Priority Based Wireless Body Area Network with Cognitive Radio

E. Seven, and A. Çalhan

***Abstract*— Wireless Body Area Networks provide to measure various physiological and biological data and monitor human body functionalities. In this study, a cognitive radio based coordinator node is designed for Wireless Body Area Networks and a data priority queue structure is constructed in the coordinator node. Cognitive Radio is capable of connecting various wireless access points with perception and adaptation features. We have developed, modeled and simulated example network scenarios by using the Riverbed Modeler simulation software for this purpose. The prominent parameters user speed, access point delay, and connection cost are taken into account when selecting the wireless access point. In this way, the coordinator node provides to deliver data to the destination with priority and ensure to send data over optimum access point with minimum delay and cost.**

Index Terms—Wireless Body Area Networks, Cognitive Radio, Data Priority

I. Introduction

WIRELESS Body Area Networks (WBAN) consist of devices which can measure and collect biological and physiological signals and send them a central unit with sensors located on wireless node.

These wireless nodes can be located in/on human body. Every year many people die from cancer, Parkinson diseases, asthma, cardiovascular diseases, obesity, diabetes and many other chronic or terminal illnesses. Researches show that early diagnosis and early response by medical units decrease death rate [1]. Also, increasing world population and expensive health services cause to increase usage of WBANs [2].

WBANs make patients to control their body functions while they're doing their daily works. As it is shown in Figure 1, data from the sensor nodes located on/in patient can be sent to health units by coordinator node such as cell phone of the patient. WBANs having different data traffics (e.g. normal and urgent) increase the importance of determining the order of data process in the queue [3].

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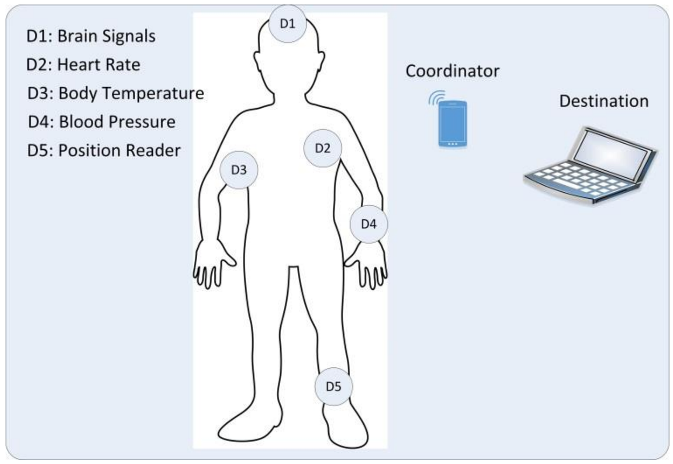

Fig.1. Wireless Body Area Network Structure

In our study, it is planned to send received data from coordinator rapidly according to order of priority. Therefore M/G/1 priority queue model is used for this purpose. With this model, when an urgent data is received it will be the first to be sent. Another part of this study is that coordinator node with M/G/1 priority queue sends data to medical center; it also has an ability to choose the most suitable access point by evaluating the parameters from all access points around. As choosing the access points coordinator node will be aware of all other access points around and will be able to send data these access points when it is requested. Because of that, our coordinator node is designed to have cognitive radio abilities in order to sense and connect the access points around [4]. In order to select the most suitable access point, the coordinator node should connect an access point by evaluating specific parameters of access points. Finally, the coordinator node will send data to a medical unit as a destination by using the chosen access point.

Using only one metric for selecting access point is not efficient since existing access points overlap with each other. Considering more performance metrics, such as delay, connection cost, user's speed etc., more realistic performance results can be achieved. For robustness of decision making in the coordinator node to connect to an optimum access point, several parameters are evaluated efficiently. Therefore, the important parameters user speed, access point delay, and connection cost are taken into account when choosing the wireless access point in this study.

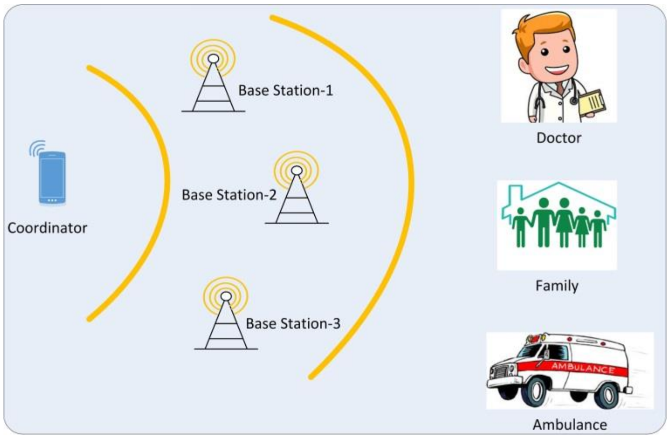

Fig.2. The designed WBAN structure

In the literature many protocols and algorithms for Wireless Sensor Networks are developed [5]. In our study Time Division Multiple Access (TDMA) protocol is used for communication of sensor nodes. Also multi-attribute decision making methods are used for choosing access points in the literature [6, 7]. In our study a data base is used in order to choose access points. Parameters coming from access points to coordinator node are evaluated by matching in the data base and the most suitable access point is chosen accordingly. By this way, as it is shown in Figure 2 the most suitable access point is chosen and patient data is sent to a medical unit.

II. Theoretical Ground

In our study, Riverbed (OPNET) Modeler software is utilized to design the structure of WBAN. Wireless sensor nodes measure the vital and biological signals (i.e. electrocardiography, electroencephalography, and electromyography) and activities, such as respiratory, heartbeat, body temperature, and glucose level in blood and send them to the coordinator node. The designed WBAN has several wireless sensor nodes with 3 different data traffic and one coordinator node. Sensor nodes collect and send first, second and third priority data to coordinator node. The coordinator node sorts the received data according to priority order. In the proposed study, first priority data are cardiac rhythm, body temperature; second priority data are position of the patient; third priority data are biological data e.g. electroencephalography (EGG), electromyography (EMG) [8].

Cognitive radio is a system which is aware of the wireless environment, can learn and can adjust itself as shown in Figure 3. It senses the wireless environment for all possible access points and changes its transmission and reception features in order to get connection to an optimum wireless access point. In our study the coordinator node has cognitive radio capabilities, and in different cases cognitive radio has to change its many parameters. Radios used in this kind of applications should have not just learning ability but also improved learning and decision making abilities. The designed coordinator node can record features of access points and when required it can connect the most suitable access point as a serving access point.

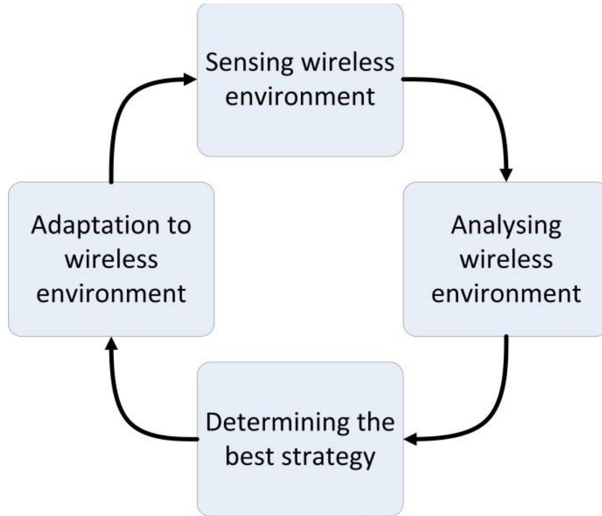

Fig.3. Cognitive radio cycle

III. Results Obtained and Discussion

In the simulation scenarios, wireless body sensor nodes are assumed to continuously collect the vital and biological signals and activities of patient, such as respiratory, body temperature, and heartbeat. Sensor nodes each have a distinct time slot in a TDMA frame, and send their packets to the coordinator node in their own time slots. The coordinator node has to organize priority queue of data from body sensor nodes as can be seen in Figure 4. By this way data which have priority can be sent to medical centers according to an order.

As data generated by sensors on the structure of WBAN increase, the data traffic on the network structure also increases. The aim of this study is to send data to medical centers with minimum delay. In order to show the performance evaluation of WBAN structure, two scenarios are executed in this study. Scenarios are designed according to frequencies of package production of sensor nodes. In the first scenario, the first node generates first priority data as 1 package/second, the second node generates second priority data as 2 packages/second, and the third node generates third priority data as 4 packages/second. End to end delay results of this scenario is shown in Figure 5. In the second scenario all nodes generate priority data as 5 packages/second. End to end delay results of the second scenario is also shown in Figure 6. As it is seen in Figure 5 and 6; when package frequencies of nodes increase, end to end delays increase as well.

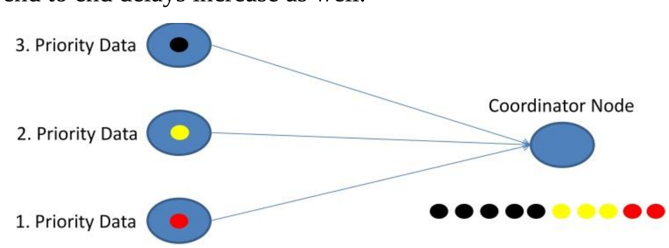

Fig.4. Data priority order in the coordinator node

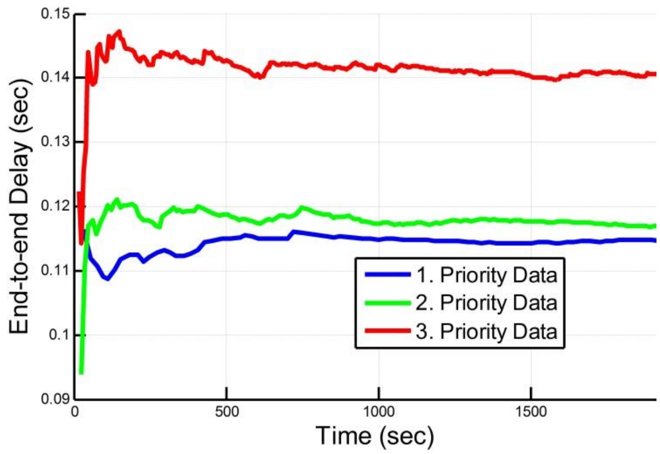

Fig.5. The end-to-end delay results of first scenario

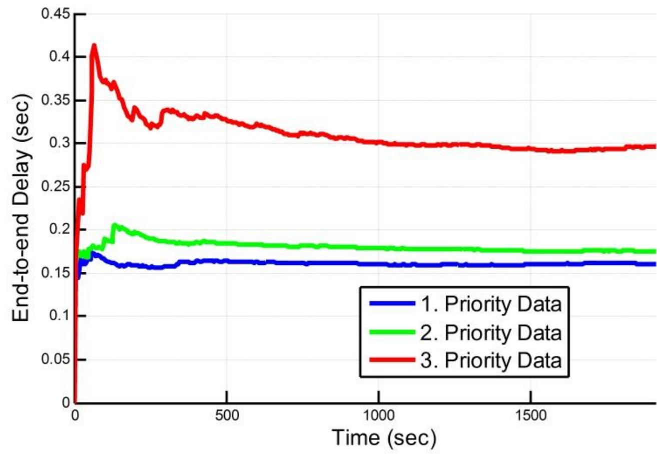

Fig.6. The end-to-end delay results of second scenario

To illustrate the performance evaluation of the proposed WBAN model, the packet generation frequencies are changed in each scenario. As can be seen in Figure 5 and Figure 6, the first priority data packets are sent to the destination with minimum delay than others. And also, the second priority data packets are sent to the destination in less time according to third priority data packets.

The coordinator node with a priority queue has been constructed on the WBAN structure and also based on cognitive radio features and can be connected to an optimum access point.

In order to make a connection to any access point, coordinator node can change some features such as working frequency, modulation technique and medium access method. The coordinator node chooses the optimum access point accordance with the features of WBAN. Some parameters are important for selecting process. In general, access point selection procedures need to consider many parameters including user profiles, application requirements and network conditions. While the optimum access point is selected as a serving access point, the coordinator node must evaluate speed of the user that has wireless body sensors, access point delay, and connection cost in this study. The coordinator node can select the preeminent access point for these three parameters.

In our study, several scenarios are evaluated under an assumption of that there are three different access points around WBAN. The features of these three access points in the scenarios are given in table 1.

TABLE I
ACCESS POINTS PARAMETERS

	Supported Speed	Access Point Delay	Connection Cost
Access P-1	0-30 km/h	2-4 sec	0.1
Access P-2	0-60 km/h	0.2-1 sec	0.8
Access P-3	0-90 km/h	0-0.2sec	1.5

TABLE II
USER PARAMETERS AND SELECTED ACCESS POINTS

	Moving speed	Delay	Selected Access Point
User-1	10 km/h	3 sec	Access P-1
User-2	50 km/h	0.5 sec	Access P-2
User-3	80 km/h	0.1 sec	Access P-3

In the scenarios, the access point selection procedure is provided for sending the data of three WBAN users. And also it is given in the table 2 that chosen access points after parameter evaluation according to the requirements of those three users. For example, speed of User-1 is 10 km/h and estimated delay is 3 seconds. Under these conditions, User-1 coordinator node will evaluate the parameters based on table 1 and choose the best access point.

As seen in the table 1, the best access point is Access P-1 under the conditions of User-1 requirements and connection price. In this way, the best access point can be chosen for three users by favor of a data base which is stored in the coordinator node structure.

IV. CONCLUSIONS

In this study, a priority based wireless body area network with cognitive radio is proposed. There are three types of priority data in the network and the developed coordinator node sorts the data in its queue and sends them to the health center with minimum end to end delay. Also, the coordinator node in the proposed WBAN is designed with cognitive radio capabilities for adopting any access point around. A WBAN needs to stay connected to a local or a wide area network by using different wireless access points. Thus, the sorted data from body sensors in the coordinator node can be sent over optimum access point to the destination. As choosing the best serving access point has critical importance to provide quality of service support and cost efficient connections for WBAN users.

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It can be seen from the analysis of the results that coordinator node can sort the data and choose the best access point for sending them to the destination within the best performance. It is also aimed to have an improvement for making a decision based on artificial intelligence of coordinator node structure for the next studies.

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