FDBSCAN: Fuzzy based DBSCAN algorithms for densely deployed wireless sensor network for prolonging network lifetime

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Abstract- In wireless sensor networks the nodes are spatially distributed and spread over application-specific experimental fields. The primary role of these nodes is to gather the information for various intended fields like sound, temperature, and vibration etc. In this paper, a new energy efficient clustering algorithm for the densely deployed network has been proposed. The efforts have been made to prolong the network lifetime by reducing the energy consumption of nodes by considering the critical issues of dense deployment. Every node will limit its chance of participation in any cluster based on the local sensor density. The proposed algorithm performs better in the case where the sensor nodes are randomly deployed. The network area is divided into high and low-density areas using the DBSCAN algorithm. The nodes in low-density areas are considered critical since there is very less probability for transmission of redundant information by these nodes. The separation of high density and low-density areas using DBSCAN helps in sleep management. Sleep management helps in the energy optimization in dense areas and thus adds in prolonged network lifetime with the improved stable region. It has been observed through the computer simulation that the proposed algorithm is more energy efficient than the LEACH and IC-ACO in densely deployed network areas while maintaining similar performance otherwise.

Keywords- *Lifetime, energy, WSN, LEACH, IC-ACO*

I. Introduction

The development in communication technologies has empowered the idea of a sensor network that is formed by tens to thousands of cheap, low-power and multifunctional sensor devices which densely deployed in an unattended environment. The most critical issue in sensor nodes is the energy consumption because sensor nodes have limited and constant power sources [1]. As a result, this restriction influences the design of WSN protocols or algorithms. The primary aim of these nodes is to spot actions in the network field, accomplish processing tasks and transmit these sensed data to one of the authorized party, such as the base station or sink node. Hence, the energy is consumed in three forms: sensing, data processing, and communication. The transmission and reception of data among the nodes consume the highest energy among the sensing, data processing and communication [2]. The most energy is spent on the communication part which involves the transmission and reception of data among the nodes.

When a network is densely deployed, the nodes which lie in close proximity tend to sense the redundant information. Redundancy is the provision of additional or duplicate resources, which can produce similar results. Redundancy in sensor networks is both friend and foe, stimulating us to highlight the positive sides and diminish the negative ones [3]. It has been observed from the literature that the redundancy plays a vital role in the improvement data accuracy but at the cost of routing complexity and network lifetime.

A classic method to enhance the consistency of measurement given by WSN is to expand the redundancy, by either waiting for information from various neighbouring sensor nodes (spatial redundancy), by waiting for numerous information from the similar sensor node (temporal redundancy), or by including substitute checking data like parity bits in in-network messages (information redundancy). Spatial redundancy depends on the in-field geographic location of the sensor nodes and includes the repetition of resources in the network's territory. In WSN there is gigantic spatial redundancy, i.e. data for a particular area might be accessible from various sensors. This sort of redundancy is normally used to offer fault tolerance, to enhance the reliability of the measurement data and to improve the information security level. Spatial redundancy is relatively inherent [3] and very practical in wireless sensor networks since they are typically deployed densely, in this way giving a lot of redundancy in network coverage and connectivity [4]. It presumes that redundant resources, e.g. sensor motes, communication links or even mathematical models, are accessible and permit the cross-monitoring depends on the comparison of duplicated information. Physical redundancy, also known as direct redundancy or hardware redundancy [5] is the most widely recognized method used to guarantee the reliability of a system. It depends on the dense deployment of various independent nodes to cover a particular zone[6].

In this paper, an effort has been made to propose an energy efficient algorithm for the densely deployed network based DBSCAN algorithm [7]. It has been observed that as the number of nodes increases the performance of routing protocols degrades dramatically. Due to the inexpensive cost and small size of sensor nodes, sensor networks are densely deployed in many applications [8]. As the number of nodes in large-scale WSNs increases, the density of the network is increased. Therefore more redundant information is created and thus makes the routing more challenging. On the other hand, in some inclement and unstable environment, a certain degree of redundancy may be desirable to provide the network with reliability [9]. A trade-off between the redundancy and the redundancy utilization is challenging. Hence, routing must be prepared in advance and maintained constantly [10]. Literature survey reveals that many hierarchical routing algorithms like EEHCRP (Energy –Efficient Hierarchical Clustering Routing Protocol), LEACH (Low Energy Adaptive Clustering Hierarchy), PEGASIS (Power-Efficient Gathering in Sensor Information System)), TEEN (Threshold Sensitive Energy Efficient Sensor Network protocol), APTEEN (Adaptive Threshold Sensitive Energy Efficient Sensor Network protocol), EHPR (Energy-aware Hierarchical Routing Protocol) suffers when the number of node increases[11]. The Survey reveals that the above-mentioned issues can be successfully addressed & resolved if we consider the following:

1. Appropriate cluster head selection (Control overhead reduction-based category)
2. Simplify the route construction method (Control overhead reduction-based category)
3. Dynamic event clustering (Energy consumption mitigation-based category)
4. Multi-hop communication(Energy balance-based category)

It has been observed if the nodes are randomly deployed than there may be a probability of uneven deployment. Some areas could be highly dense while others could be less dense. Since some areas are highly dense. Hence, these areas have highly probable transmission of redundant information, thus resulting in a waste of energy of these nodes. While the areas which are less dense are very critical and those few nodes are of prime consideration. Hence, the energy of these nodes should be conserved [12][13]. In the proposed algorithm the network is densely deployed and random deployment may lead to high as well as low-density areas of nodes. The DBSCAN algorithm is used to identify the low-density areas and high-density areas [14].

The complete paper is structured as detailed below: Section 2 briefs about the related work is done so far and DBSCAN algorithm. Section 3 entails the Radio Model used for the implementation of the algorithm. Section 4 has the implementation detail, process layout, flowchart, algorithms and detail discussions about the proposed algorithm. In section 5 simulation results are shown which reveals the significant improvement in various parameters in comparison to existing approaches. Finally, section 6 concluded the research and the suggestions that could be accomplished as a future enhancement to the proposed work are discussed in this section.

II. Related Work

2.1 LEACH (Low-Energy Adaptive Clustering Hierarchy)

LEACH [15] is a clustering based hierarchical routing protocol. The formation of the cluster depends on the strength of receiving a signal and CHs are used to transmit the processed information to the sink. The transmission is done by only such CHs, thus it helps in saving node's energy in the network. Data processing like aggregation and data fusion are performed locally within the cluster. As compared to direct transmission and minimum transmission energy routing protocols LEACH outperforms in terms of reduction of energy dissipation over a factor of 7 and 4-8 respectively.

2.2 FMCHEL (Fuzzy Master Cluster Head Election LEACH)

FMCHEL [16] is a hierarchical homogeneous routing protocol, which is developed for an application where the sink node is positioned very far from the sensor network area. In this protocol, the fuzzy logic-based CH selection is used to maximize the lifetime of WSNs. The CH election mechanism is similar to CHEF, but the proposed approach also has the master-CH election mechanism in which only master-cluster-head node transfers the processed information to the sink node. FMCHEL is more energy efficient, having prolonged network lifetime, more stable region as compared to LEACH and CHEF protocol.

2.3 EAUCF (Energy-Aware Unequal Clustering with Fuzzy)

A fuzzy energy aware unequal clustering algorithm EAUCF [17] is an algorithm which is developed to improve the network lifetime of WSN. EACUF is a distributed competitive algorithm which chooses the CHs through the energy-based competition among the tentative CHs. Cluster–heads are selected using a probabilistic model. For making prudent decisions, it uses the distance to sink node and residual energy and customs fuzzy rules to knob reservations in completion range estimation.

2.4 CHEF (Cluster –Head Election mechanism using Fuzzy Logic)

CHEF (Cluster –Head Election mechanism using Fuzzy Logic)

In CHEF [18], the fuzzy if-then rules are used for the selection of CH. Energy and the proximity distance are the two linguistic parameters which are used for the choice of CHs in CHEF. The CHEF is more efficient than LEACH in terms of stability period. CHEF is a fuzzy-based approach, in which CH election is performed in a distributed manner. It ensures that no two clusters-heads can exist within r distance using the candidate method, the fuzzy logic control permits the node which is locally optimal and having higher energy than the others chosen as CH [20].

2.5 DBSCAN (*Density based Spatial Clustering of Applications with Noise)*

Density-based clustering algorithm has occupied a vibrant role to discover a non-linear shape, structure on the basis of the density. Density-Based Spatial Clustering of Applications with Noise (DBSCAN) is the most extensively used density-based algorithm. The DBSCAN algorithm can classify clusters in huge spatial datasets by observing at the local density of database elements, via a single input parameter. Besides, the user gets a recommendation on which parameter value that would be suitable. In this way, the minimum information of the domain is required. The DBSCAN can likewise figure out what information ought to be categorized as noise or outliers. In spite of this, its working process is fast and scales extremely well with the size of the database directly.

By utilizing the density distribution of nodes in the database, DBSCAN can sort these nodes into partitioned clusters that characterize diverse classes. DBSCAN can identify clusters of arbitrary shape, as can be found in figure 1 [7]. In any case, clusters that lie close to each other have a tendency to have a place to the similar class.

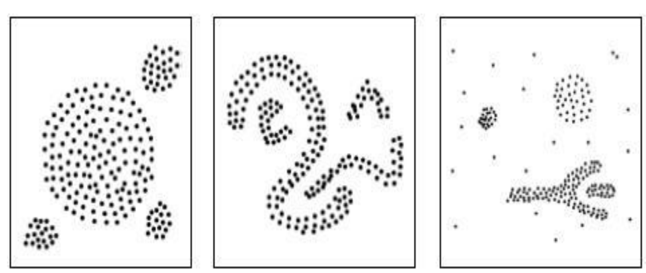

Figure ***1***. The Node Distribution Of Three Different Databases, Taken From SEQUOIA 2000 Benchmark Database**.**

The accompanying section will portray the functioning of DBSCAN algorithm. Its computing procedure depends on six guidelines or definitions, making two lemmas.

Definition 1: *(The Eps-neighborhood of a point)*

$$N_{Eps}(p) = \{q \in D | dist(p,q) < Eps\}$$

For a point to have a place inside a cluster it needs to have at least one other point that lies closer to it than the distance Eps.

Definition 2: *(Directly density-reachable)*

There is two sort of points having its place within the cluster; these are border points and core points, as can be found in figure 2 [7].

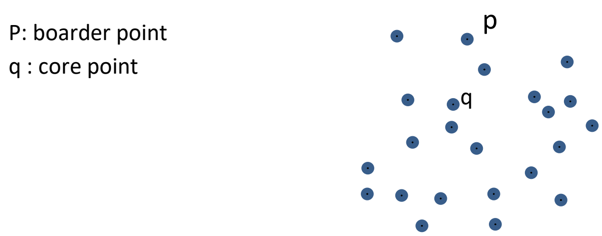

Figure 2: Border- and core points

"The Eps-neighborhood of a border point incline to have considerably fewer points than the Eps-neighborhood of a core point."[7]. The border points will, in any case, be a part of the cluster and by taking account of these points, they must incorporate the Eps-neighborhood of a core point q as seen in figure 3 [7].

1)$p \in N_{Eps}(q)$

All together for point q to be a core point it requires to have the least number of points inside its Eps-neighborhood.
2)$| N_{Eps}(q)| \geq MinPts$ (core point condition)

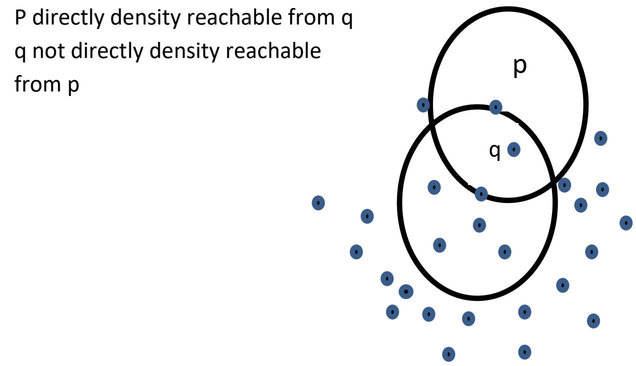

Figure 3: Point P Is Directly Density-Reachable From Point Q Bunt Not Vice Versa

Definition 3: *(Density-reachable)*

"A point *p* is *density-reachable* from a point *q* with respect to *Eps* and *MinPts* if there is a chain of points

$p_1 ...,p_n$, $p_1=q$, $p_n=p$ with the end goal that p_{i+1} is *straightforwardly density-reachable* from p_i.". *Figure 4* **[7]** demonstrates an outline of of a density-reachable point.

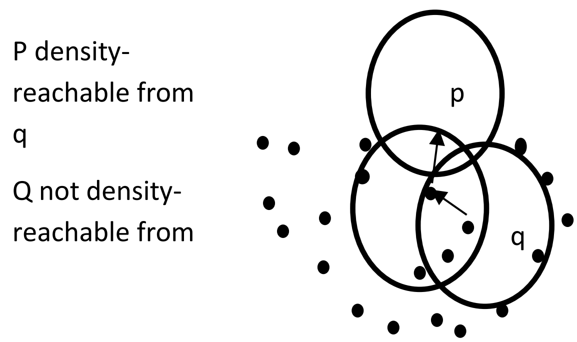

Figure 4. Point *P* Is Density-Reachable From Point *Q* And Not Vice Versa.

Definition 4: *(Density-connected)*

There is a situation when two border points will have a place within the similar cluster however where the two border points don't share a particular core point. In these circumstances, the points won't be density-reachable from each other. There must, however, be a core point q from which they are both density-reachable. Figure 5 [7] indicates how density connectivity functions.

“A point p is *density-connected* to a point q with respect to *Eps* and *MinPts* if there is a point *o* to such an extant that both, *p* and *q* are density-reachable from *o* as for *Eps* and *MinPts*.”

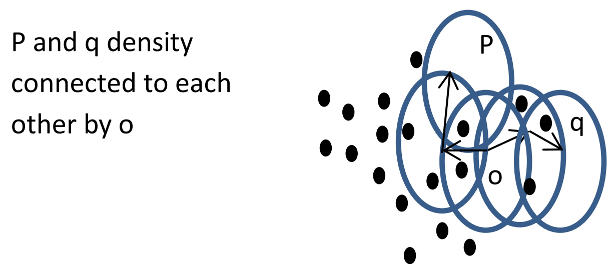

Figure 5. Density connectivity.

Definition 5: *(cluster)*

If the event that point p is a part of a cluster C and point q is density-reachable from point p with respect to a given distance and a minimum number of points inside the distance, at that point q is additionally a part of cluster C.

1) "∀ p, q: if p ϵ C and q is density-reachable from p with respect to Eps and MinPts, then q ϵ C.

Two points having a place within the similar cluster *C* is the same as saying that *p* is density-connected to *q* with respect to the given distance and the number of points inside that given distance.

2) "∀ *p*, *q* ϵ *C*: *p* is *density-connected* to *q* with respect to *Eps* and *MinPts*.

Definition 6: *(noise)*

Noise is the set of points, in the database, that doesn’t have a place with any of the clusters.

Lemma 1:

A cluster can be framed from any of its core points and will continuously having the similar shape.

Lemma 2:

Let p be a core point in cluster C with a given minimum distance (Eps) and a minimum number of points within that distance (MinPts). If the set O is density-reachable from p regarding the same Eps and MinPts, at that point C is equivalent to the set O.

"To identify a cluster, DBSCAN begins with a subjective point p and recovers all points density-reachable from p with respect to Eps and MinPts. In the event that p is a core point, this technique produces a cluster regarding Eps and MinPts (see Lemma 2). If p is a border point, in this situation no points are density-reachable from p and DBSCAN visits the following point of the database." [7]

5.1.1. Algorithmic steps for DBSCAN clustering

Let X = {x1, x2, x3, ..., xn} is the arrangements of data points. In the DBSCAN algorithm having two parameters: ε (Eps) and the smallest possible points essential to shaping a cluster (MinPts).**Begin with an arbitrary initial point that has not been traversed.**

1) Concentrate the neighborhood of this point using ε (All points which are within the ε distance are neighborhood).

3) If there is adequate neighborhood around this point, at that point the clustering process begins and the point is set apart as visited else, this point is labeled as noise (Later this point can turn as the part of the cluster).

4) If a point is observed as a part of the cluster, at this point its ε neighborhood is additionally the part of the cluster and the above technique from step 2 is continued for all ε neighborhood points. This process is continued until all points in the cluster are resolved.

5) Another unvisited point is recovered and after processing leads to the disclosure of a further cluster or noise.

6) This procedure proceeds until all points are set apart as visited.

DBSCAN is the most commonly used clustering algorithm since it has numerous favorable circumstances. It does not require a-prior description for the number of clusters. It can distinguish noise data while cluster. DBSCAN algorithm can discover and estimate arbitrarily size and arbitrarily shaped clusters. But, in case of varying density clusters sometimes DBSCAN algorithm fails.

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III. Energy Model Analysis

In the proposed approach, a simple first-order model proposed by the Heinzelman et al has been used The model consists of transmitting and receiving electronic and transmitting amplifier as shown in figure 6. The power attenuation is dependent on the distance between the transmitter and the receiver. The free space model and the multi-path fading channel model are used in the construction of radio model.

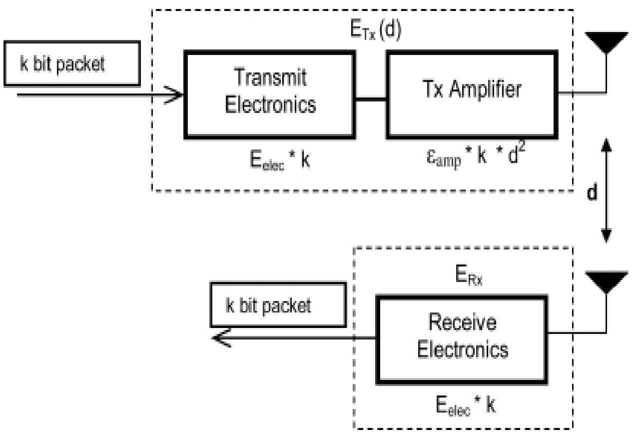

Figure 6: Energy Dissipation Diagram

When the sensor node transmits k-bit data from its transmitter, the energy dissipation is:

$$E_{Tx}(k,d) = E_{elec} * k + \epsilon_{fs} * k * d^2 \quad \text{if } d < d_0 \qquad (1)$$

$$= E_{elec} * k + \epsilon_{mp} * k * d^4 \quad \text{if } d \geq d_0 \qquad (2)$$

The energy dissipation on receiving a k-bit data packet is given as:

$$E_{Rx}(k) = E_{elec} * k \qquad (3)$$

Eelec is the energy dissipation parameter required for electronic circuits. Here, k is the packet size, d is the distance between two nodes and Efs and Emp are the transmitter amplifier characteristics.

IV. Proposed Approach

In the densely deployed network the nodes lie in the close proximity, hence, there is a high probability that the nodes will sense the redundant information. Since the network is randomly deployed so the size of the cluster and node density could vary [19]. Hence the nodes in the low-density areas are very critical and the probability of redundancy is very low in those areas. So, If we separate out the region as high-density areas and low-density areas than the nodes with low-density area will be treated as critical and they could send the information directly to the base station and the selection of the nodes those will be going to sleep mode will be easy, since the critical nodes are not participating in any cluster. The nodes in the high-density areas could be treated as non-critical since these areas are highly redundant in nature [20]. If some of the nodes go into the sleep mode than the energy of those nodes could be optimized in order to increase the network lifetime.

The proposed approach is processed in two-phase the setup phase and the steady state phase as in LEACH. The cluster head is chosen by the Fuzzy inference system. The proposed approach has completely superseded the LEACH algorithm and IC-ACO [21] algorithm as we have shown in the simulation results. The brief description of the setup phase and the steady state phase of the proposed approach is as given:

- **Setup Phase**

Formation of Clusters using DBSACN

Literature reviews reveal the various shortcomings of clustering in WSN. Finding out the number of clusters and formation of well-distributed clusters are major problems areas in clustering. An Association of all the nodes with any cluster based on the distance, even if a node is spatially far away from a cluster than the base station sometimes increase the cost of clustering in terms of energy when the network is densely deployed [20]. Hence the DBSCAN algorithm is used for identifying the dynamic cluster in which some of the nodes are identified as noise or outlier and they will not participate in any cluster formation. However to cover the entire region they will also participate in sensing and sending data to the base station directly or to the nearest cluster heads. With the help of the DBSCAN algorithm, the High Density and Low-density areas are identified and the clusters are formed in high-density areas and low-density areas.

Selection of cluster heads using Fuzzy Logic

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It is envisaged that if the approximate reasoning power of Fuzzy logic is combined with the wireless sensor network, it may be easier to handle the complex behavior of the wireless sensor network. There are numerous soft computing techniques available, which could be used for enhancing the network lifetime through optimizing various processes like the selection of optimal cluster heads, the formation of the cluster and in finding an optimal route for routing. Fuzzy inference is the process of formulating the mapping from a given input to an output. The mapping then provides a basis from which decisions can be made. The inference engine makes use of inputs and fuzzy if-then rules to simulate reasoning by fuzzy inference. The interface transforms the fuzzy set obtained by the inference engine into a crisp output value. In the proposed approach fuzzy-if-then rules are applied on the two input parameters, namely the energy of the node and proximity distance. Fuzzy logic optimizes the cluster head selection procedure, which was earlier done randomly in Leach and IC-ACO[21].

- **Fuzzy Logic Control**

Classical techniques only consider the true and false values while fuzzy logic can consider the partial truth value of parameters. The model of fuzzy logic consists of fuzzifier, fuzzy rules, fuzzy inference engine, and a defuzzifier as shown in figure 7. In the proposed approach the MAMDANI model is used. The crisp values are converted into fuzzy sets by the fuzzifier then; the fuzzy if-then-else rules are applied on the fuzzy sets to produce an output in the form of the fuzzy set[22][23]. The defuzzifier then converts the output fuzzy set to crisp output using defuzzification technique.

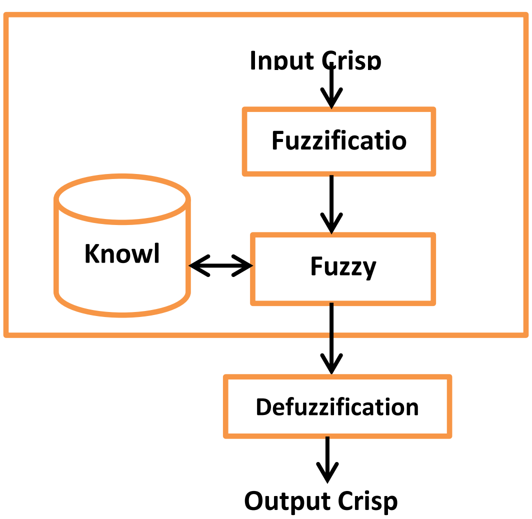

Figure 7: Structure Of Fuzzy Logic Model

It has been investigated that the proper cluster head selection mechanism can significantly improve the stability period and network lifetime of the wireless sensor network. In the setup phase, Cluster heads are identified based on two fuzzy descriptor distance and residual energy of the battery.

Knowledge Representation

The setup phase involves the selection of cluster heads, which is done using the Fuzzy logic. The proposed algorithm implements the fuzzy logic using the FIS editor which is a GUI based tool that makes it easier to explore the features of Fuzzy logic[22].

Here, we use two input functions that are:

- Distance: This parameter represents the distance of each node to the base station.
- Residual energy: Remaining energy of the sensor nodes.

When the distance and the residual energy of the nodes are passed to the Fuzzy Inference System (FIS), they are converted to the fuzzy sets and represented using the membership functions.

Table 1: Fuzzy Set For Input Variable

Input Variable	**Fuzzy Set**		
Residual Energy of battery	Low	Average	High
Distance	Near	Medium	Far

These two parameters are here known as input variables. There are three different membership function associated with each input function as shown in table 1.Since the proposed approach is homogeneous and all the nodes are having similar initial energy, hence, the residual energy variable could take the values ranging from 0 to 0.5 as shown in figure 8. The distance variable could take the values ranging from 0 to 75. The linguistic variable representing the distance is represented using three levels that are near, medium and far as shown in table 1. The membership function for residual energy and proximity distance is shown in figure 9 and figure 10.

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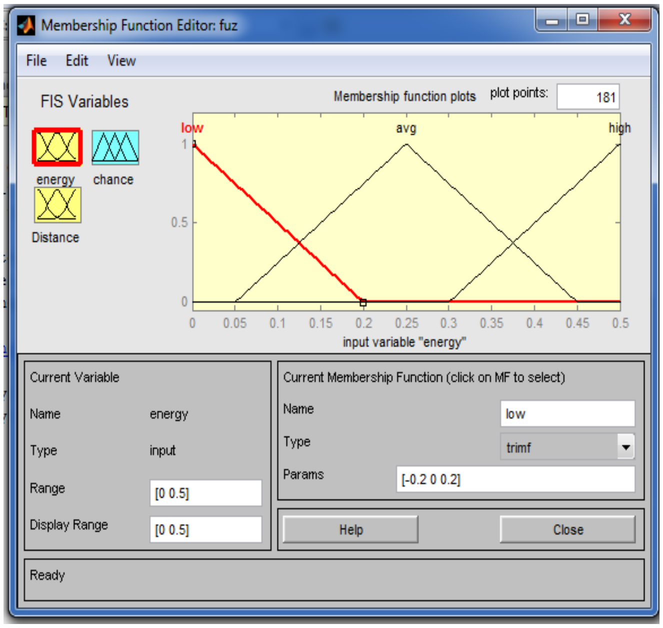

Figure 9: Membership Function Editor For Residual Energy

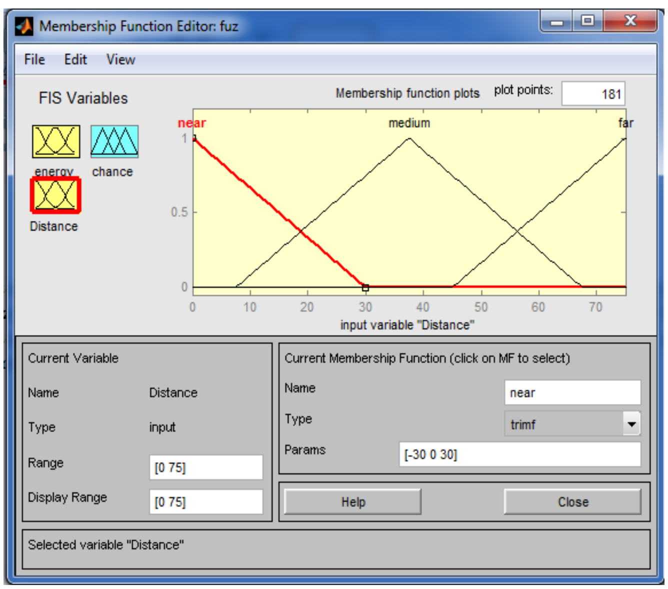

Figure 10: Membership Function Editor For Distance

After the conversion of the information to the membership functions, these functions are passed to the fuzzy inference engine where they are manipulated using the rule base, which comprises of if-then statements that manipulate these linguistic variables and produces the output. The rule base and its representation in the proposed approach is as shown in Table 2:

Table 2: Inference Rules

S.No.	ENERGY	DISTANCE	CHANCES
1	Low	Near	Low
2	Low	Medium	Low
3	Low	Far	Low
4	Average	Near	High
5	Average	Medium	High
6	Average	Far	Low
7	High	Near	High
8	High	Medium	High
	High	Far	High

- **Steady State Phase**

In the second phase (Steady state phase) minimization of redundant data transmission and routing of data is performed in both the regions i.e. High-density areas and low-density areas. In the steady state phase the sleep management takes place for the minimization of redundant node for the energy optimization.The Following steps are repeated until all the nodes are dead in the sensor system.

1. Minimization of Redundancy and Sleep Management: The minimization of redundancy is based on the sleep management of nodes within the high-density areas [24]. The selection of nodes those will goes to the sleep mode will be based on the temperature sensed by the nodes within the cluster. The nodes which lie in close proximity to each other having the maximum probability to send the redundant information. In order to save the energy lost in the transmission of this redundant information the temperature of nodes has been taken into consideration. It is assumed that all the nodes in the network randomly sensing temperature between the value 20 and 50-degree centigrade. Inside each cluster, a cluster head has been chosen based on two fuzzy descriptor distance and energy as discussed in the setup phase. For each cluster, a pattern code table has been generated. This table will be unique for each cluster. Each node calculates its own pattern code depending upon the range of the temperature. All the nodes having the same pattern code will be grouped and only 5% nodes those are having higher energy than their group members will participate in transmission. The other group members will be in sleep mode in the current round. Hence, they will be considered as redundant nodes and they will not participate in the transmission. The 5% nodes, those are selected for the transmission will send their information to the cluster.The information received and processed by the cluster head then transmitted to the base station. The pattern code table formed during each round for each cluster head is as shown below.

Table 3: Pattern Code For Node As Per Temperature

Node	Temperature	Code	Energy
Sensor 56	45	3	0.45
Sensor 62	22	1	0.42
Sensor 77	47	3	0.46
Sensor 32	23	1	0.32
Sensor 43	35	2	0.33
Sensor 89	43	3	0.18
Sensor 64	46	3	0.42
Sensor 93	43	3	0.37
Sensor 23	32	2	0.32
Sensor 52	37	2	0.27

It has been observed from the above table that if the temperature value of the nodes is in between 20 to 30 the pattern code value will be one. If the temperature value of the nodes is in the range of 30 to 40, the pattern code value will be two and if the temperature value of the nodes is in the range of 40 to 50, the pattern code value of the node will be three. All the nodes having the same pattern code will be grouped together. Hence, for the above table, the three groups Group1 (sensor 62, sensor 32), Group 2 (sensor 43, sensor 23, sensor 52), Group3 (sensor 56, sensor 77, sensor89, sensor 64, sensor 93) are formed. Only 5% of the group members having higher energy than the group members have been chosen for the transmission and rest will be in sleep mode.

2. To route the data packets within the cluster: Within the cluster, the nodes which are in sleep mode for the current round will not participate in the transmission of sensed information to the base station, since these nodes are considered as redundant nodes. Thus, the routing task is initiated by the remaining 5% nodes from each group and they will transmit the information to the base station. This process is repeated for all the clusters formed in high-density areas.

The nodes lie in low-density areas are considered as a critical node.All the nodes of low-density areas will participate in transmission and no node will go into the sleep mode from this region. Since in low-density areas the probability of redundancy is very low, hence, all the nodes will transmit data to the base station based on the distance. All the nodes will calculate its distance with the cluster heads and the base station. The distance from nodes to cluster heads is calculated as D1, here i is the identity of the node.

$$D_1=\sqrt{(S(i).x - CH(k).x)^2 + (S(i).y - CH(k).y)^2}; \quad (4)$$

The distance between cluster heads and the base station is calculated as D2

$$D_2=\sqrt{(CH(k).x - BS.x)^2 + CH(k).y - BS.y)^2}; \quad (5)$$

The distance between nodes and the base station is calculated as D3

$$D_3=\sqrt{(S(i).x - BS.x)^2 + (S(i).y - BS.y)^2}; \quad (6)$$

The total distance, D_{total} is the distance between the node to cluster head cluster and cluster head to the base station is as below

$$D_{total}=D1+D2; \quad (7)$$

If the distance D_{total} is greater than the D_2 then the critical nodes transmit the data directly to the base station otherwise the nodes transmit its data to the nearby cluster-head.

The following algorithm represents the steps to be followed in the implementation of the proposed approach

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for the formation of clusters, selection of cluster heads and for finding the optimal path to the destination:

1. Following steps are repeated until all the nodes are dead in the network.

2. The network is divided into low-density areas and high-density areas using the DBSCAN algorithm.

3. The two Fuzzy descriptors namely residual energy and proximity distance are passed to the Fuzzy Inference System, which processes the information based on the predefined fuzzy rules and produces the output.

4. Output produced by the FIS system is used for selection of cluster heads in the high-density region.

5. After cluster formation and the selection of cluster heads efforts have been done to minimize the redundant information based on the temperature value sensed by these nodes. Only 5% nodes with higher energy within each cluster will participate in the transmission of data in each round, rest will be in sleep mode.

Flowchart for the proposed algorithm is presented through figure 11.

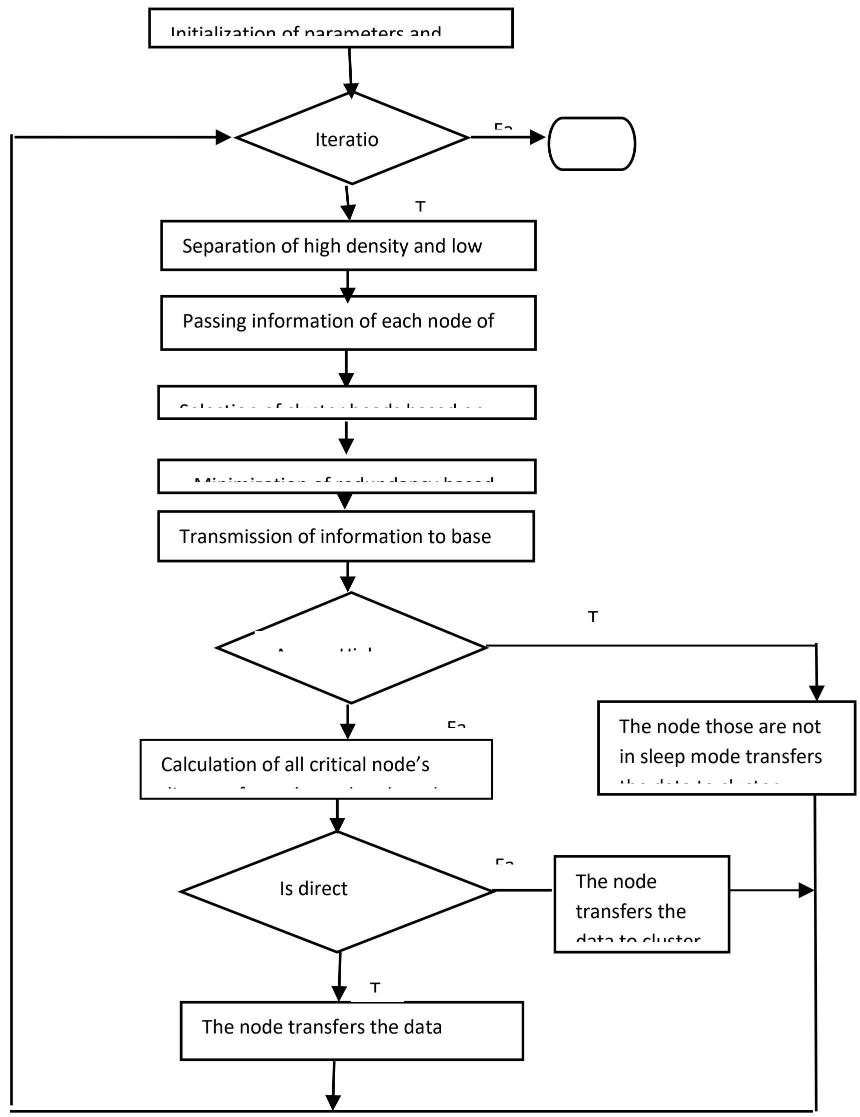

Figure 11 : Flowchart For Proposed Approach

V. Simulation Results

This section briefly describes the simulation results of the proposed approach and the performance of the three protocols, namely LEACH and IC-ACO and FDBSCAN have been compared with similar network and parameter settings. The transmission range of all the nodes is similar. The sink node lies at position (50, 50). The results obtained depicts that the fuzzy logic approach calculates the linguistic rules in a natural way and the requirement of accurate representation of the environment could be avoided. For simulation 100 and 200 and 300 nodes are randomly placed in a 100*100 region. The parameters used for the simulation are presented in Table 4.

Table 4: Parameter Values Used For Simulation.

PARAMETERS	**VALUES**
X and Y coordinate of the sink	50,50
Cluster head radius	5 meters
Initial Energy (Eo)	0.5 Joules
ETX=ERX	50*0.000000001 Joules
Transmit Amplifier types Efs Emp	 10*0.000000000001Joules 0.0013*0.000000000001 Joules
Data Aggregation Energy (EDA)	5*0.000000001 Joules
Maximum number of rounds (rmax)	3000

The basis of the comparison of the three algorithms (LEACH, IC-ACO and FDBSCAN) is:

1. Stable region: The stable region is the region (or round) up to which all nodes are alive.
2. The number of data packets received at the sink node.

It could be clearly seen from the simulation results that as compared to LEACH and IC-ACO, the proposed approach has an improvement in the stability period as well as in the overall network lifetime of the network. is also found to be superior in terms of energy utilization when we compared it with the LEACH and IC-ACO. Table 5 indicates the values of rounds at which the first node dead for LEACH, IC-ACO and FDBSCAN with 100, 200 and 300 sensor nodes.

Table 5: First Dead Node Value Of LEACH IC-ACO And FDBSCAN Approach

Description	LEACH	IC-ACO	FDBSCAN
First node Dead_ round No of nodes 100	436	930	1337
First node Dead_ round No of nodes 200	222	948	1356
First node Dead_ round No of nodes 200	133	962	1397

The figure 12 and figure 13 Shows the formation of the cluster and the selection of cluster heads when the number of nodes is 100. The nodes which are not part of any cluster are considered as critical nodes, figure 14 and figure 15 shows the formation of cluster and selection of cluster heads when the number of nodes is 200. Figure 16 shows the formation of the cluster when the numbers of nodes are 300. Hence, increasing the number of nodes from 100 to 200 and 300 shows the performance of the proposed approach while the network is denser.

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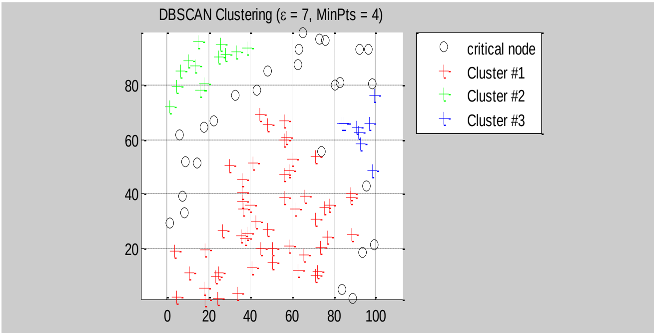

Figure 12: Formation Of Cluster When Number Of Nodes:100

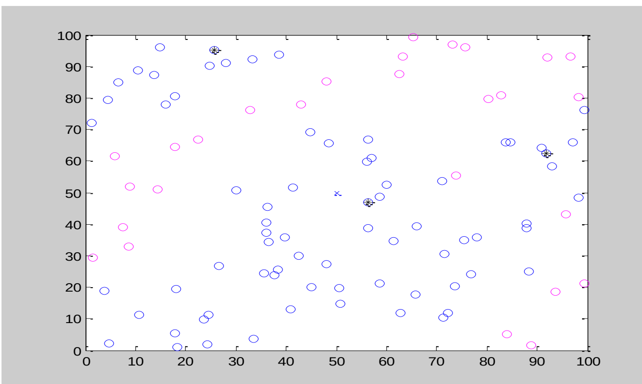

Figure 13: Selection Of Cluster Head Nodes When Nodes =100

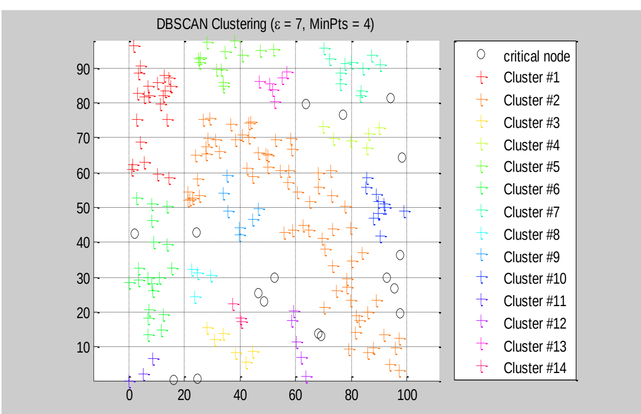

Figure 14: Formation Of Cluster When Number Of Nodes:200

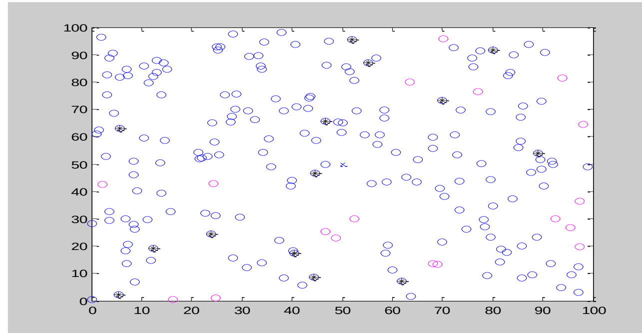

Figure 15: Selection Of Cluster Head Nodes When Nodes =200

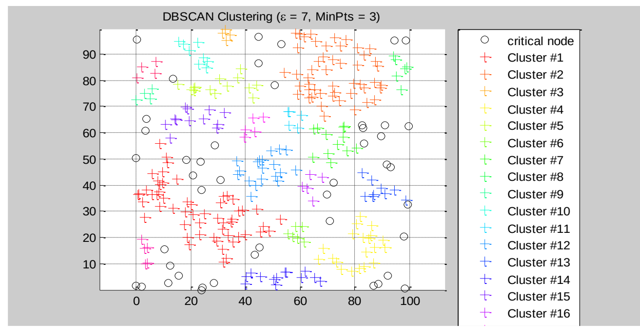

Figure 16: Formation Of Cluster When Number Of Nodes:300

Figure 17 shows the total number of nodes alive at different rounds, which specifies the network lifetime when 100 nodes are installed, it could be clearly seen from the figure that the performance of proposed algorithm is much better as compare to LEACH and IC-ACO. In LEACH the first node dead at 436 rounds, in IC-ACO at 930 rounds and at 1937 in FDBSCAN which illustrates the substantial progress in the stable region.

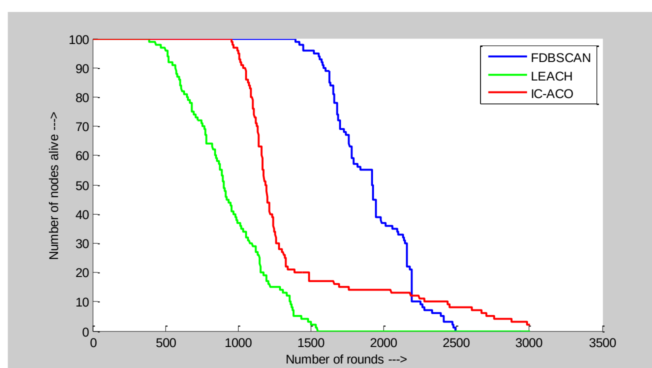

Figure 17: Total Number Of Nodes Alive Within The System At Different Rounds Of Iterations (Number Of Nodes: 100)

Figure 18 depicts the total number of nodes alive at different rounds, which specifies the network lifetime when the network is much dense as 200 nodes are installed within the network, the figure 18 illustrates that the performance of FDBSCAN is much better than LEACH and IC-ACO in dense environments. In LEACH protocol the first node is dead at 222 rounds, at 948 rounds in IC-ACO and 1356 in FDBSCAN, which clearly demonstrates that the performance of LEACH protocol is degraded in case the network is densely deployed, but the performance of IC-ACO algorithm is significantly improved whereas the performance of FDBSCAN is better than IC-ACO.

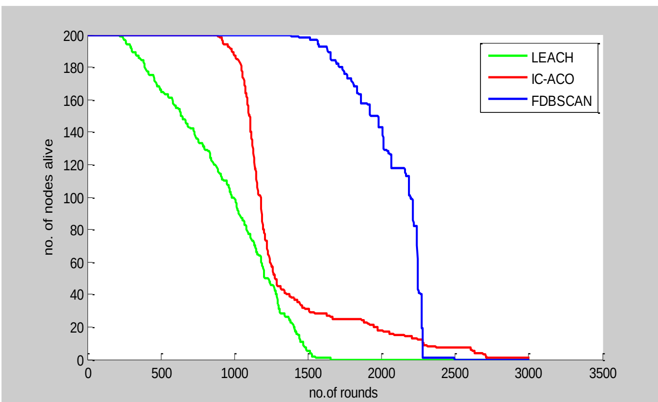

Figure 18: Total Number Of Nodes Alive Within The System At Different Rounds Of Iterations (Number Of Nodes: 200)

Figure 19 depicts the total number of nodes alive at different rounds, which specifies the network lifetime when the network is much dense as 300 nodes are installed within the network, the figure 19 illustrates that the performance of FDBSCAN is much better than LEACH and IC-ACO in dense environments. In LEACH protocol the first node is dead at 133 rounds, at 962 rounds in IC-ACO and 1397 in FDBSCAN, which clearly demonstrates that the performance of LEACH protocol is degraded in case the network is densely deployed, but the performance of IC-ACO algorithm is significantly improved whereas the performance of FDBSCAN is better than IC-ACO.

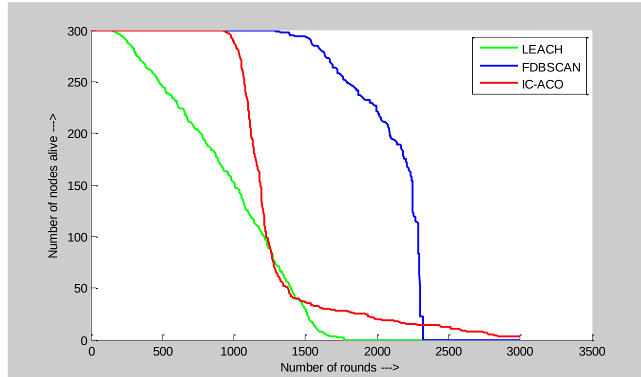

Figure 19: Total Number Of Nodes Alive Within The System At Different Rounds Of Iterations (Number Of Nodes: 300)

Figure 20 shows that the data packets transmitted to the sink node with 100 wireless sensor nodes in the network. It is clearly visible that even if the redundant information has not been transmitted in FDBSCAN similar to IC-ACO approach the total number of data packets transmitted to the sink node is increased because FDBSCAN has a higher network lifetime in comparison to LEACH protocol.

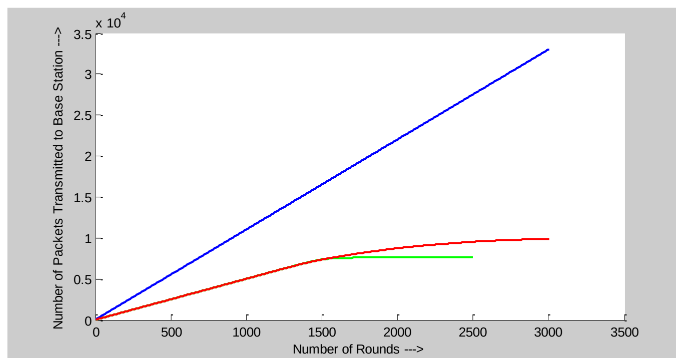

Figure 20: Total Number Of Packets Transmitted To The Sink Node At Different Rounds Of Iterations (Number Of Nodes: 100)

Figure 21 shows that the data packets acquired by the sink node when 200 wireless nodes are installed in the network. It is clearly seen that in FDBSCAN approach the total number of packets transmitted to the sink node is higher as compared to existing LEACH and IC-ACO algorithm in a densely deployed network.

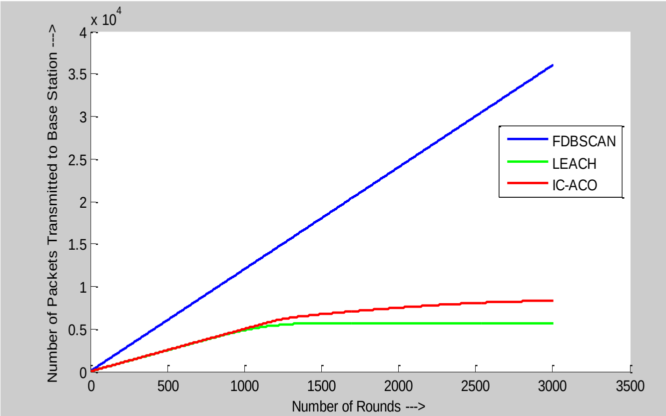

Figure 21: Total Number Of Data Packets Received By The Sink Node At Different Rounds Of Iterations (Number Of Nodes: 200)

Figure 22 shows that the data packets acquired by the sink node when 300 wireless nodes are installed in the network. It is clearly seen that in FDBSCAN approach the total number of packets transmitted to the sink node is higher as compared to existing LEACH and IC-ACO algorithm in a densely deployed network.

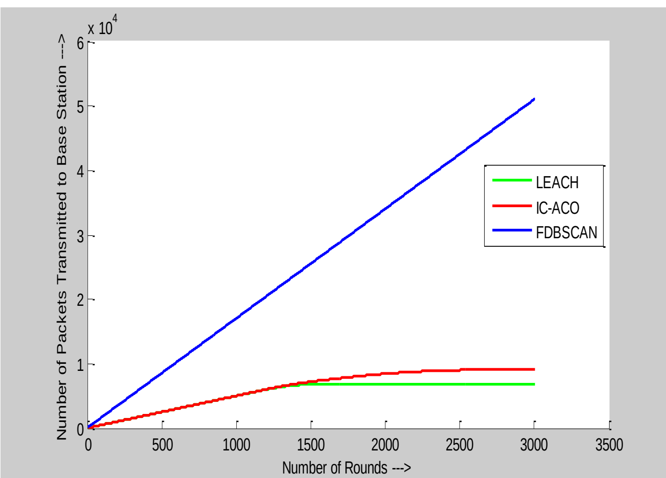

Figure 22: Total Number Of Data Packets Received By The Sink Node At Different Rounds Of Iterations (Number Of Nodes: 300)

Simulation results have the following conclusions:

1. The stability period is significantly improved as compared to existing IC-ACO and LEACH protocol in dense environments.
2. The proposed algorithm is more energy efficient since the overall network life time and the round at which first node dead is improved.
3. There is a considerable improvement in the number of data packets received by the sink node for the similar network scenario.

VI. Conclusion And Future Work

Selection of cluster head, cluster formation and discovering an optimal path in a dynamically changing environment of the sensor network are very challenging issues. The primary objective of the proposed algorithm is to extend the network lifetime in a densely deployed network. It has been observed that in a dense network the sensor nodes are usually placed in close proximity and used to transfer redundant information to the sink node, hence, energy is wasted in processing that redundant information. In the proposed framework the application of Fuzzy logic and DBSCAN Algorithm is used for cluster head selection and cluster formation and for the selection of nodes those will goes into the sleep mode in a particular round. The experimental results show that despite the extra overhead of selection of critical nodes, division of high-density areas and low-density areas and sleep management, FDBSCAN is competent to provide improved results in terms of elevated amount of packets transmitted, prolonged network lifetime, improved stability period and higher energy efficiency in a network where nodes are densely deployed. The proposed protocol was considered for various network scenarios by increasing the number of nodes in a densely deployed network and the simulation results noticeably capture the extended network lifetime, enhanced stable region and the higher number of packet transmission. In FDBSCAN algorithm the simulations have been done considering that the network is homogeneous, as a future work further result could be enriched and upgraded for the heterogeneous network. In the future, various methods like the incorporation of a mobile sink and mobility context of sensors in a dense environment shall be studied, which are considered as a big challenge in the wireless sensor network. In the FDBSCAN, the nodes are randomly arranged which could be further improved for future enhancement by incorporating any systematic deployment methodology. Thus, systematic deployment could further increase the overall energy efficiency with improved and enhanced coverage region.

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