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Original Article

Energy Capable Clustering Approach to Enhance the Duration of Mobile Smart Dust Network

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Abstract - Smart dust nodes in Mobile Wireless Sensor Networks (MWSNs) are typically placed in isolated places for extended periods with little to no social interaction and restricted energy resources. As a result, energy consumption becomes a crucial problem for smart dust deployment and layouts. To reduce energy consumption, a novel Energy-Capable Clustering Approach for the Smart Dust EC2ASD environment is a revolutionary tactic that is presented in this research. It depends on a two-phase clustering representation and offers the most environment coverage while using the least amount of energy possible. For self-governing heterogeneous techniques of establishing the characteristics in compliance with the signalling sequences wherein roughly the same data rates are supplied for every smart dust, this methodology utilized an efficient aware resource scheduling strategy. This resource-competent clustering technique can create energy-stabilized clusters as well, extending the network's life span and enhancing environmental coverage. According to simulation studies, EC2ASD outperforms DBSCAN and FCEEC in terms of network lifetime while also obtaining greater network coverage. The suggested technique not only provides a novel and improved method for choosing Cluster Heads (CHs) to minimise energy utilisation of network participants, producing greater overall stability of smart dust networks, but also identifies an appropriate cluster size with minimal energy dissipation.

Keywords - Smart dust, Energy competent clustering, Cluster head selection, Network coverage, Network duration.

1. Introduction

Lower-cost and low-consumption microscopic electromagnetic nodes have gained popularity due to recent advancements in MEMS devices. The WSN is made up of minute smart dust nodes that work together to build an ad hoc, dispersed data sensing and dissemination network to gather environmental data. Such networks combine detection and surveillance with mobile communications and minimal on-board processing resources. A "smart dust," sometimes known as a "sensor", is defined as each of these parts combined into a single system. The lifespan of wireless smart dust networks largely depends on their batteries, which are frequently tiny and non-replaceable. The vast majority of the energy used by smart dust networks is used for radio communication.

Consequently, creating a good clustering technique that keeps transportation costs within and across clusters to a minimum is crucial. Defence and domestic purposes extensively utilise these networks, including target detection, monitoring, and vulnerability assessment [1, 2]. By integrating the data gathered from numerous smart dust, each of which provides a rough estimate and assigns a unique identifier, the network's control and surveillance abilities could generate a precise global image of a target location.

The primary goal of a smart dust network is to obtain information from the pervasive environment and then deliver it via many hops to the Base Station (BS) [3]. Data routing protocols are categorised into three categories according to the network architecture. Hierarchical clustered relating routing protocols represent the most popular and energy-efficient of these [4]. From the previous study, consider the following as examples: LEACH, LEACH-C, LEA2C [5], EECS, etc. When nodes are clustered together, those that are significantly closer together create clusters. A Cluster Head (CH) for every cluster that serves as the regional BS. The LEACH method and LEACH-C, which is a centralised variation of this method, have already been published by the author.

Those techniques are clustering-based. The clustering strategy, wherein data are obtained through one prominent smart dust of every group, is one of many strategies available for energy-efficient smart dust networks. For such a smart dust network with a large number of smart dust nodes, it enables high stability. The clustering strategy also balances energy consumption amongst smart dust nodes, extending the network's lifespan. However, one smart dust node would be broadcasting information to the base station at a particular time due to chain-related methodologies' attempts to conserve energy while creating a link from the origin to the sink. Consequently, data aggregation occurs at every smart dust network node, allowing all pertinent information to spread throughout the network.

The CH's duty in LEACH is to obtain data from nearby nodes and transmit it to the BS. The position of CH is shifted amongst nodes; however, this movement is dependent on the possibility of doing so in every cycle, making it a reactive algorithm. While LEACH-C and LEACH-N are renditions of LEACH, neither of them was successful in preventing the nodes from experiencing premature energy loss, which resulted in an early termination of the live nodes. The researchers of [6] suggest a methodology called Tree-Based Clustering (TBC), in which moveable nodes inside a clustered structure construct a tree between the CH and the core. It successfully lowers and regulates the energy usage across the nodes. The enhancement of TBC upon LEACH versus the previous lifeless node is 70%.

Nevertheless, as more cycles occur and many more nodes start to die, the tree structure grows more intricate. A Zone-Based Hierarchical Organization (ZBHF) has been presented by the researcher of [7]. Reduced energy usage during the independent formation phase for energy competent WSNs is a key component of this strategy. Although the outcome of this approach is superior to that of LEACH and LEACH-C, their application in a meshed network is constrained by its network structure.

Nevertheless, the network's lifespan was increased by almost 50% inside the instance of LEA2C, which utilized two-stage clustering [9]. In the instance of LEA2C, CH was chosen based just on the node with the highest energy. The concept for EECA came via LEA2C and was inspired by this research on extending network longevity. Utilizing the K-means idea and multiple criteria, including energy and length, researchers’ first regrouped clusters in this research. This reorganization ensures that energy is distributed equally throughout all clusters. This suggested methodology differs from the prior clustering protocol in that it uses multiple parameters using the K-means idea, enabling it to dynamically cluster the nodes depending on their activity levels and geometrical similarity [8].

The calculation time can be cut down. Whenever the CH maintains meets the total energy requirements, simulation findings suggest that the proposed scheme can increase the network lifetime by 144% over Density-Based Spatial Clustering of Applications with Noise (DBSCAN), 62% over Fully Connected Energy Efficient Clustering (FCEEC). The smart dust nodes' unpredictable demise also provides a greater communication range. Smart dust that compromises off functionality for energy as wireless smart dust computation technology evolves; there is a significant amount of research being done on processing activities. Nevertheless, in order to ensure energy-efficient processing functioning, configuration, and topology, it is really required to identify and combine improvement methodologies and parameters influencing the exchange between energy and effectiveness in many energy conservation domains. The previous research on resource optimization in smart dust places an emphasis on certain sub-domains, like offloading techniques [8].

The structure of this research is as follows: An energy utilization analysis in the smart dust is presented first. Subsequently, the suggested procedure was explained, along with proposed methodology, EC²ASD Initial, and therefore, by utilizing several criteria for clustering, it assists in creating an energy competent cluster framework. Ultimately, provide some confirmation of the novel process through a number of experiments and discuss the implications for the future [9].

The proposed methodology contains the following problem or research gap.

- Inconsistent energy consumption among nodes causes hotspot problems and early node malfunctions.
- Ineffective Cluster Head (CH) selection that disregards important factors like transmission load, remaining energy, and node accessibility to the Base Station (BS).
- Node heterogeneity and changing external factors are not sufficiently taken into account.
- Absence of flexible systems to improve routing, along with clustering over time.

In order to regulate the consumption of electricity, increase network endurance and coverage, and minimize transmitting overhead, an intelligent and flexible energy-efficient grouping strategy is required.

2. Literature Survey

A clustered routing system for a smart dust environment was suggested in earlier research. In order to reduce the use of energy and increase the system's lifespan, a clustered routing algorithm is suggested. One common multilayer method of routing is clustering. The basic principle of clustering is to split the entire network into smaller groups of smart dust nodes and disperse them around the network, which is referred to as a "cluster." Numerous protocols, including Hybrid Energy-Efficient Distributed clustering (HEED), have been developed to enhance the LEACH methodology. The most popular technique for clustering in a smart dust environment is the one described above [10]. Regarding the selection of CH, this approach uses mixed variables based on transmission expenses and node efficiency. To divide tasks between cluster nodes, every mini-cluster talks to the CH smart dust node [11].

A customized Low-Energy Adaptive Clustering Hierarchy (LEACH-M) is suggested to alter the selection of CHs [12]. Conversely, a Distributed Energy-Efficient Clustering (DEEC) technique is suggested to choose the CH node based on a node's remaining energy divided by the network's overall energy. Nevertheless, the previous approach did not consider the cluster nodes' proximity to the BS. In the network environment, this will result in the hot spots issue, where nodes would use more energy when sending and receiving data [13]. Among these is an Energy-Efficient Unequal Clustering technique (EEUC) for smart dust environment data aggregation applications.

It is suggested that Fuzzy-Based Unequal Clustering (FBUC) be used [14]. Using an amount of neighbour nodes along with the remaining energy as inputs, the fuzzy structure technique calculates the circumference of nodes. This approach has the benefit of lowering transmission latency. Nevertheless, this approach results in a rise in overhead, which shortens the network lifespan. Energy-conserved unequal clusters with fuzzy logic (ECUCF) is one approach that has been suggested to address this issue. It reduces energy use and resolves the hot spots issue. According to the likelihood among nodes, CH is chosen at random, whereas BS is rotated at random [15]. Table 1 shows the comparison of existing methodologies.

Table 1. Shows the comparison of existing approaches

Approach / Protocol	Key Features	CH Selection Criteria	Advantages	Limitations
LEACH	Basic clustered approach	Random selection	Simple implementation	Energy imbalance, hot spots
HEED	Hybrid energy-efficiency distributed clustering	Broadcasting cost & node efficiency	Improved over LEACH	May still have an energy imbalance
LEACH-M	Modified LEACH	Customized CH election	Enhanced CH election	Does not consider BS proximity
DEEC	Distributed energy-efficient clustering	Remaining energy / total energy	Energy-based CH election	Ignores node proximity to BS → hot spots
EEUC	Energy-efficiency unequal clustering	Unequal cluster sizes	Reduces hot spots	More complex setup
FBUC	Fuzzy-based unequal clustering	Remaining energy & neighbor count (via fuzzy logic)	Lowers transmission delay	Increases overhead, shortens lifespan
ECUCF	Energy-conserved unequal clusters with fuzzy logic	Random CH based on node probability, rotating BS	Reduces energy use, fixes hot spots	Increased randomness, possible instability

3. Prototype for Energy Utilization

Essentially, energy utilization among smart dust nodes is the main topic of this research work. However, due to the nature of both the network and its operating model for smart dust activities, as well as various other extraneous material impacting the model's efficiency, separating the energy consumed from the overall energy depletion is challenging.

These characteristics, it seems, have rendered this investigation an extremely difficult task.

- Classifying smart dust environment sub-processes and describing their behavior with regard to energy usage.
- Due to the large number of processes the equipment performs simultaneously, recognizing irregular energy depletion noticed for various actions in smart dust and determining its root causes is an extremely difficult challenge.
- The equipment processing's many functional and operational regions influence the efficient optimization approaches used. It is rather difficult to put together these strategies and identify applications of a similar strategy across diverse aspects.

It appears that the majority of existing methods concentrate on the sub-processes as a distinct entity. These difficulties make developing a flawless, efficient mechanism for smart dust networks a difficult undertaking. As battery capacity has not advanced at the same rate as supercomputing, smart dust communications technology, energy optimization is becoming increasingly important in smart dust nodes. Additionally, due to restrictions on battery capacity put in place to keep the equipment portable, energy usage by numerous software and hardware elements has become a crucial consideration. Figure 1 illustrates the demonstration of communication for smart dust nodes. Many energy theories have been put forth thus far that show various elements essential to smart dust environment energy utilization. Finally, the total power used by the smart dust node, the sum of the power used by the processing, network, and visual elements, has been generically defined as follows. All such primary consumers have also been divided into precise functional areas where they use the equipment's energy.

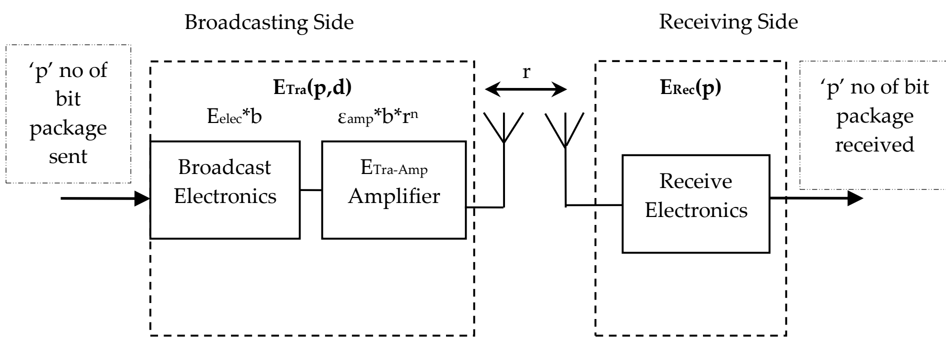

Fig. 1 Communication demonstration for smart dust nodes

$$E_{smart} = E_{visual} + E_{process} + E_{Env} \tag{1}$$

The exponential increase in equipment computing power and the unintended energy leaks that frequently go unnoticed highlight the seriousness of the battery problem for smart dust. Communication uses the most energy during transmission and reception compared to other operations. The broadcaster needs to use the following resources to send a p bits of information d metres away:

$$E_{Tra(p,d)} = E_{Tra(l)} + E_{Tra-Amp(p,d)} \tag{2}$$

$$E_{Tra(p,d)} = p.E_{ele(p,d)} + p.\varepsilon.d^2 \ if \ d < d_{cross} \tag{3}$$

$$E_{Tra(p,d)} = p.E_{ele(p,d)} + p.\varepsilon.d^4 \tag{4}$$

The energy utilization for receiving p bits of information is calculated as in equation 5,

$$E_{Rec(p)} = p.E_{ele} \tag{5}$$

Where, E_{ele}energy of electronic broadcast/reception, p quantity of a message, d remoteness between transmitter and recipient, E_{Tra} broadcast energy, $E_{Tra-Amp}$ amplification energy, ∈ amplification parameter, d_{cross} boundary remoteness more than which broadcast parameter transform of cost, E_{Rec} receiving energy.

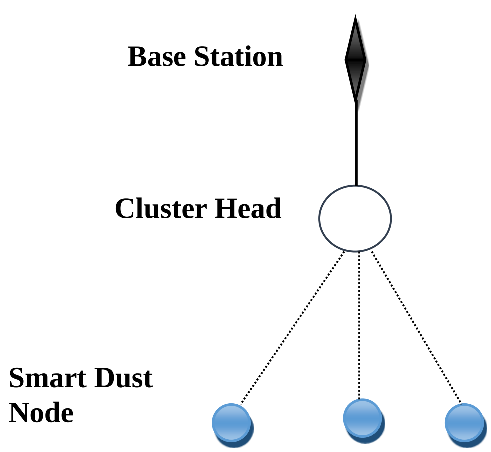

Fig. 2 Architecture of smart dust environment

4. Proposed Methodology

The EC²ASD method here has been suggested to minimize the energy consumption of the network, increasing the lifespan of the network. This suggested Energy Capable Clustering Approach for Smart DustEC²ASD Scheme considers the smart dust nodes' remaining energy, location, and information latency when choosing the CH. The moveable sinks project has a time delay. The smart dust node that can send the most packets while still retaining a significant level of leftover energy is selected as the CH. The movement between two states is calculated by using a Markov representation.

The Markov representation of the smart dust node and movement operations mostly depends on the current state rather than the background. Therefore, initially go through the system model, commencing with the presumptions, followed by going over every step of the suggested routing protocol in depth after providing pseudo code for the intended EC²ASD methodology. Figure 2 shows the architecture of the Smart Dust environment.

EC²ASD clustering technique and FCEEC have a close relationship. Similar to FCEEC, the services are organized into cycles. Every round begins with a clustered setup phase, where the cluster is organized, and ends with a communication session. Information from common smart dust sensor nodes is sent to CH during a communication session. Data is collected by CH and sent to BS. BS must assign a primary function for every smart dust sensor node in the cluster during the cluster setup phase; in this case, the roles are 0 for an idle smart dust node, 1 for an energetic smart dust node, and 2 for CH.

They consider that there is no restriction on BS energy. Additionally, the BS fully understands the location and energy status of every network smart dust sensor node. Smart dust sensor nodes are considered heterogeneous, meaning that at the beginning of the procedure, they all have the same energy, transmission, and processing capabilities. Several of the term descriptions used throughout the proposed method are listed in List 1 below.

4.1. Protocol 1: EC²ASD

Set of inputs for: "Number of smart dust nodes, Installation area, Cycle" Output: "Dead smart dust nodes after every round".

Call to function: Protocols 2, 3, 4, 5, and 6.

START:

1. Repetition of steps 2 to 4. Do 2 for round=1 to aliveSmartNodes! = 0 Call Algorithm 2; initialize smart dust node energy and range component if round===1
2. Initial cluster creation using the CALL Protocol 3
3. [Further optimizing the first clusters] CALL Protocol 4
4. Else
5. If the component is deadNodes! then
6. For smart dust nodes where vitality falls below the threshold, set the nodeID value to 0.
7. End Choose the m most active smart dust nodes as CHs if CALL Protocol 2 is used.
8. Retaining the CH acquired in Olattice earlier.
9. [Create first cluster depending on greatest energy] CALL Protocol 3.
10. CALL Protocol4; [Additional optimization, using maximum energy in the cluster head.]
11. End If CALL Protocol 7, [Role to each smart dust node is given.]
12. CALL Protocol 8; [Update of the number of activeNodes.]
13. [The outermost for loop comes to an end.
14. Marking the conclusion of each cycle.]

END

4.2. Protocol 2: CH Choice

Input: {Collection of configuration of contribution smart dust Nodes} Outcome: {m CHs}

BEGIN
If cycle= = 1then:
Begin x, y by arbitrary cost; opening energy to entire smart dust node= 0.55J;
Cost for an m is tartan using Davies-Bouldin directory, on behalf of an m amount of CHs;
Choose an arbitrary CHcost for *m* CHs;
Regularize input and CH set by applying Min-Max Normalization;
Duplicate regularized Input smart dust Nodes asinput_Temp;
Duplicate regularized CH as centroid_Temp;
Else,
Choose m the majority of active smart dust nodes as CHs.
Revisecentroid_Temp with a fresh set of regularized CHs;
End If
END

4.3. Protocol 3: Primary Cluster Construction

Input: {m CHs, range of configuration of Input smart dust Nodes, input_Temp, centroid_Temp}
Output of simulation: {m amount of energy uniform primary clusters}

START
Replicate (For a= 0) to a<factor proceed
If (I[a]. SDnode_ID! = 0) afterthat
Calculate Euclidean remoteness of the smart dust node of input_Temp through every smart dust node of centroid_Temp utilizing dual power as well as x, y points;
Acquire the adjacent smart dust sensor node to a particular smart dust sensor node;
Build a cluster contain ith the smart dust moveable sensor node that belongs to the adjacent smart dust moveable sensor node;
Close If
Close For
END

4.4. Protocol 4: Cluster Enhancement Procedure 4:

Input parameter: { *m*primary energy uniform clustering}
Output simulation: {Revised n value clusters}

Start
Begin old_Centroid by O_lattice;
Beginnew_Centroidas0;
CALL Protocol 5; [Reevaluate centroid] Return 0;
END

4.5. Protocol 5: Reevaluate Centroid

Input: {selection of arrangement of Input smart dust Nodes, New_Centroid, ACentroids}
Output simulation: {Amount of fresh Clusters}

```
Start
Reevaluate acentroid_fn:
(For a=0) to a<amount_of centroids do
If(Amount_of_ath_cluster_Element>1) next continue
(For b=0) to b<number of ath clustered component proves to do Sum_x = sum_x+x_of_bth_element_of_ath
Cluster; Sum_y=sum_y+y_of bth element in ath Cluster;
close For
x_of_new_Centroid of ath_cluster=Sum_x/ Amount _of ath_cluster_Element;
y of_new_Centroid of ath_cluster=Sum_y/ Amount  of ath_cluster_Element;
Else x_of_new_Centroid_of_ith_cluster= x_of_old_Centroid_of_ath_cluster;
y_of_new_Centroid_of_ath_cluster=y_of_old_Centroid_of_ath_cluster ;
Close If
Close For
If new_Centroid is equivalent to old_Centroid then:
Return 0; [Return with fresh clustering group]
otherwise
CALL Protocol 6; [Reevaluate Clustering]
Close If
END
```

4.6. Protocol 6: Reevaluate Clustering

Input: {Set of new_centroid, range of construction, Input smart dust sensor Nodes}
Output simulation: {fresh cluster group in environment }

```
START:
Duplicate For(a=0) to a<component do
If I[a]. SDnode_ID! =0 then
For(b=0) to b<Amount_of ACentroids, calculate Euclidean remoteness among the ith input smart dust sensor
node as well as the bth centroid;
End For
Achieve the neighboring centroid to ath smart dust sensor node associated;
Close If
Close For
CALL Protocol 5; [Reevaluate centroid]
END
```

4.7. Protocol 7: Responsibility Allotment by BS

Input: {Enhanced n clusters}
Output: {Every smart dust node with restructured responsibility allocated byBS}

```
BEGIN
Replicate For(a=0) to a<component do
If ath smart dust sensor node energy>thresholds_energy AND I[a].c==1 next
For centroids
Responsibility =2; close If
If ath smart dust sensor node energy>thresholds_energy AND I[a].c==0 next
For  clustering component
Responsibility =1; close If
```

If ath smart dust sensor node energy<threshold_energy, next: responsibility=0;
Close If
Close For
END

4.8. Protocol 8: ActiveSDNodes Updating

Input function: {n clusters contains restructured responsibility}
Output Simulation: {Revise the amount of active SDNodes}

START
Revise information used for every smart dust sensor node with responsibility=1; cumulative information at the smart dust moveable sensor node with responsibility=2;
Transmit information towards BS; revise the energy of every smart dust moveable sensor node;
If smart dust moveable sensor node energy <threshold_energy, next:
active SDNodes--;
Close If
Return active SDNodes;

5. Cluster Deployment with Setup

5.1. Clustering Setup Stage

The clustering approach provides a three-segment approach. The setup technique is first.
When performing primary gathering with setup, consider two distinct sets of information: energies and locations. Because of this, we have been using the min-max normalization method [8], wherein min_b and max_b are the maximal and minimal values for any displaying results 'b'. For instance, in a particular instance, utilize the x coordinate, y coordinate, and vitality as characteristics, and apply the min-max normalization method to match every one of these characteristics in the range of (0,1). A value a is mapped to the range of (0,1) by following the calculation in Equation (6),

$$A' = (a - min_a)/(max_a - min_a) \tag{6}$$

Whereas N is the total number of clustering groups, c_p is the centroid, p, τp is the average remoteness from the centroid c_p of both the cluster to each of its members, and $r(c_p, c_q)$ is the separation among centroids c_p and c_q. The clustering approach that results in gathering of clustering information only through minimum DB indices remains considered the best optimization method within this criteria because techniques that generate clusters with modest intra clustering lengths and extraordinary inter cluster ranges result in small DB indices. Equations 1, 2, and 3 refresh the network system's energy after each transmission process.

Despite earlier techniques, the one suggests reforms to the network clusters and creates fresh CHs using normalized information, which is then transmitted via the setup primary technique to create primary clusters. Davies-Bouldin indices are used to validate the result for k. Davies-Bouldin (DB) indices determine the proportion of intra-cluster dispersal to inter-cluster lengths.

$$I_{db} = \frac{1}{N}\sum_{k=N}^{N} Max\left(\frac{(\tau p + \tau q)}{r(c_p, c_q)}\right) \tag{7}$$

5.2. Cluster Head Picking Stage

In a related smart dust environment, the CH is crucial. These are the responsibilities of collecting data from every cluster network element while transmitting it where it is needed. Different standards are used to choose the

CH. These primarily depend on the closest smart dust to the BS or the peak power level. The smart dust with the most energy has been selected as the CH.

5.3. Data Broadcasting Stage

Once clusters have been established and a CH chosen, it is time to deliver information packets sensed at regular smart dust nodes towards the corresponding CHs. The CHs will then perform a data gathering technique before sending the packets of information to a BS. The energy usage is calculated at the end of every cycle. The location of the cluster's centroid is indeed the parameter that must be reduced in Primary cluster construction.

$$\sum_{l-m}^{l=1} \sum_p QL||(X - C_l)||^2 \tag{8}$$

QL is the lth cluster, and the cluster centroid is Cl, This article's primary cluster construction initial algorithm generates initial clusters using energy and length criteria. Primary cluster construction is used to optimize further the cluster that was obtained in this process. lth cluster and represents *QL*, cluster C_l centroid in equation 8. The new roles of every smart dust node are covered in the simulation, and the outcomes of the proposed methodology are covered in the following section.

6. Outcomes of Simulation

The NS2 tool is used to execute the suggested methodology. In order to contrast the outcomes of these simulations, both the FCEEC and DBSCAN algorithms are used.

Table 2. Factor of simulation

Smart Dust Deployment	100X100
Smart Dust sensor nodes	400
Packet Size	800bits
Starting Energy	0.5J
Energy loss in movement	0.00006J
Energy in transmission	50nJ/bit
Amplifier energy	10pJ/bit/m^2

The parameter sets given to the EC^{2}ASD technique are displayed in Table 2. For easier outcomes contrast, the information supplied contains the same values as those used for FCEEC.

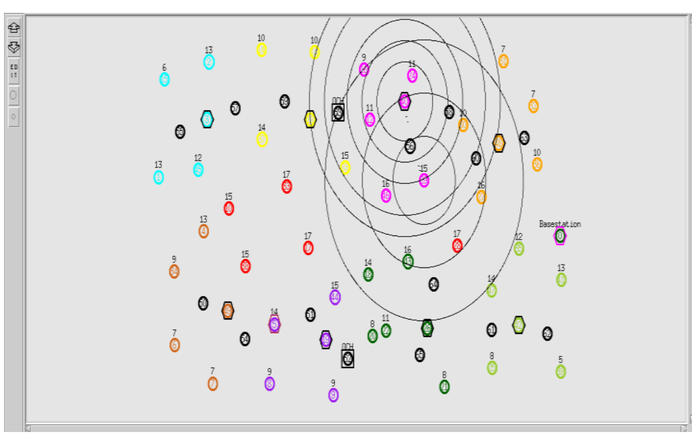

Fig. 3 Smart dust sensor nodes in the designated region

Figure 3 depicts the initial, arbitrary placement of smart dust moveable sensor nodes in a designated environment. Smart dust moveable sensor nodes are located in a 100x100 environment. To compare the findings, the region and the smart dust node count are exactly the same. Earlier results were already provided underneath this region. Figure 4 shows the network existence for the DBSCAN, FCEEC, and EC²ASD systems. 400 smart dust nodes are first supplied as input to each method.

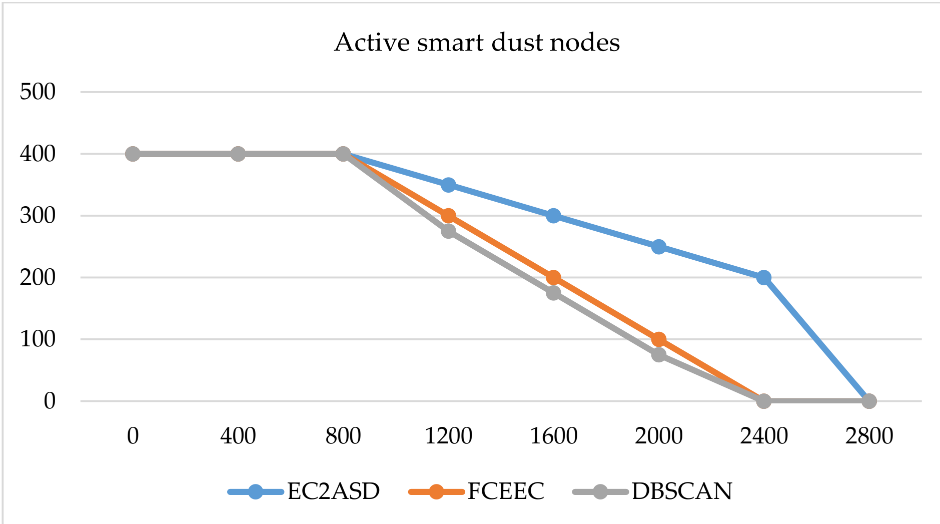

Fig. 4 Active smart dust nodes VS cycles in FCEEC, DBSCAN and EC²ASD

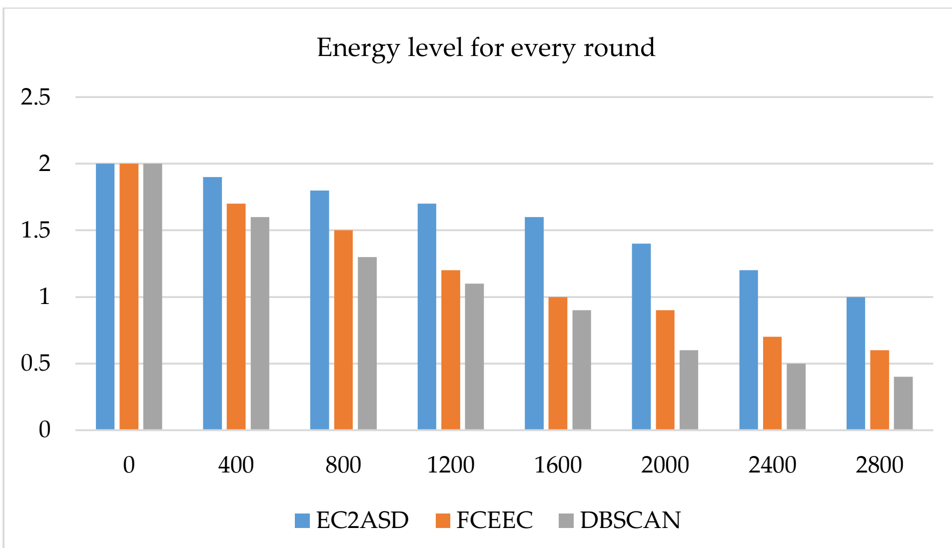

Fig. 5 Entire Energy of the Network accessible throughout every round in EC²ASD

For accurate analysis, every three of these approaches are contrasted utilizing the same measuring unit. The network's life duration can reach 950 rounds when the cost utility for DBSCAN is used, and the initial smart dust node starts to fail at around 780 cycles. Due to the greatest energy requirement for CH selection in FCEEC, the initial smart dust node dead time is significantly longer than under other circumstances. With respect to both initial smart dust node dead time and overall network lifespan, FCEEC's performance over DBSCAN can be seen as superior. At about 800 cycles, the initial smart dust node is dead. Approximately 1010 rounds make up the network's whole lifespan. Using EC²ASD, the initial smart dust node expires after 700 cycles, and the number of smart dust nodes continues to drop.

As illustrated in Figure 4, this system can last up to 2893 cycles. The proposed method, EC2ASD, significantly outperforms FCEEC and DBSCAN regarding network lifespan. Figure 4 shows that a smart dust node is initially close to dying with FCEEC and DBSCAN; however, the network longevity using the greatest energy as a requirement is astonishingly obvious. Figure 5 shows the network's amount of energy over the course of every cycle. Using 400 and 100 smart dust nodes, complete energy is readily available. Figure 5 demonstrates that relatively little energy is lost throughout each cycle. As the EC²ASD system always chooses the CH node with the most energy, it avoids any individual smart dust energy from being used up too quickly. Assuming a starting energy of 0.5 J, a system's energy is first 200 J for 400 smart dust sensor nodes, then 50 J again for an arc of 100 smart dust moveable sensor nodes in Figure 5. It is evident that perhaps the network energy level does not significantly decrease until the final cycle. Figure 6 shows the network's regular energy usage for networks with 400 smart dust nodes and 100 smart dust nodes in every cycle. Figure 6 shows a vertical bar chart with two bars, one representing a network with 400 smart dust nodes and another with only 100. The unit of measurement for energy utilization is the joule. The average usage of energy is extremely low due to energy-efficient clustering. The primary cluster construction technique described in the proposed EC²ASD methodology, in contrast with previous algorithms like FCEEC, DBSCAN, etc., develops an initial energy competent cluster that is later significantly optimized by the primary cluster construction approach. As a result, the overall amount of energy utilized is relatively small, which undoubtedly influences the network's lifespan.

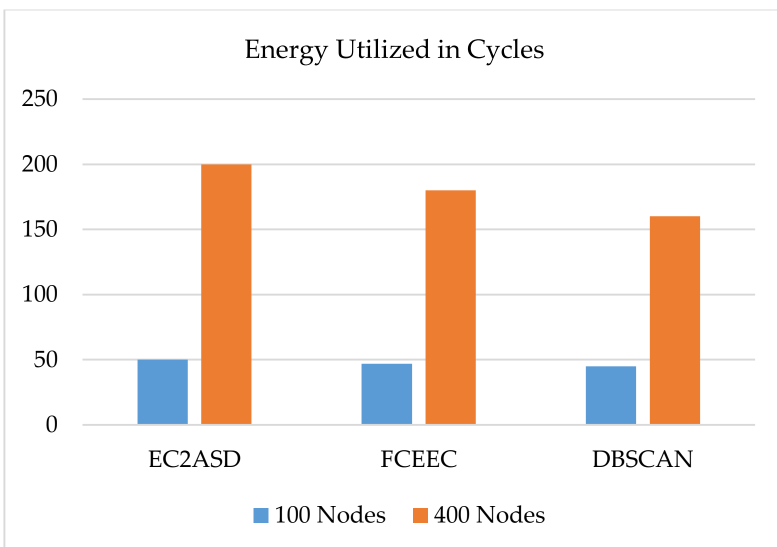

Fig. 6 Regular energy utilized per cycle

7. Conclusion

In this suggested method, the Energy Capable Clustering Approach for Smart Dust EC²ASD, for a smart dust environment, increases the overall network lifetime in this research work. Compared to DBSCAN and FCEEC, EC²ASD guarantees an advantage. When contrasted to network lifetime, the outcomes are incredibly positive. The ideal cluster size is one in which the nodes lose the least amount of energy when sending data. Preliminary clusters were made utilizing both the energy and length criteria in a two-phase clustering process. By using primary cluster construction, required energy-stable clusters were produced. The primary cluster construction clustering technique has considerably improved the fundamental technique. In comparison to other widely used clustering algorithms, total energy as a parameter for choosing CHs has shown improved outcomes in simulation. Future studies will focus on early energy-efficient clustering utilizing particular optimization techniques, such as hierarchical self-organizing maps that will create an energy-balanced cluster before forwarding it to later phases of clustering, in an attempt to enhance results. By improving the primary cluster construction approach directly, the preliminary energy-efficient clustering proposed in the methodology.

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