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Enhancing the Energy Efficiency of WBAN Sensor Nodes by Employing Fuzzy Logic Technique

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ABSTRACT: Restricted size of the battery results in limited energy storage and various other problems likely. So the sensors should be properly used during their energy use, as their batteries are not to be replaced quite often. Efficient strategies for providing data are needed while ensuring secure communication. Here, in this manuscript Fuzzy Logic Cluster Head Rotation is implemented and evaluated on sensor nodes of Wireless body area networks. Cluster Head is chosen based on two characteristics i.e. proximity distance and energy. Among the other nodes in the network, the fuzzy based technique chooses CH as the node with the highest energy and local optimality.

KEYWORDS: Wireless Body Area Network, Bit Error Rate, Time Division Multiple Access, Hash based Message Authentication Code, certificate less signature

1. INTRODUCTION

1.1 Wireless Body Area Network

These networks comprise sensor nodules that may be worn within the body or implanted there. These sensor nodes will serve as network nodes when we require two-way communication, that is, communication from sensor to sensor and sensor to coordinator. Wireless broadcasting has been playing an increasingly important part in our everyday lives. It helps in a number of ways since it is a necessary component of many real-world applications, including monitoring, automation, and the tracking of appliances and gadgets [1]. Because of the world's constantly expanding population, average life expectancy, WBAN can provide automated healthcare services by remotely tracking patient's vigorous structures. Devices are strategically installed above/inside the patient's physique that can send vital biological indications of the physique such as fever, heartbeat, blood pressure, heart movement monitoring, ECG gesture, etc. The movement sensor can be used for monitoring movement of the patient [2].

1.2 Energy Effectiveness

Energy competence should be the major aim for any researcher to design WBANs because of their small size and battery operable nature. Some patients may be on bed for extended period, so energy dissipation should be always minimum [3]. Many protocols and designs for the same has been proposed throughout the time to minimize the energy consumption.The WBAN system acknowledges the difference between emergency signals and normal signals; therefore, reliability is the major concern. Another significant problem for the bio-sensors, especially the implanted sensors, is the restriction of energy [4][5]. Restricted size of the battery results in limited energy storage, so the sensors need to be extremely careful during their energy use, as their batteries are not likely to be replaced quite often. Efficient strategies for providing data are needed while ensuring secure communication [6].

In the next section, i.e. second sections, survey done in WBAN sensors are discussed. The proposed work is described in section 3. Results and discussions are explained in 4th section and at last summary in the form of conclusion is presented.

2. RELATED WORK

In WBANs, Sensor nodes are responsible for collecting vital information of patient and further communication with the coordinator node. For an effective and reliable system latency and transmission schemes of data plays an important role. **[7]** have developed a revolutionary TDMA centered MAC procedure for group sensor systems that uses Time Division Multiple Access. H-MAC targets to raise energy effectiveness thru performing temporal synchronization using heartbeat rhythm data. **[8]** have established a supple procedure that offers an advantage over current systems in footings of effectiveness, dynamism use, and safety. The protocol provides a decent packet distribution percentage and output. Energy preservation is as well taken care of through the stringent enforcement of a sleep-wake schedule for all sensor nodes. It's significant that the protocol is adaptable enough to support an encryption module for data security. Due to wireless communication, the communications and

data transfer in WBAN are still compromised. Therefore, it is particularly challenging to maintain dependability and fault tolerance in WBAN. In order to overwhelm the above problems, **[4]** recommended a MIMO- based energy effective accommodating recognizing arrangement for WBANs. In order to examine Bit Error Rate (BER) in data communication, the authors in this study employed a network coding approach. The suggested method places a strong emphasis on four factors: low BER, patient mobility acceptability and help, cheap cost of contact, and low energy needs. In order to guarantee the privacy of remote WBAN users, two remote authentication techniques for strong and lightweight certificates have been proposed. These authentication methods are based on a novel certificate less signature (CLS) technique that has been shown to be secure from existential falsification on adaptively selected communication assaults and computationally efficient in the random oracle model [9].

The primary problems with WBAN are energy use and latency. Considering this, the author in [10] suggested a unique MAC protocol that defines a new channel access method for the WBAN network using a hybrid technique of CSMA-CA and TDMA. Every single sensor node is proposed with an order awaiting state, and the transmission overhead is moved to the personal station side. The key difficulties that WBAN faces while implementing a fixed time slot allocation system in IEEE 802.15.4 have been covered in the work done in [11]. The author suggested a dynamic time slot allocation system for medium access management, which improved device performance in terms of energy efficiency and network longevity. Efficient Harvested-Aware Clustering (E-HARP) protocol for WBAN has been proposed by the author in [12]. The proposed protocol carries out two main functions, namely choosing a cluster head from a group of candidates based on their determined Cost Factor (CF) and Signal to Noise Ratio (SNR), and then routing data using E-HARP with cooperative routing. The study that was presented mostly concentrated on Link Quality to choose the following hop for data transfer. The suggested method makes advantage of network efficiency and residual energy as a routing parameter for data transfer. Node mobility is still impacted even if the suggested solution works well in terms of next-hop selection. Changing a node's location might result in a decline in the network's overall performance [13][14].

3. PROPOSED WORK

WBAN characteristics in the context of healthcare are significantly impacted by issues linked to the network's brief lifespan. Reliability is the key concern since the WBAN system can distinguish between emergency signals and ordinary ones. Energy shortage is a significant problem for biosensors, especially implanted sensors. Sensors must be judicious in their use of energy because of the battery's restricted size and the possibility of frequent battery replacement. It is necessary to find efficient ways to share data while ensuring a secure connection. FL is an Artificial intellligent strategy that simulates decision-making. It is used to manage hazy thinking or inadequate information. The "truth-value" scale used by FL ranges from 0 to 1. FL is thought to be a promising approach for successfully analyzing a number of factors. It is suitable for addressing WSN issues including routing, data aggregation, and deployment and makes decision-making easier while using fewer resources. CH is chosen based on two characteristics: closeness and energy. CH is chosen as the network node with the highest energy and local optimality by the fuzzy-based method.CH is chosen based on two characteristics, proximity distance and energy. Among the other nodes in the network, the fuzzy based technique chooses CH as the node with the highest energy and local optimality. The main flow with this protocol is that none of the nodes have GPS trackers, which means that in some areas they would not be able to transmit location data.

We employ fuzzy system to estimate the competition radius for tentative CHs by considering two parameters: distance to the sink and node remaining energy.

In order to calculate CH Competing Radius (CR), we applied the three fuzzy input variables (descriptors). The first one is the Distance to the BS (DBS). The linguistic variables defined for this input are: close, medium and far. A trapezoidal membership function (MF) is chosen for close and far. On the other hand, the MF of medium is a triangular MF. The second fuzzy input variable is the Remaining Energy of the tentative CH (RE). The fuzzy MFs that describe this input variable are: low, medium, and high. The low and high linguistic variables have trapezoidal MFs while the medium has a triangular MF. The third fuzzy input variable is the Cluster Density of the tentative CH (CD). Sparse, normal and dense are the linguistic variables of this fuzzy set. Sparse and dense linguistic variables have trapezoidal MFs while normal has a triangular MF, as shown in Figure 1.The various simulation parameters for the experiments are tabulated in Table 1.

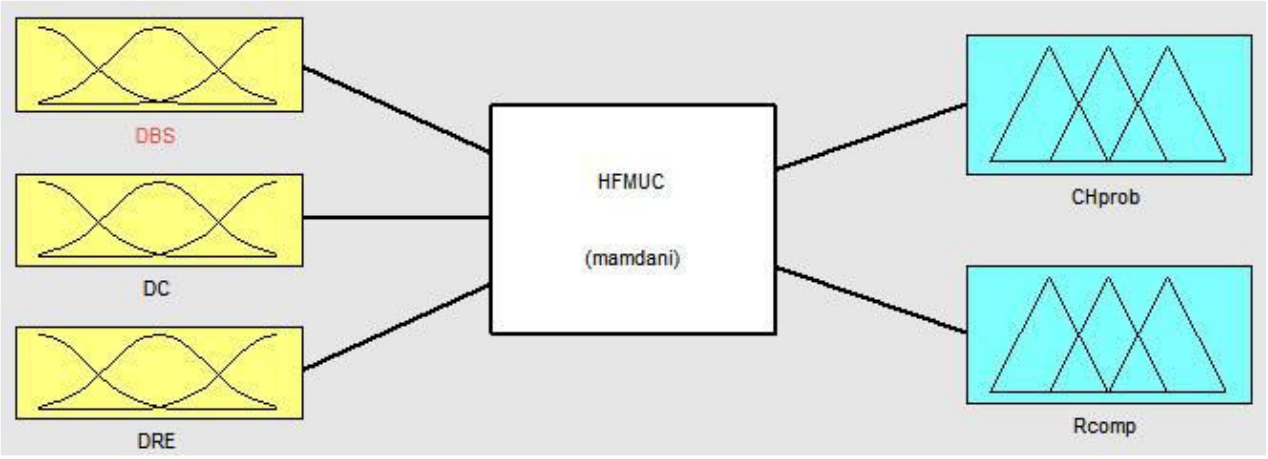

Fig. 1. Fuzzy System

Table 1. Simulation Parameters

Name	Description
Sensor Nodes	1000
No. of Clusters	64
Base Station Location	100,105
Network size	200X200 m^2
Initial Energy	1j
Routing Protocol	Low Energy Adaptive Clustering Hierarchy

Figure 2 shows the 1000 sensor nodes deployed in 100X100 m^2. Base station is located at 100,105.

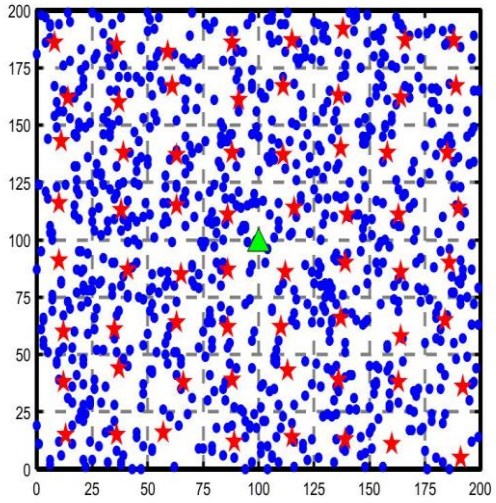

Fig.2. Sensor Nodes Deployment

4. RESULTS AND DISCUSSION

Results are computed in three different sections firstly without cluster head, secondly by cluster head and at last by using our proposed technique i.e. Fuzzy logic technique.

Phase 1. Node to Base station

Here all nodes are sending data directly to Base station without cluster heads. Table 2 shows the node number and the total number of rounds. Here the dead nodes are 3. The observations are presented below

Node No: 643 Round: 80
Node No: 32 Round: 81
Node No: 448 Round: 81
No. of Dead Noes: 3
Total Rounds: 82

Table 2. Total Rounds (Node to Base station)

Node No.	Total Rounds
1	82
2	82
3	82
4	82
5	82
6	82
7	82
8	82
9	82
10	82

Table 2 shows total rounds of first 10 nodes.

Phase 2. Node to CH to Base station

In the Table 3 i.e., in the second phase, all nodes are sending data first to cluster head and then to Base station. The dead nodes are 1.

Node No: 440 Round: 81
No. of Dead Noes: 1
Total Rounds: 82

Table 3. Total Rounds (Node to CH to Base station)

Node No.	Total Rounds
1	82
2	82
3	82
4	82
5	82
6	82
7	82
8	82
9	82
10	82

Phase 3: Fuzzy Logic Cluster Head Rotation

In this section, CH is chosen as the network node with the highest energy and local optimality by the fuzzy-based method. The observations are presented in Table 4.

Node No: 154 Round: 2379

Node No: 615 Round: 2472

No. of Dead Noes: 2

Table 4. Total Rounds (Fuzzy Logic Cluster Head Rotation)

Node No.	Total Rounds
1	2437
2	2485
3	2516
4	2434
5	2550
6	2546
7	2545
8	2578
9	2435
10	2472

4.1 Lifetime Comparison of three phases

Above tables shows lifetime (Rounds) comparison of all the above phases in which experiments are performed, which shows that number of rounds using Fuzzy technique is very high as compared to other two phases.

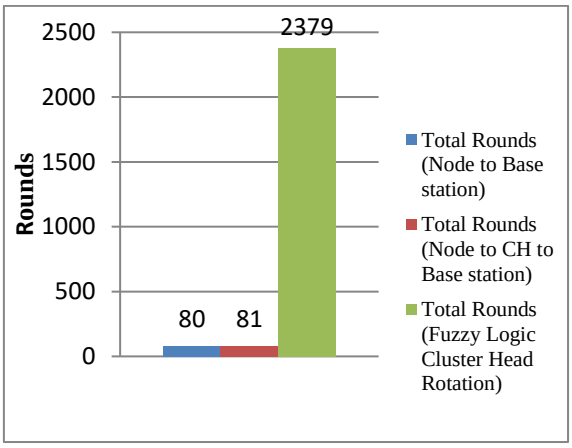

Fig.3. First Dead Node Comparison

The above figure shows the first dead node comparison of all the experiments which proves that the proposed technique provides the superior results.

CONCLUSION AND FUTURE SCOPE

The LEACH protocol appears to be saving node energy; nevertheless, with minor adjustments, this protocol could become more appealing and extensively used. This article suggests an energy-efficient clustering protocol for WBAN that makes use of fuzzy logic. Cluster Heads are chosen to deliver the message to a base station by selecting appropriate fuzzy descriptors. The proposed Fuzzy logic Cluster Head Rotation significantly improves network lifetime. The main flaw with this protocol is that none of the nodes have GPS trackers, which means that in some areas they would not be able to transmit location data.Fault tolerant algorithm to cope with topology changes due to postural mobility can also be implemented and evaluated.

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