stays in an active state and a sleep state to reduce energy consumption. When a node is in sleep state, it cannot participate in data transmission or reception. In general, the time a node stays active is relatively short. Also, in a duty cycle network, it can be divided into a sender-initiated asynchronous MAC and a receiver-initiated MAC. In sender-initiated asynchronous MAC, packets are transmitted between the sender and the receiver through the sender's long preamble.

The scheduling of the MAC protocol proposed in this paper for data packet transmission is as follows. First, the entire operation cycle is divided into 4 sections. That is, Sync1 period, Data period, Sync2 period, and Sleep period [3]. Like other duty cycle protocols that form a virtual cluster and exchange data with each other, all nodes belonging to the cluster wake-up in the Sync1 period to achieve synchronization with each other and share transmission scheduling information. In the Data period, nodes with data to transmit send the SRF (Slot Extension Frame) indicating that it will want to send data packet. This control frame not only has the RTS/CTS function used in the CSMA/CA protocol [7], but also includes the number of packets to be transmitted and the attributes of the data. The attribute of this data indicates whether it is abnormal data exceeding a threshold value or normal data. Abnormal data packets take precedence in transmission. The coordinator node that receives control frames from several source nodes in the Data period decides whether to extend the entire frame or not.

If abnormal data packets are sent in the Data period and the number of packets to be transmitted is large, the coordinator node sends frame extension information to all nodes. If there is no node with the abnormal data packet, frame extension is not necessary. In order for the coordinator node to notify all nodes in the cluster of this information, all nodes should wake up again in the Sync2 period. If there is a node that wants to send abnormal data and a node that wants to send normal data exist at the same time in the Data period, the coordinator node does not grant permission to transmit packets to the node that wants to send normal data packets. Nodes that do not transmit control frames in the Data period enter sleep mode to reduce energy consumption after obtaining information on whether or not to extend the entire frame from the coordinator node. Nodes that transmit control frames in the Data period transmit their own data packets in the Sleep period. At this time, even if the control frame is not sent in the first slot of the Data period, the node transmitting the packet can reduce transmission delay by transmitting the packet in the first slot of the Sleep period.

In addition, abnormal signals in WBSN often indicate the patient's critical condition. At this time, other information closely related to the abnormal signal information may also be needed in order for the medical staff to accurately identify and deal with the patient's condition. To this end, in the Sync2 period, the coordinator node can instruct the node that did not send control information in the Data period to send necessary information. Therefore, the nodes that receive data packet transmission requests from the coordinator node in the Sync2 period transmit the requested data packet while staying active in the Sleep period. However, nodes not participating in data transmission immediately go into sleep mode to reduce energy consumption. Through this transmission method, medical staff can quickly obtain information about abnormal conditions and necessary information related to this information, so they can make accurate and quick diagnoses of patients.

The figure 1 below shows the operation of this MAC protocol. As shown in the figure, the nodes that wake up in the Sync1 period achieve full frame synchronization. Nodes A and B having data packet to transmit send control frames in the Data period. Here, it is assumed that the control frame sent by node A is high-priority data and the control frame sent by node B is a low-priority periodic signal. Therefore, since there is an emergency signal from node A, the coordinator node transmits the entire frame extension information to all nodes in the Sync2 period. Also, in the Sleep period, node A sends a packet to the coordinator node, but node B does not transmit. Instead, node C receives a request for transmission of information related to node A's information from the coordinator and transmits the requested data packet in the related-priority section.

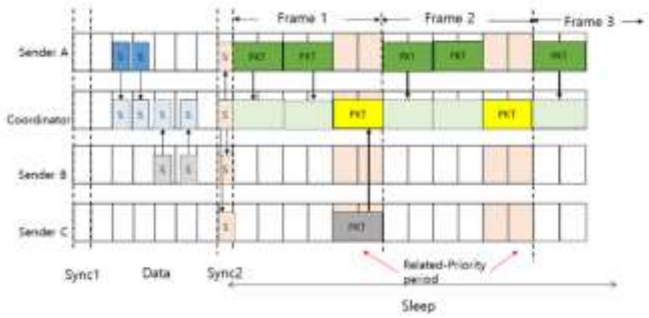

Figure 1. Example of the protocol operation

III.PERFORMANCE EVALUATION

Table 1 shows the network parameters used in this simulation [8]. It is assumed that all sensor nodes are located at a distance of 1 hop from the coordinator node. The performance comparison is the average of 10 simulation results.

Table 1. Network Parameters

Parameter	Value	Parameter	Value
Bandwidth	20Kbps	Data pkt size	50 Bytes
T x power	0.5W	T sync1	55.2 ms
R x Power	0.5W	T sync2	10 ms
Idle Power	0.45W	T data	142.0ms
Sleep Power	0.05W	T sleep	426.0 ms
SIFS	5ms	PION	14 Bytes
DIFS	10ms	SRC	14 Bytes
RTS,CTS,ACK	10Bytes		

Figure 2 shows the comparison of abnormal data packet transmission delay according to the frequency of occurrence of a critical event occurrence. The MR-MAC protocol proposed in this paper shows better performance as the frequency of emergency situations increases. This is because in the case of an abnormal occurrence, the proposed MAC protocol extends the frame and transmits the related data in the priority-related slots. Figure 3 shows the result of network life time comparison according to the number of nodes in a cluster. As can be seen from the figure, as number of nodes in a cluster increases, the network lifetime in the proposed protocol is better.

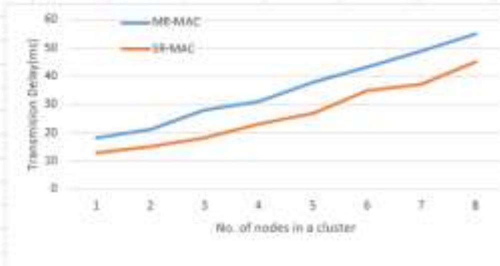

Figure 2. Comparison of the average transmission delay

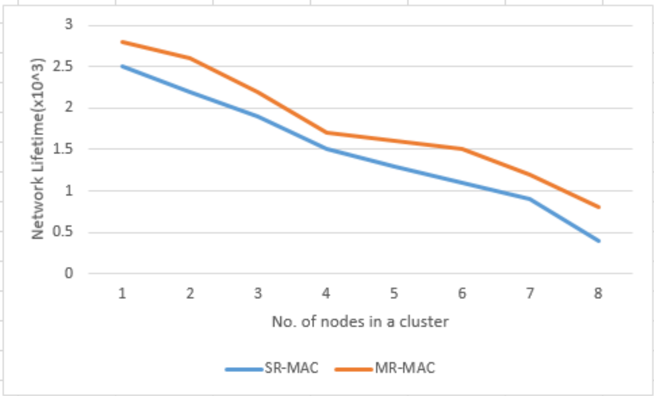

Figure 3. Comparison of the network lifetime

IV. CONCLUSIONS

In order for WBSN to operate for a long time, it is important not only to reduce the energy consumption of the nodes it consists of, but also to quickly and reliably send data indicating abnormal conditions to medical staff. In this paper, we proposed a MR-MAC protocol that can quickly and reliably send data packets sent from the node that measured the patient's abnormal condition to the medical staff. The proposed FR-MAC protocol can reduce the packet transmission delay and prolong the network lifetime compared to existing similar MAC protocol.

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