

A Fuzzy based Methods in Wireless Body Area Network for Controlling Congestion

Navpreet Kaur Samra, Ramanpreet Kaur

Abstract: *With the wireless communication, the ways of communication in present era of technology has changed which helps in fastest and efficient way of communication in each and every domain. In the field of medical science, to sense the human body activities such as heartbeat, blood pressure and other activities performed by internal body parts of the human, Wireless Sensor Network is employed. Then this sensed data is transmitted to the centralized server. The information that is collected is made to transfer to the destination through a dedicated route created by routing protocols in form of data packets. Thus, the network sometimes faces the issue of congestion due to increased data traffic to the nodes. The present paper defines an enhanced congestion handling concept for Wireless Body Area Network. For this purpose, the cost function of the nodes is evaluated on the basis of major factors such as distance, residual energy and delay. Additionally, by applying the Fuzzy Inference System, the congestion control model is executed. It also improves the routing strategy by introducing the firefly algorithm based forward-looking node selection approach. For evaluation, the proposed work is simulated in MATLAB and compared with the traditional congestion technique. The simulation results show that the lifetime of the network increases by 30%. The efficiency of packet received at sink improves by 18%. Path loss in the present study is 33% less as compared to traditional approach. And, also consumes near about 8% less energy.*

Index Terms: Congestion Control, Firefly Algorithm, Forwarder node selection, Fuzzy Inference System, WBAN.

I. INTRODUCTION

The utilization of wireless sensor network based communication has been adopted in each and every domain specifically, commercial fields like medical science etc. Wireless Body Area Network (WBAN) is the part of wireless communication which is used in medical domain, agricultural environment, etc. In WBAN, to collect the data from the patient's body, the sensors are planted on it, conducive to catch the movements performed by various body parts such as heartbeat, nerves, etc. after which, the collected data is transferred to the centralized server that is fixed at the side of physician. On the basis of the obtained data, the physicians take decision regarding physical conditions of the patient. The advantage of WBAN is that the patient has no need to visit the physician.

In WBAN, the data transmission is also done by following the basic routing concept as Wireless Sensor Network (WSN). Therefore, it also suffers from various issues that exist in WSN as well. The primary intentions for this study are to resolve the issues of congestion that occurs due to massive transmission of data packets [1].

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WBAN has attracted a lot of authors to conduct their research work related to congestion and energy consumption. The variant attempt has been made by the researchers in this domain but with having different perspectives. As in [2], the authors developed Adaptive Threshold-unaware Energy efficient Multi-hop Protocol (NEW-ATTEMPT) mechanism for energy efficient routing. This traditional protocol proposed in this method uses a heterogeneous sensor network in the human body. An integral cost function is used to forward the data from one node to node. For evaluating the cost function, different parameters are used i.e, the distance between the nodes, sending data rate and the remaining energy. To form the energy efficient protocol, the concept of residual energy in WBAN is used. Delay can be avoided by selecting the best node using the distance parameter. The drawback of this proposed work was that the authors did not consider the results regarding the energy consumption. In [3-4], authors suggested a stable, dependable, intensity beneficial directing convention for versatile Wireless Body Area Networks. The main aim was to extract the extra vitality of hubs with an expansion to establish lifetime of network. But, the route selected by this convention was lack of energy management and route security. An ANT Colony Optimization (ACOBAN) Clustering [5] for observing Body Area Network information was proposed to enhance the lifetime of network, vitality, stack adjusting on the general system. Election of cluster head level by level increases the complexity in the network and also concentrated on channel demonstrating, and vitality preservation at Network/MAC layer. A Link-Aware and Energy Efficient convention for remote Body Area systems (LAEEBA) and Cooperative Link-Aware and Energy Efficient convention for remote Body Area systems (Co-LAEEBA)[6] steering plan was also presented.

In another work [7], authors proposed a plan, which was named as the tree-based Energy-Efficient Routing Scheme (EERS), with low overhead to sum up the address versatile power control and steering in multi-hop WBANs. But, this consumes high energy and there is lack of data packet scheduling process.

In [8], authors proposed directing conventions besides their points of interest and downside which demonstrates that proposed steering convention is better as far as execution when contrasted with other steering conventions. Authors in [9] developed a congestion control mechanism which works on the basis of queue length and delay but still more improvement can be set by including the energy consumption approach with the congestion control concept in the network [10]. Also, some challenges are there that is needed to be addressed such as packet recovery and congestion control data loss [11].



In preceding paper of this chain, it was concluded that the various factors such as energy consumption, distance, counts of packets transmitted to the destination and speed of data transmission highly affects the overall performance of the network. And to maintain these factors in the network, the concept of multi hop was introduced in which the next hop selection is the tedious task to perform. In such way, the distinctive attempts have been engaged to establish the novel and upgraded mechanism for selecting the next hop in line. As per the review done by the previous work, it was obtained that the traditional work evaluates the cost function of individual node to select the next hop in the sequence of nodes.

The traditional cost function is:

$$costfunction = \frac{R.E(i)}{d * q} \quad (1)$$

Where, d represents the distance between node and sink node, Q is average data rate and RE is residual energy of node i.

The parameters that were used for cost function were not quite sufficient. So, to conquer the backlogs of conventional work, a scenario is imported by achieving the new cost function, by updating the earlier cost function to figure out the congestion rate with the residual energy, average data rate, distance from node to node and distance from node to source. Two aspects are put forward for the calculation of congestion rate i.e. Delay and Queue Length by applying Fuzzy Inference System. The FIS evaluates the congestion rate which can vary from 0 to 1 only using Sugeno model and rules.

The optimization algorithm i.e. Firefly optimization [12] will be used for selection of the forwarding node so that an effective route for data transmission can be selected. Different parameters are calculated to control the congestion in the proposed design are shown below:

- Path loss PL(f, d)

$$PL(f, d) = PL_0 + 10 \log_{10} \frac{d}{d_0} + X\sigma \quad (2)$$

Where, d is distance among the transmitter and receiver, d₀ is reference distance, PL is path loss coefficient, X is Gaussian random variable, σ is standard deviation.

- Energy on nodes

$$E_{Tx(k,d)} = E_{elec} * k + E_{amp} * n * k * d^n \quad (3)$$

Where, E_{Tx(k,d)} is transmission energy, E_{elec} is electrode energy, E_{amp} is amplification energy, n is constant, k is number of packets and dⁿ is distance which should be less than d₀.

The Firefly algorithm for optimization uses the concept of fireflies in which the blinking nature is used for the optimization purpose. It uses three rules which are as follows:

A. It is considered that every firefly is unisex and these fascinate towards one another irrespective of the sex.

B. The feature of fascination can be directly related to the brightness emitted by two fireflies and that means the less bright firefly moves toward the brighter one and in case if both the fireflies having equal brightness then it will exhibit the random motion. Moreover, the brightness of both the fireflies' decreases as the distance among them goes on increasing.

C. Fireflies' brightness got directly affected by surroundings of the intended function. Two things are important to consider in the firefly algorithm: the brightness of fireflies is directly proportional to encoded objective function landscape and variation in light intensity should be defined.

The firefly algorithm is selected over the other optimization algorithms because it is quite efficient in terms of population generation, complexity and reliability. The flow of present study can be described below:

- Start
- In this step, the network is deployed to the defined area in reference to the x and y axis. Along with this, it is mandatory to define the nodes count in the network. The nodes initial energy is also defined in this step. After defining the initial parameters, the network is deployed on the basis of the parameters.
- After deploying the network, next step is to design the proposed fuzzy inference system
- Evaluate the congestion route on the basis of the decision derived from the designed fuzzy inference system.
- For route creation, first of all the initial population is generated.
- After population generation, the cost function is evaluated by using the following formulation:

$$CF = \left(\frac{1}{\text{Congestion Rate}} \right) * \frac{R.E(i)}{d * q} + \frac{1}{d_{i,forth \text{ node}}} \quad (4)$$

The cost function is evaluated using the remaining energy of the nodes, distance between the each node, distance from node to sink, delay and queue length. The evaluated congestion rate varies from 0 to 1 only.

- After then, the initially generated population is refurbished by using the firefly algorithm.
- With the help of the new population, the new cost function is evaluated by using the equation (4).
- If the newly evaluated cost is found to be greater than the previously evaluated cost function, then the cost function is updated. Otherwise update the population again by using the firefly algorithm.
- On the basis of the updated icost, the best solution is attained and the forward-looking node is selected for data transmission.
- After transmitting the data, the performance of the proposed work is evaluated.
- End.

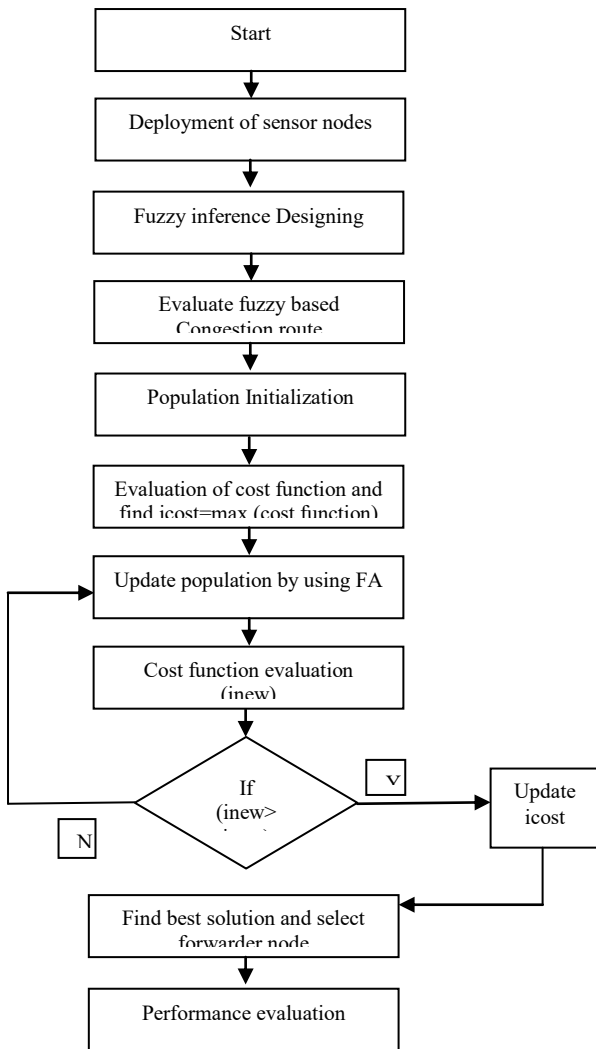


Fig 1: Proposed Framework

II. PERFORMANCE ANALYSIS

The present study describes the comparative analysis of proposed and traditional protocol in terms of dead nodes, energy consumptions, path loss and packet received at sink. The analysis of without fuzzy & optimized protocol is done with an objective to monitor the performance level of the present study in comparison to earlier protocol.

The graph in Figure 2 represents the comparative analysis in terms of counts of dead nodes rises in the network. To control congestion in the network, number of dead nodes should be less. Whenever a node runs out of its energy then it is considered as dead node and it increases the congestion. Therefore, lower the numbers of dead nodes lower is the congestion. The curve in blue refers to the dead nodes found in without fuzzy & optimized protocol while; the curve in red depicts the count of dead nodes in fuzzy optimized protocol. The analysis evaluates that the total number of dead nodes found in present work is 4 whereas in without fuzzy & optimized protocol, number of dead nodes is 8. In the graph, the highest count of dead nodes points that the system is less efficient and also less effective to sustain for longer.

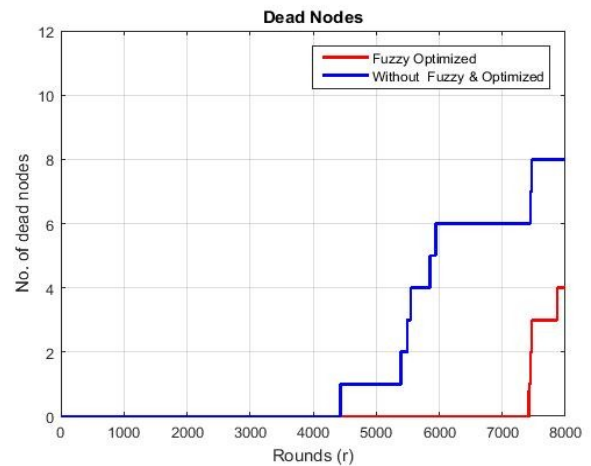


Fig 2: Comparative Analysis of dead nodes

In Figure 3, the correlation is done on the basis of the packet received at sink for fuzzy optimized and without optimized system. If whole transmitted packets are collected at the sink node then it means there is no congestion at all, which means higher the packets earned at the end node, then less congestion will be there in the network. The amount of packet received at the sink is higher in present work as compared to the without fuzzy & optimized protocol. From initial point the packets received at sink in present work are high which kept on increasing in context with without fuzzy & optimized protocol. In fuzzy optimized protocol, 3.5 packets are received at the end of 8000 communications rounds whereas; without fuzzy & optimized protocol has 2.7 packets collected in the end of 8000 communication rounds.

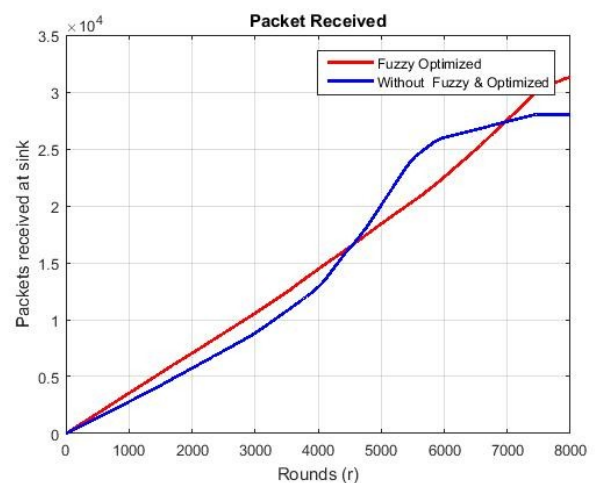


Fig 3: Comparative Analysis of packets received at sink

Figure 4 shows the comparison of path loss for the two cases. If the transmitted packets lost their paths then it contributes to the network congestion as these packets will terminate in the middle before reaching the destination node and are lost in the network. As noticed in the graph, after 7500 rounds the fuzzy optimized system has approximately 80 dB path loss, but without fuzzy & optimized network has near about 120 dB.

Hence, it represents that the path loss without fuzzy



work is higher than the present work. The highest path loss in without fuzzy & optimized work makes it less effective.

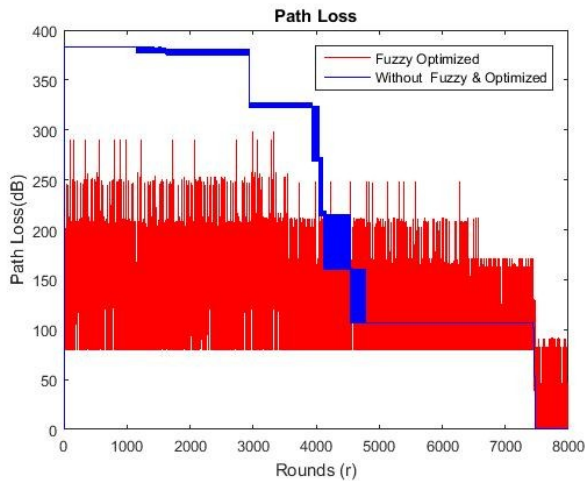


Fig4: Comparative Analysis of path loss

Figure 5 shows the comparison of present work and without fuzzy & optimized work in terms of energy consumption. Node’s energy plays a main role in the network. As there is finite amount of energy in the network therefore its efficient utilization is necessary. Least the energy in the network more it leads to congestion issues. As seen in the graph, after 7000 rounds without fuzzy system consumes all energy whereas, fuzzy optimized protocol still holds a value of 0.6 in the network.

The curve of energy consumption in traditional work is higher in contrast to the fuzzy optimized work. Thus, it can be concluded that the present work is much effective from energy consumption point of view.

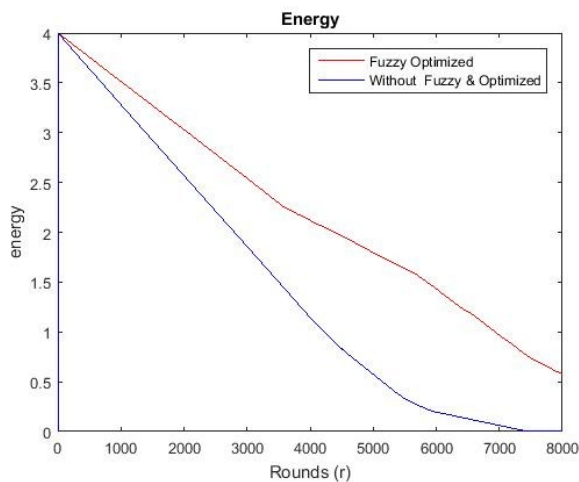


Fig 5: Comparative Analysis of energy consumption

III. CONCLUSION & FUTURE SCOPE

The congestion is the major issue that needs to be addressed in wireless body area. It is required to control the flow of data traffic in wireless network so that the situation of congestion in the system can be avoided. An enhanced approach to control the congestion is introduced in this work. The present technique uses the concept of electing next hop by calculating distinct parameters such as dead nodes, packet received at sink, etc. in which, congestion is one of it. Accordingly, by evaluating this, all over congestion of the system gets diminished. The present cost

function is evaluated on the basis of the distance from node to node, distance from node to sink, residual energy of the nodes and standard data rate of the network. FIS system has been used for controlling congestion in the network based on Sugeno model. The firefly algorithm is implemented to create the efficient path for data transmission.

The evaluated performance matrices delineate the proficiency of the present work over without fuzzy & optimized protocol. The present protocol is quite effective to resolve the issue of congestion in the network by maintaining the energy consumption of the nodes. It is again concluded that energy consumption improves by 8%; Path loss decreases by 33% etc. In forthcoming years, the concept of data processing techniques can be introduced in the system. As, till yet most of work is done on routing schemes in system. Therefore, in future various data processing and data security related amendments are possible in present work.

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