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Research Article

A QoS-aware routing algorithm for Monitoring Hospitalized Patients for Body Area Networks

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Abstract
Background and Objectives: Body Area Networks (BAN) is an example of a Wireless Sensor Network (WSN) that includes several small electronic sensors that are placed inside or outside the human body. By collecting information and sending it to medical centers, these sensors can significantly help patients, the elderly and reduce treatment costs. One of the challenges in these networks is routing emergency packages to send to medical centers.
Methods: To reduce the delay of sending packets in the proposed protocol, packets are divided into two categories: emergency and normal. In order to send emergency packages, in addition to the delay of the nodes, we have also considered the traffic so that the packets are sent from the route with less delay and traffic. To send normal packets, the path with the most energy is selected from the shortest possible paths. In this research, we simulated the proposed algorithm using MATLAB software.
Results: The analysis and simulation results of the proposed algorithm show that the delay of sending emergency packets in the proposed protocol is 34% improved compared to the other protocols.
Conclusions: In this study, we have expressed the importance of sending emergency packets as quickly as possible in the body's wireless sensor networks, and by providing a delay-sensitive routing protocol, we have been able to delay the delivery of emergency packets compared to previous protocols.
Keywords: Body Area Networks, delay sensitive, routing protocol, quality of service

Background and Objectives

Wireless sensor networks consist of many small sensors in different scales, for example 0.1 to 0.2 cm or larger. The nodes scatter at an extremely high density in the sensor field. Network monitoring will be the responsibility of the well. Also, all the required items are collected through the well and finally the commands are published with the help of the well.

Sensor networks were initially introduced to the resident with the aim of working on military needs and over time have been used in various cases, some of which are in the field of security, industry, medicine. Some of the specific features of sensor networks are the power of cooperation in sensor networks. All sensor nodes have a unique feature, and that is the presence of a powerful processor in its own body, which causes a series of basic processes on the obtained data. And finally sends incompletely processed information[1].

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In some systems, the wireless sensor has a better cost for network configuration. On the other hand, in order to improve the work, only small systems are used instead of hundreds of meters of wire. WSN and BANs sometimes face several challenges, such as area, density, size, task, network topology, wireless technology, and fast communication. In these networks, the environment is studied in varied sizes and also additional nodes are used to cover a wide area. The small size of the node does not matter much and therefore the topology is proven in its value and also the investigation of some events and happenings can be disordered. In mobile phones, the technology required for Bluetooth, WLAN and GBR. Real-time communication is not used and needed everywhere. Also in BAN, the body area continues in dimensions of a few centimeters and is examined up to dimensions of a few meters. The low density of the node helps the node to perform several different tasks.

As far as we know, small size is required in nodes. Different movements of the body undergo topological changes and also the physical health of the body is examined at different time intervals in different periods[1,2].

Figure 1 indicates the range of WSNs compared to other wireless networks such as regional wireless networks, local wireless networks, urban wireless networks and wireless networks. As shown in Figure 1, wireless networks can be classified according to their geographical coverage. The body's wireless sensor networks operate near the human body with a communication range of 1 to 2 meters[3].

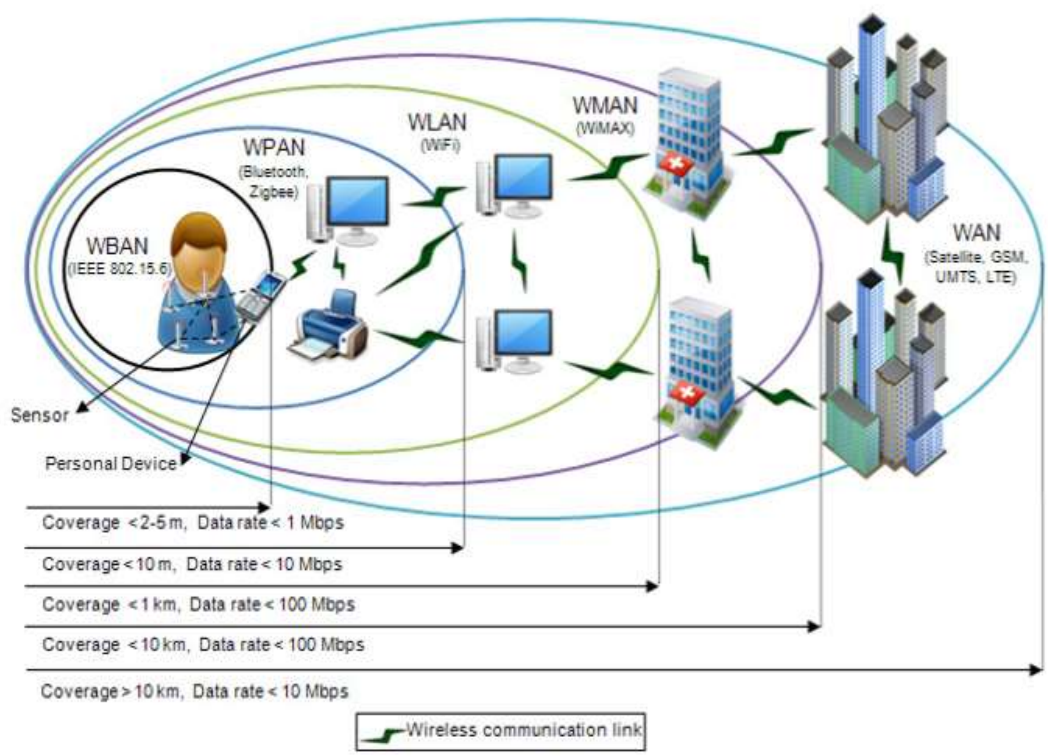

Figure1. Body Area Networks compared to other wireless networks[4]

The communication architecture of wireless sensor networks of bodies can be divided into three diverse levels as follows[5]:

Level 1: Communication within the Body Area Networks
Level 2: Communication between the Body Area Networks
Level 3: Communication beyond the Body Area Networks

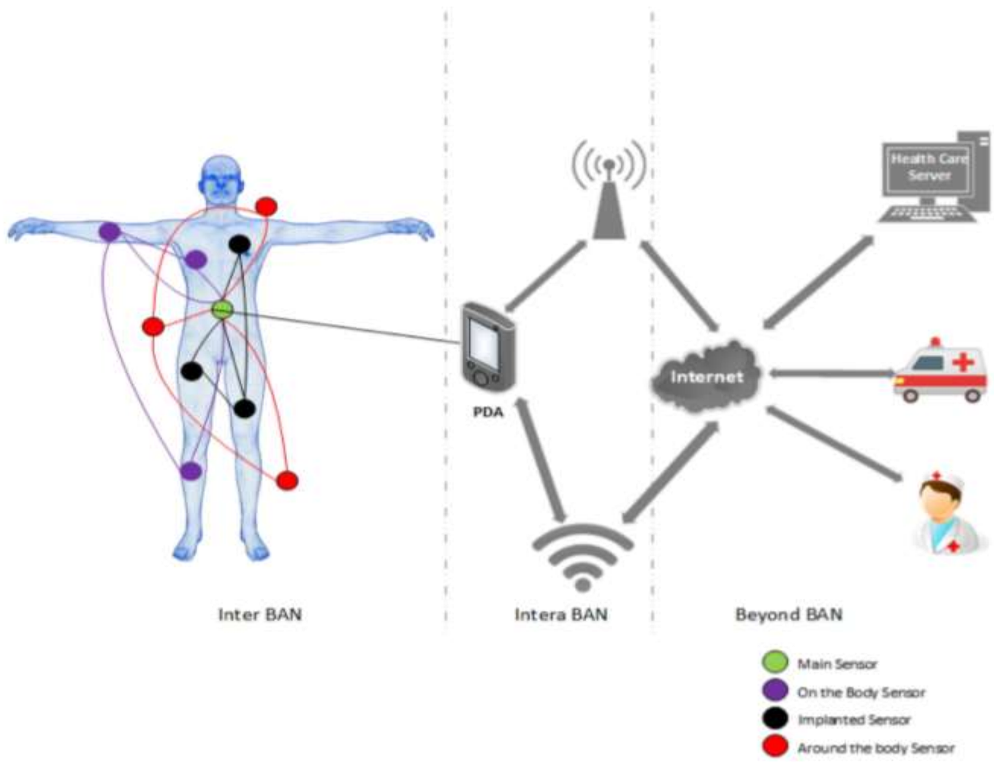

Figure 2. Different levels of Body Area Networks[6]

Figure 2 shows the communication levels in a component-based system for the Body Area Networks. In Figure 2, the nodes are scattered throughout the centralized network architecture and their exact location is based on their applications. However, the body may be moving (for example, running, walking), the ideal body position of the sensor nodes is not always the same. Therefore, wireless sensor networks do not consider the body static.

Prominent issues in this area include: security, routing and Quality of Service (QoS). QoS includes issues such as latency, reliability and node energy. The packets must reach the base station with the least delay and at the right time. Each packet must contain accurate and reliable information and the reliability of the packets must be guaranteed. Each node must have the necessary energy to send the packets to the desired destination. Violation of any of these cases in an emergency can be an alarm for the patient's condition or even lead to his death[7,8]. Therefore, due to the importance of timely receipt of data and also the substantial number of data packets, we must use a framework to send packets that can send a large volume of packets in the shortest possible time.

Related Background

Studies have shown that work done in recent years has taken precedence over packages sent. For emergency packets. By considering the traffic criteria, a route with a shorter delay can be selected for sending emergency packages.

In 2012, the QOS-aware peering protocol was introduced for delay-sensitive data. The next hop is determined based on the selected path. For each destination, the routing table contains information about the next hop connected to the route with the least end-to-end delay. For each delay-sensitive data, if the path delay is less than or equal to the required delay, ninety sources send the delay-sensitive data through that path[9]. In 2015, an adaptive incentive mechanism for the delivery of delayed-sensitive medical packages was proposed, which according to the delay-sensitivity strategy and considering the priority lines, a consistent pricing function for each transitional medical package is proposed. A higher priority medical package that arrives can prevent the service of lower priority packages, i.e. exclusive mode (that package is either in the queue or in service mode). When another packet with a higher priority is not in the queue, the ones that have stopped are resumed from the preemptive-resume queue. Therefore, the waiting time of each package in this mechanism is defined as the start time from the time when the request to send this package occurs until the moment it is fully accepted[10].

DM-QoS is multi-objective data-driven protocol in the human body's peripheral network. The network model assumptions used in this protocol relate to several nodes connected to the human body and data are sent from this node to the cluster or central node. The central node (coordinator) has relatively high energy and better computing power. Several sink nodes are available on the network[11].

Method

Proposed Algorithm

The main purpose of node clustering is to divide the primary nodes into several different clusters based on their similarity to each other. Therefore, the nodes in each cluster are more similar to each other, and the nodes in different clusters are less similar to each other. Most of the methods presented for feature clustering have drawbacks. Among these shortcomings are the following:

- In most sensor clustering methods, the number of clusters must be determined before performing the clustering algorithm. In other words, in most of these methods, the parameter k, which specifies the number of clusters, must be specified by the user. In general, it is difficult to determine the number of clusters for the initial characteristics of the work, and the number of optimal clusters can be determined only by trial and error.
- Data distribution in a cluster is one of the most important criteria in clustering, which is not considered in most of the previously proposed methods for clustering sensor nodes. Considering the scatter of features in a cluster can greatly improve the performance of the clustering algorithm.

- In most existing methods for clustering sensor nodes, all properties are considered the same during the clustering process and will have an equal effect on node clustering. However, in some cases it is better to have a greater impact on the clustering process for a few nodes that are more similar to each other.

Optimization of Clusters

The main purpose of this step is to select a cluster center from each cluster based on a defined set of criteria. The following three criteria are used to select cluster centers:

1) Total energy of selected cluster centers

2) The total distance of the nodes of that cluster from the center of the cluster

3) The total distance of the selected cluster centers from each other

As can be seen in this regard, the higher the first criterion and the lower the other two criteria, the better the cluster centers. As a result, the proposed method is a multi-objective algorithm that must be optimized.

One of the most important parts of any algorithm is the introduction of a goal function or fitness function for that algorithm. In the proposed method, due to the multi-objective problem, the fitness function is defined as follows:

f_1: Total energy of selected cluster centers

f_2: The sum of the nodes of that cluster from the center of the cluster

f_3: The total distance of the selected cluster centers from each other

The final fit function is defined as follows:

$$fitness = \alpha f_1 + \beta \frac{1}{f_2} + \gamma \frac{1}{f_3}$$

Here, α, β and γ are three constant parameters that determine the effect of these three different criteria. As can be seen, the goal of the algorithm in this part is to maximize the objective function above. Since the second and third criteria must be minimized, they are therefore inversely placed in the fitness function.

Results

Simulation Results

Simulation scenarios are performed in two modes with 100, 200. For network configuration in 100-node mode, the network size is 200 x 200, the packet size is 4000 bits, the initial node energy is one joule, the Eamp energy is 100 PJ / bit / m2 and the Eelec energy is 50 nJ / bit. Has been.

For network configuration in 200-node mode, the network size is 200 x 200, the data packet size is bit4000, the initial energy of the nodes is one joule, the Eamp energy is 100 PJ / bit / m2 and the Eelec energy is 50 nJ / bit.

The network assumptions are as follows:

1- Sensor nodes are randomly deployed.

2. All sensor nodes and base station are fixed after installation.

3- Nodes are able to adjust the transmission power according to the distance from the receiver node.

4- The distance between nodes can be calculated based on the received signal strength. Therefore, there is no need to pinpoint the exact location of the sensor nodes.

5. All sensor nodes have the same energy at the beginning of the installation.

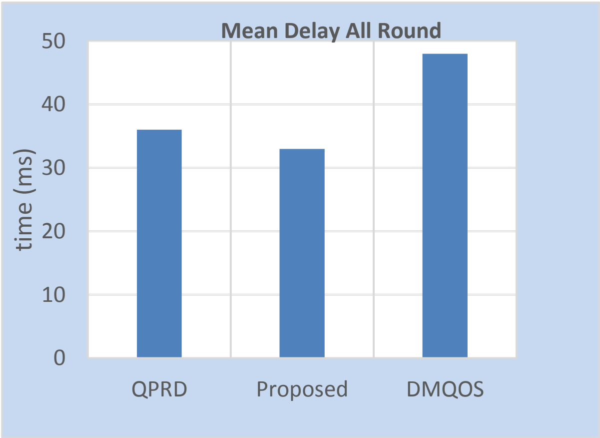

Figure 3. Minimum delay of protocols for sending the same emergency and normal packets

According to Figure 3, the proposed protocol sends emergency packets with a minimum delay of 30 milliseconds. In comparison, the QPRD protocol provides a minimum delay of 45 milliseconds for sending emergency packets. While the DM-QOS protocol has a minimum delay of 72 milliseconds. Proportional to the proposed delays, the proposed protocol has a 17% improvement over the QPRD protocol, a 33% improvement over the DM-QOS protocol. Due to the delay in sending packets in the proposed protocol and the 2 compared protocols, the delay in sending packets in the proposed protocol is much less than when all nodes are fixed, and it can be said that emergency packets. They will be sent to medical centers in a shorter time.

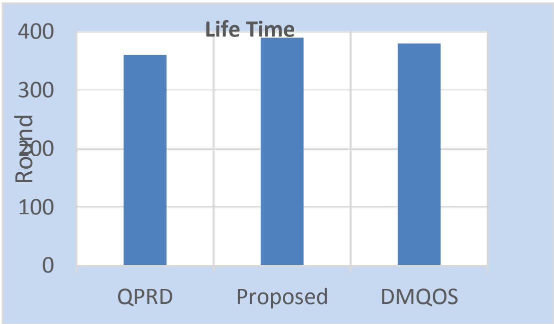

Figure 4. Network Life Time

Network longevity is one of the most key factors in WSN. The life of these networks is short due to the limited power supply of the nodes. Figure 5 shows the lifespan of the proposed protocol and the QPRD and DMQOS protocols. As the Figure 5 indicates, the proposed network protocol life is longer than the QPRD protocols and is relatively equal to the MDM-QOS protocol. The proposed protocol can be used to receive patients' vital signs in more time.

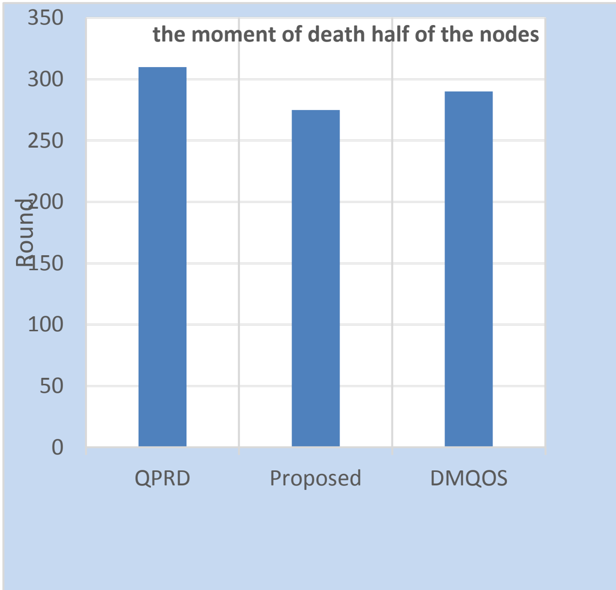

Figure 5. Half Node Death Moment

If half of the network nodes die, it can be said that the network is disappearing. Figure 5 shows the death moment of half of the nodes in the proposed protocol and the QPRD, DM-QOS protocols.

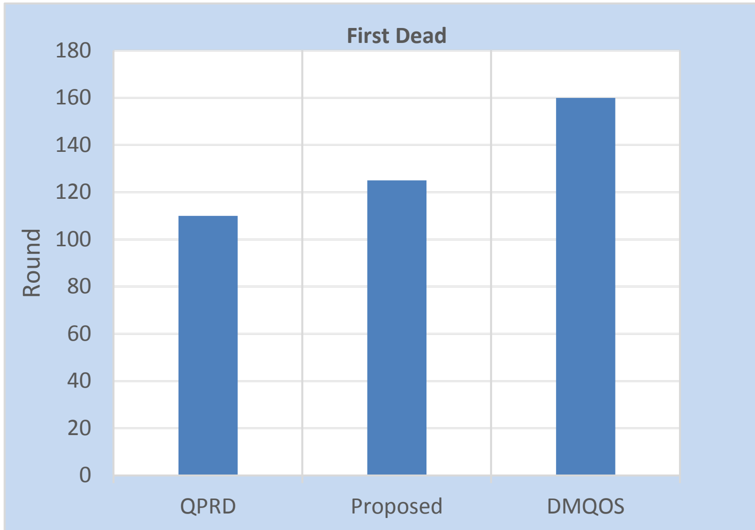

Figure 6. First Node Dead

Figure 6 shows the death of the first node in each protocol. As the Figure 6 indicates, the first node of the proposed protocol dies in round 123, and the death of the first node of the QPRD protocol occurs in round 110, and for the DM-QOS protocol in round 160. With the death of the first node of the DM-QOS protocol at 160 rounds and the greater number of live nodes of the proposed protocol, according to Figure 6, the network life of the proposed protocol is relatively the same as the DM-QOS protocol.

Conclusion

The Body Area Network benefits include reducing the cost of treatment, optimal use of inpatient resources, early diagnosis and treatment. Some packages produced by nodes are sensitive to delay and must be sent to medical centers very quickly. Delays in sending these packages can be dangerous and, in some cases, may even endanger the patient's life and lead to the patient's death. In this paper, we tried to find a solution to reduce the delay of these types of packages as much as possible. In addition to improving the delay, we tried to pay attention to other parameters such as power consumption, network life, routing overhead and the number of live nodes.

Conflicts of Interest:

The author declares that, there is no conflict of interest.

Authors' contributions:

Authors have the equal contribution in this article.

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