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Efficient Routing Protocol Algorithm for Wireless Sensor Networks

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Abstract: ***These Recently, different applications of wireless sensor networks in the industry fields using different data transfer protocols has been developed. As the power of sensor nodes is limited, prolonging network lifetime in wireless sensor networks (WSNs) considered a critical issue. To develop the network permanence, researchers had considered power consumption in routing protocols of WSNs by using modified Low Energy Adaptive Clustering Hierarchy. This article presents a developed effective transfer protocols for autonomic WSNs. An efficient routing scheme for wireless sensor network regarded as significant components of electronic devices is proposed. An optimal election probability of a node to become cluster head has being presented. In addition, this article uses a Voronoi diagram, which decomposes the nodes into regions around each node. This diagram used in management architecture for a wireless sensor network..***

Keywords: Wireless sensor networks, routing protocol, Voronoi, LEACH. .

1. INTRODUCTION

Recently, there has been a significant focus in designing autonomic WSNs for their utilization in the industry. In previous studies, some algorithms and protocols used for traditional wireless Ad-hoc networks, just like the Ad-hoc on-demand distance vector (AODV) and the dynamic source routing (DSR). However, the suffusion applications of WSNs require more unique features [1, 2].

The main approach for designing energy-efficient is clustering, especially providing powerful and highly enhancement with sensor networks [3, 4]. The connections overhead mostly decreased by the regulation clustering, that way gaining decreasing the confusion between the sensor nodes as well as the energy consumption [5-8]. Furthermore, specified node, which is the Cluster Head (CH) responsible for collecting the sensor's data decreasing the overall value of data to the base station as well as the bandwidth resources and economic power [9-12]. The clusters generated by some protocols mostly setup on domestic features which are generally not optimal. Creating load balance power and effective clusters should giving better importance [13, 14].

In the previous researches, so many research approaches have been used to solve the problem of WSNs. Researchers [15-18] suggest many approaches based on different criteria. Many protocols for WSNs proposed previously assume that the nodes are static. Therefore, new routing algorithms needed to process (topology and mobility) variation in such power-affected surroundings. Data damaged caused by the mobility of the nodes are possible to disconnect the cluster members from their CHs. In mobility scenario, selecting the CH by suitable technique to success deliver the data packets to the base station. To extend the network existence, researchers should consider energy consumption in routing protocols of WSNs.

An enhanced efficient routing protocol for autonomic WSNs was presented in this article. First, the general model for the proposed efficient routing protocol was presented and then an efficient routing scheme for static and mobile WSN was suggested.

In general, the WSNs are consisting quantity of sensor nodes that densely deployed inside or closer to the physical phenomenon, as represented in Figure 1.

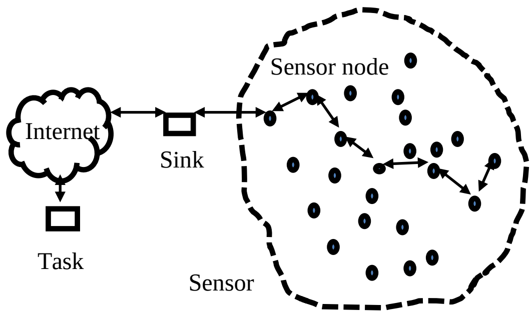

Figure (1): A WSN connected to the internet via sink node [1]

The sensor nodes transceivers usually disperse in the sensor domain where every node capable to gather and transmit data back to the sink/gateway, whiles the end users using a multi-hop infrastructure to minimize the architecture over the sink. Furthermore, by using the sensor nodes processing ability to domestic process illiterate computations and transfer only the required and sections processed data. Through the internet, satellite or any type of wireless network had used to communicate the sink with the end users, which made things possible in the internet.

However, in many cases the end-users connected directly from the sink, with possibility to contain multiple sinks and end-users included in the architecture. Some of infrastructure minimal networks like WSNs serve an urgent task in monitoring. Monitoring becomes easier coincidence the improvement of wireless sensing systems. The end-user could get new devices and software progressions are getting available in WSN frequently. The WSNs become complex because the stated fast growth with huge number of devices in the network. Mostly the deployment domain for WSNs is out of the human reach.

The System, which works independently and rules itself on its own based on pre-defined rules and gain the knowledge via the time called autonomic system. The autonomic system has four functional areas for self-management: Firstly, Self-Configuration represented by automatic configuration of components. Secondly, Self-healing representing automatic both discovery and correction of faults. Thirdly, Self-Optimization representing the automatic both monitoring and control of resources to ensure the optimal working with respect to the defined requirements. Fourthly is the last, Self-Protection representing the protection from arbitrary attacks and proactive identification.

The main challenges that affect the sensor networks are the low power availability. The energy available for the sensor based upon the battery lifetime. For the transmission of the signal, multi-hop routing will be of more significance as it consumes less power than direct communication.

Some nodes have added responsibilities in hierarchical approach to reduce the load on other nodes in the network. In location based, the sensor nodes knowledge areas exploited to route the query to the event from the base station.

The main aim of this article is to design an efficient routing scheme, which results from the incorporate of autonomic computing in designing of the WSN, to build an efficient routing protocol for autonomic WSNs. To gain this aim, this research has focused on the following areas: In order to prolong network lifetime, suggested an improvements with respect to the power efficiency to the existing cluster-based protocol for static sensor networks. In this article, the efficient cluster-based routing protocol for static WSN was proposed. In the proposed protocol, the sensor nodes were clustering by a modified FCM to decrease the transferring distance. Moreover, a suitable CH for every cluster elected based on fuzzy logic system. The parameters (process, energy, concentration and centrality) used for the election. Every CH collected data that belonging to their clusters from the sensors and send it to the Base Station (BS).

Many fuzzy logic algorithms for clustering have been applied in WSNs. In [19], a multi hop clustering proposed, which called fuzzy clustering algorithm, prolong the lifetime of WSNs. This method adjusts the cluster-head radius considering the residual energy and the distance to the base station parameters of the sensor nodes. The authors in [20] proposed an energy efficient hierarchical clustering algorithm uses the fuzzy logic method for cluster formation and cluster head selection. To determine the cluster head selection, three input functions convert the inputs into fuzzy sets, such as distance, nodes density and battery level.

2. PROTOCOL METHOD

The chosen protocol represented by centralized protocol, where the process of the clusters which are the formation and head election controlled by the base station. The protocol executed in number of rounds where in each round passed through the setup and steady state phases. The cluster formation, CH election and time division multiple access (TDMA) schedule decided in the setup phase while the data transmit phase is the steady state phase responsibility. The general model for the proposed routing protocol presented in followed Figure 2.

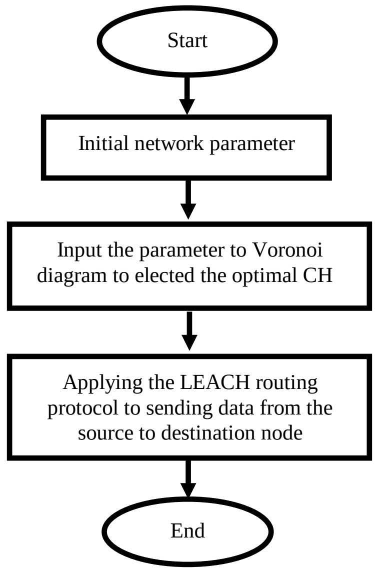

Figure (2): Protocol structure representation

The detector nodes uniformly clustered for the proposed routing protocol by using a FCM method to reducing the broadcasting distance. Furthermore, the fuzzy logic approach used by some protocol for clustering and backup the head election in mobile WSN.

The authors in [21] applied the number of live neighboring nodes and remaining energy of network nodes to select better nodes for clustering. By creating more symmetric clusters, they reduced the energy consumption of the sensors and increased the lifetime of the sensor network.

LEACH or Low Energy Adaptive Clustering Hierarchy proposed by [22]. LEACH is a hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station (sink). Each node uses a stochastic algorithm at each round to determine whether it will become a cluster head in this round. LEACH assumes that each node has a radio powerful enough to reach directly the base station or the nearest cluster head, but that using this radio at full power all the time would waste energy. Nodes that have been cluster heads cannot become cluster heads again for r rounds, where P is the desired percentage of cluster heads. Thereafter, each node has a 1/P probability of becoming a cluster head in each round. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster. The cluster head then creates a schedule for each node in its cluster to transmit its data. Probability function for elect the node as CH, can get the threshold value as below equation:

$$T(n) = \begin{cases} \frac{P}{(1-P*mod\left(r, round\frac{1}{P}\right))} & if\ n \in G \\ 0 & Otherwise \end{cases} \quad (1)$$

With the above equation, we have used the characteristics of Voronoi diagram. The sensor field divided into Voronoi cells by the calculation of sensors, and the sensor working direction evaluated based on Voronoi vertices [23].
Clustering head selection by using modified LEACH with Voronoi diagram shown in Figure 3 as below.

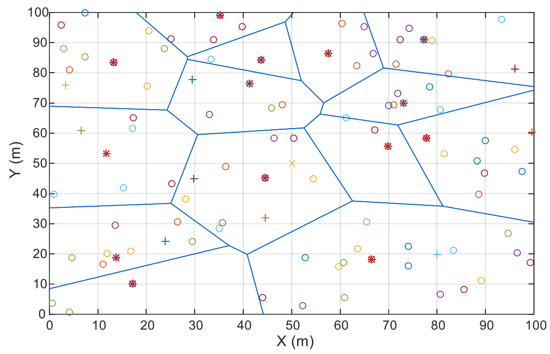

Figure (3): Clustering head selection with Voronoi cells

In this model, proactive and reactive data reporting is being applied. The proactive networks transmitted the interested data after frequently sensed the perimeter for the nodes therefore, a clear image about the sensed attribute provided at regular intervals. The proactive networks capable for periodic data monitoring to the applications request that. However, in reactive networks, the nodes interacted if unexpected and considerable alteration amount of sensed features. Receiving and transmitting data caused energy dissipated for each sensor node. The measurement of the energy dissipated based on the distance between receiver and transmitter through the wireless transmission with free-range broadcast or the multi-path fading models. If the range is, less than a threshold distance value $d_o$the free-range broadcast model, utilized on the other hand multi-path fading channel model utilized.

As indicated in Figure 4, a simple model for the radio energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics.

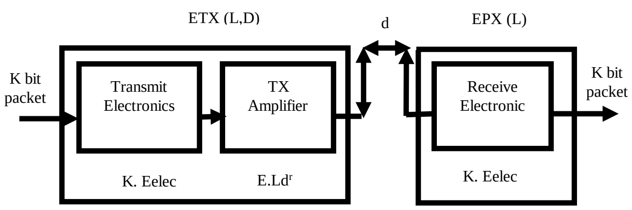

Figure (4): Radio energy dissipation model

To achieve an acceptable signal to nose ration in transmitting a K-bit message over a distance d, the transmitter loss power to broadcast K-bit packet:

$$E_{TX}(K,d) = \begin{cases} KE_{elec} + K\,\epsilon_{fs}\ d^2 if d < d_o \\ KE_{elec} + K\,\epsilon_{mp}\ d^4 if d \geq d_o \end{cases} \quad (2)$$

Where the threshold $d_o$defined by:

$$d_o = \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}} \quad (3)$$

Where E_{elec} Is the power loss to run the electronics circuits. ϵ_{fs} and ϵ_{mp} are the transmitter amplifier attributes. In addition, d represented the range in the midst of two communicating ends.

Power loss to get a K-bit packet:

$$E_{RX}(K) = KE_{elec} \quad (4)$$

Likewise, data gathering in the cluster head caused losing power just like the previous power growing. EDA represented The Energy Data Aggregation.

3. THE PROPOSED METHOD

Two phases of rounds consists in the suggested protocol, which are setup and steady state phases. All nodes assumed here to be stationary; that is mean, once the all nodes classified so they are no longer dynamic. In addition, for simplicity, data packages transferring per round to the BS after produced by each sensor node. The proposed routing protocol model for static WSNs is represented in Figure 5. The main goals of setup phase representing by the cluster head election and the formation's clusters.

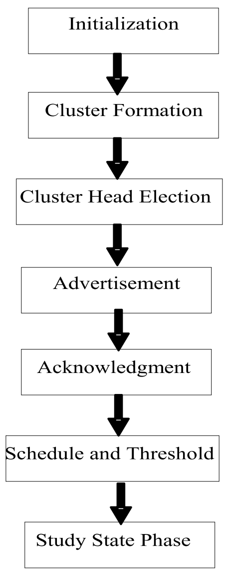

Figure (5): Proposed Static WSN Protocol Structure.

Initialization

Starting from setup phase, the base station receiving messages that sensor nodes send. Once the base station received the data, the clusters formation started.

Cluster Formation

The sensor nodes clustered utilized by modified LEACH. The primary average of points LEACH algorithm established randomly. The modified algorithm calculates the primary average of points while in the proposed protocol. Reducing the iteration time for creating clusters significantly gain by efficient setting of primary average of points.

Cluster Head Election

Each node that has the probability elected itself a cluster-head for the current broadcast an advertisement message to the rest of the nodes. The non-cluster-head nodes must keep their receivers on during this phase of set-up to hear the advertisements of all the cluster-head nodes. After this phase is complete, each non-cluster-head node decides the cluster to which it will belong for this round.

This decision based on the received signal strength of the advertisement. Assuming symmetric propagation channels, the cluster-head advertisement heard with the largest signal strength is the cluster-head to whom the minimum amount of transmitted energy needed for communication. In the case of ties, a random cluster-head was chosen.

After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be member of the cluster. Each node transmits this information back to the cluster-head again. During this phase, all cluster-head nodes must keep their receivers on.

The cluster-head node receives all the messages for nodes that would like to be included in the cluster. Based on the number of nodes in the cluster, the cluster-head node creates a TDMA schedule telling each node when it can transmit. This schedule broadcast back to the nodes in the cluster.

The radio of each non-cluster-head node can turned off until the node has allocated transmission time, thus minimizing energy dissipation in these nodes. The cluster-head node must keep its receiver on to receive all the data from the nodes in the cluster.

Base Station computing chances of all nodes then compared with fundamental chances. Cluster head elected from the cluster the node with the maximum chance. The node with more energy selected to break the relevance among numerous nodes holding the maximum chance. Furthermore, node closest to center is selected. In accordance with the formation of the clusters and cluster head election, all sensor nodes know its task from the clusters BS broadcast the routing information to them such as (Cluster head, non-cluster head).

Advertisement

In accordance with selection of cluster head, Sensor nodes must keep their receivers ON so the CH will broadcast an advertisement message to them.

Acknowledgment

Sensor nodes after receiving the advertisement message from CHs, furthermore CHs must keep their receivers ON to receive the acknowledgment messages notified belonging to them from their sensor nodes.

Schedule and Threshold Creation

The acknowledgment received messages from the sensor node, regarding number of nodes the CHs will create the TDMA schedule to allocate the time for every sensor node in the cluster into cluster members and broadcast it. For the reactivate classification of data broadcast, cluster heads will also broadcast Hard Threshold (HT), which is a value that cluster heads broadcast to all of their members to inform them of its range of interest for the sensed attribute.

The moment that clusters have been generated and the cluster heads are elected, data transmission can begin. The proactive network allowed nodes periodically figure out the environment and transmit the important data. Therefore, they provide a clear image about the figured out attribute at stable periods. Therefore, they are completely suitable for applications demanding frequent data monitoring, while the other classification is appropriate for applications do not require frequent data supervising. The nodes react in reactive network, only to (unexpected, vehement) variation for characteristic behind pre-determined threshold, Hard Threshold (HT); therefore, the sensor node must transfer the figured out data to its CH if an absolute amount of the characteristic is over this HT.

For monitoring applications, the proactive behavior of wireless sensor network can be used for reporting the monitored data in a regular basis. For example, monitor machinery used by wireless sensor network for error discovery and diagnosis. In this type of network, the non-cluster head, nodes correspondence to their allotted table in each steady-state phase sense the surroundings then transfer sensed data to their cluster head. The base station received aggregated data from the cluster head. The user should have a clear image of the whole area covered by the network.

While in the wireless sensor network applications that do not require continuous reporting about the sensed attribute, for example (in intrusion detection and explosion detection), the reactive behavior is useful and efficient if the sensed characteristic with range of interest allowing nodes to transmit data to gain reducing the number of transmissions. Consequently, in reactive network, CH will receive the data from their sensor nodes if sensed value in the domain of interest, above the HT, otherwise, small sized special packet will send by the sensor node notification to CH referring for is yet alive and checked environment.

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4. SIMULATION RESULTS

In this section, the simulation results of the proposed will presented using Matlab software package.

This simulation has focused on prolong network lifetime, suggested an improvements with respect to the power efficiency to the existing cluster-based protocol for the sensor networks. In the proposed protocol, the sensor nodes were clustering by a modified LEACH method to decrease the transferring distance. Moreover, a suitable CH for every cluster elected based on LEACH. The concentration for each node computing by the base station that checking the amount of the rest nodes around center node within the area of (100X100) meters. Depending on these, two crisp numbers, when the value of the parameters with the measurement of the membership function crossing point will run out the membership function. Each input function linked to the next membership functions which used for representing power and concentration input parameters, while are used for input parameter representation centrality.

Create the new node architecture using LEACH algorithm in beginning of each round, optimal election probability of a node to become cluster head and run the clustering algorithm have been prepared. Taking the root mean square values to calculate the optimum values for number of nodes. In the simulation section, 100 nodes in a 100*100 meter area have been considered. To implement the simulation, several parameters values have to be predefine to run the simulation. Table 1 represents the simulation parameters that have been applied in the simulation scenarios.

In Figure 6 is being displayed the random distribution of the node sensors. Basic part of code is to randomly place the sensor nodes in the given space then connecting each two nodes if the distance between them less than or equal to the communication radius.

The connections of each two nodes sensors based on the coverage communication criteria depends on the calculation of the distance to each CH and find smallest distance.

Table (1): Simulation parameters

Parameter	Value
Number of nodes	100,200
Network size	100*100
BS location	100*100
Data packet size	4000 bit
Initial energy	0.5J
E_{elec}	$50*10^{-9}$
Optimal election probability	0.1
Alpha	1
Maximum number of rounds	500
Data aggregation energy	$5*10^{-9}$

Using modified LEACH method in cluster head selection and the formation of the wireless network hierarchy overcome the randomness of cluster head election in LEACH protocol and uneven distribution of node energy. At the same time, generating the cluster node consequence through network initialization reduces the energy consumption when network constantly selects the cluster head and prolongs the life cycle of wireless sensor network.

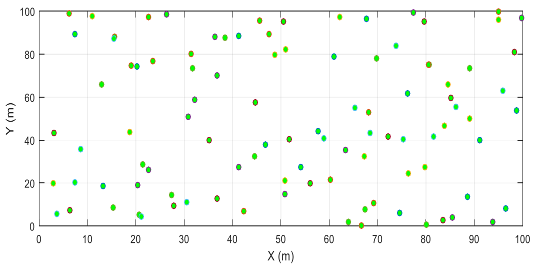

Figure (6): Distribution of 100 node location sensors.

In Figure 7, Voronoi classification of random distribution of the node sensors. Basic part of code is to randomly place the sensor nodes in the given space then connecting each group nodes if the distance between them less than or equal to the communication radius. Our design uses a Voronoi diagram, which decomposes the space into regions around each node.

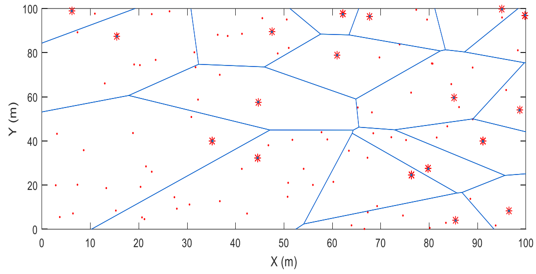

Figure (7): Voronoi classification of random nodes.

Figure 8 shows the number of dead nodes increase with respect to the number of round.

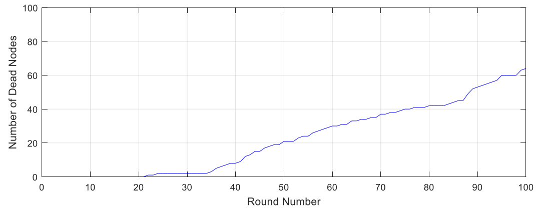

Figure (8): Number of dead nodes.

Figure 9, shows the decreases behaviors of the corresponding of average energy consumption with respect of number of round.

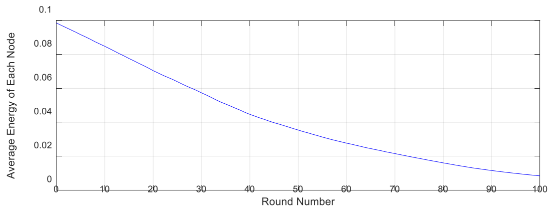

Figure (9): Corresponding of average energy consumption with respect of number of round.

In Figure 10 is being displayed the random distribution of the node sensors. Randomly distributions of the sensor nodes in the given space then connecting each two nodes if the distance between them less than or equal to the communication radius.

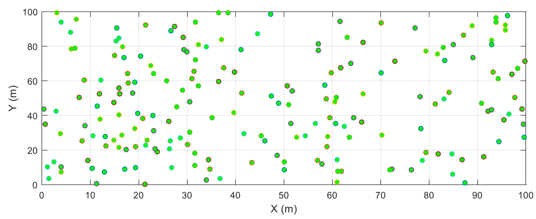

Figure (10): Random distribution of 200 node sensors.

Figure 11 shows the number of dead nodes increase with respect to the number of round, the number of nodes is 400.

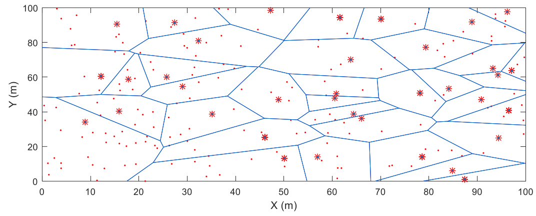

Figure (11): Voronoi classification of node sensor.

Figure 12 shows the number of dead nodes increase with respect to the number of round.

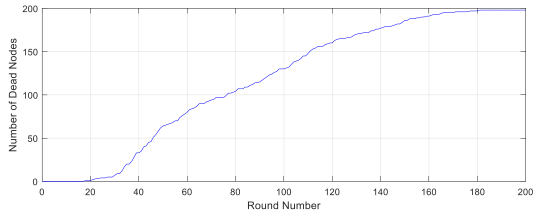

Figure (12): Corresponding of number of dead nodes with respect of number round.

Figure 13, shows the decreases behaviors of the corresponding of average energy consumption with respect of number of round.

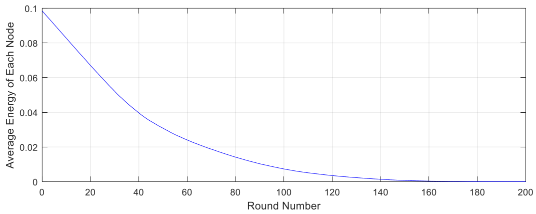

Figure (13): Corresponding of average energy of each node.

The effectiveness of the proposed transfer protocols for autonomic wireless sensor networks has been evaluated. Time evolution of the corresponding number of packets with respect to nodes, number of dead nodes and energy dissipations shown in Figure 7.

5. DISCUSSIONS

The aim of this paper is to discuss some of the most relevant issues of WSNs, from the application, design and technology. For designing a WSN, we need to define the most suitable technology to be used and the WSNs protocols to be implemented. These choices depend on different factors. Different aspects that must take into consideration in the design of a WSN. The actual possible choices that could done, in terms of technologies. The aim is to help the designer in the choice of the most suitable technology, for which also some potential performance levels are provide. A self-elected cluster head collects data position from all sensor nodes in its cluster, calculates the Voronoi diagram, and transmits its decision back to the nodes in a distributed fashion.
Figures (8) and figure (12) give the impression that the number of dead nodes increased gradually with respect to the number of rounds.

The performance of the modified LEACH is compared with a several results found in the researches [21] and [22] as shown in table (II) below using the same parameters.

Table (2): Performance of modified LEACH with previous researches

Specifications	Modified LEACH		Fuzzy Logic[21]	LEACH [22]
Nodes number	100	200	100	100
Round number	100	200	700	1400
Number of dead nodes	65%	99%	90%	80%

6. CONCLUSIONS

Evaluated the effectiveness of the proposed protocol then compared with previous protocols for different kinds of criteria. We compare it against Optimized fuzzy clustering algorithm. This article improved an enhanced efficient routing protocol for autonomic WSN. The general model for the proposed efficient routing protocol and an efficient routing scheme for WSNs. Through simulation results proved the proposed method is found be better sensor nodes. A Voronoi diagram has been applied to solve other problems in a wireless sensor network.

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