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WSN Clustering Based on EECI (Energy Efficient Clustering using Interconnection) Method

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Abstract- ***in WSN, clustering gives an effective way to enhance the network lifetime. Moreover It has been observed that the clustering algorithm utilizes the two main technique first is selection of cluster head and cycling it periodically in order to distribute the energy among the clusters and this in terms increases the lifetime of network. Another challenge comes with this is minimize the energy consumption. In past several algorithm has been proposed to increase the lifetime of the network and energy consumption, however these methodologies lacks from efficiency. In this paper, we have proposed a methodologies named as EE-CI (Energy Efficient Clustering using Interconnection), along with the random updation. Here the networks are parted into different clusters, the cluster updation are done based on the CHC scheme. Moreover, in proposed methodology cluster updation and data sample is determined through the change in sensor data. Here we propose a method for sampling sensor and CHC for selecting the cluster head to balance the energy and improvise the energy efficiency. Moreover, the proposed methodology is evaluated and the result is demonstrated by considering the Leach as existing methodology, experiments results shows that the proposed methodology outperforms the existing methodology.***
Keywords: WSN, Clustering, EECI.

I. INTRODUCTION

Wireless sensor Networks are the networks that are made up of several distributed micro devices that are embedded with the several sensing abilities, the device with sensing abilities are known as sensors [1]. These sensors are used for sensing the data node and sending back to the application or the end users. The technologies related to the WSN were introduced almost two decades ago and since then there has been many research from the academia point of view as well as the industrial point of view. WSN constitutes three main component, the architectural view of the WSN starts with the sensor node. These sensor nodes have the several attributes such as they have the limited power supply which is fulfilled by the battery and these sensor nodes can be deployed randomly , their main task is to collected the data and send the data to the further i.e. base station . When any data are sensed through the sensor node of the event detection takes place, the data are received by the Base Station, which is the second component of the WSN. Base station receives the data and by using the multi-hop architecture [2].

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Moreover, the third component is the end user or the application. The below diagram shows the typical WSN architecture.

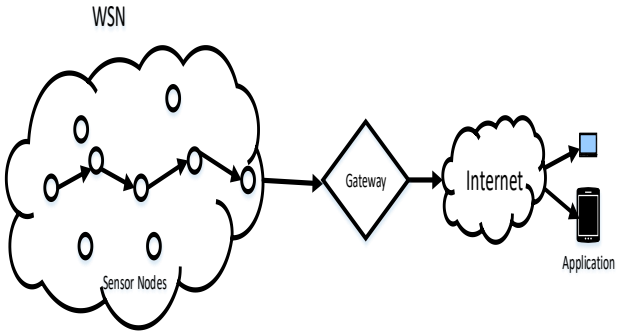


Figure 1 Typical WSN architecture

Moreover the Wireless sensor networks are equipped with the limited power supply i.e. battery, and hence any other power resources are not required from the outside [3]. This scenario has made essential for the WSNs to function in the efficient manner in order to improvei8se the lifetime of the network. WSNs are capable of solving the many real time issue and implemented in various areas such as defense where the WSN are placed in the battlefield for monitoring the soldier movement, vehicles and transmits the data related to the battle [4, 5]. In Environmental application, it is used for monitoring the oceans, volcanoes, forest and glaciers and others [6, 7]. It is also applicable for monitoring he Structural monitoring such as tunnels, flyovers, bank and bridges [8], other application such as in agriculture field for monitoring the crops and the automatic watering system, which helps in the reduction of wastage[9]-[14]. Similarly, on health environment it is applied for scaling the Blood pressure breath rate and hear rate [15-17]. Therefore, it can be said that WSN is a vast emerging technology that has gained the enormous popularity. In case of the clustering environment the fields are parted into the various groups, these are known as clusters, every cluster has a particular leader named as CH (Cluster Head) [18]. The CH performs the data processing after receiving the data from the cluster member, this is done for discarding the redundant data and only the absolute data is transmitted. All this is done to save the energy as energy consumption is consider as one of the prime factor in case of WSN .For energy consumption several methods have been proposed in the past, which has helped in the achieving the better lifetime of the network, and the energy consumption.
Clustering is introduced for the energy consumption, clustering is applicable.

In this research work, we have proposed a methodology to improvise the clustering performance. Here our intention is to form the balanced as well as the stable clusters. In order to achieve the balanced and stable clusters determinants nodes are introduced to form the minimum number of clusters, this guarantees us the cluster stability, this improvises the cluster performance and the energy efficiency, other contribution of this paper is given as follows

- In order to sample the sensor random method has been proposed
- Data sampling probability of the node and CH-Selection probability is direct proportional to the rate of change in the data sensed.
- In order to sample the data a random method is proposed along with CHC scheme for improvising the energy

This paper is organized as follows; first section of this research discuss about the basic origin of WSN and their application, later part of the section shows the contribution of our proposed methodology, second section discusses the various existing systems that helps in designing the proposed methodology. Meanwhile proposed architecture is presented along with proposed flow diagram, network model, energy model and algorithm in the third section. In order to evaluate the performance comparative analysis is done in fifth section.

II. LITERATURE SURVEY

Lately, they introduced several different protocols for WSN, which improves the security issues, enhance the boost energy efficiency and network reliability [19] [20]. Game theory and ML (Machine Learning) has been employed in the solutions of computing routing for the wireless networks [21], [22]. The energy consideration is associated with the help of battery, which is based on the wireless networks, extending the lifetime of network is the main key issue. This can be amounted to maximize the researcher's interest in the realization of G-wireless-IoT network (Green-wireless-IoT). In [23], [24], they deliberate the requirement of G-IoT and different hardware and software-based technologies needed to permit its realization. The EE (Energy-Efficient) if inter-node communication and enhanced the routing methods that has been recognized as the problems which is required to be address to facilitate the LS adoption of G-IoT (Large scale). Many network deployment schemes and routing protocols have been considered for the WSNs. Routing protocols for the WSNs have been classified into 3 various groups such as location based routing, hierarchical routing and flat routing. In [25] the protocol includes randomized CH of rotation for routing load distribution among the more than one sensors. Fusion and DA is employed to minimize the data size, which is transmitted. LEACH is most extensively adopted the algorithms of EE-routing for SNs and they treated it as the baseline of their method. From the historical perspective another methods of EE have been introduced the MTE (Minimum Transmission Energy Protocol) routes data via nearby the neighbors node to reduce the transmission energy. When the network utilizes the MTE nodes, which is closest, to BS that are exploited with the help of routing related load processing and therefore they run out of the battery. Via the collaborative routing, the uneven routing distributing effort has been diminished in many protocols, which includes the FCM and LEACH [26]. LEACH suffers from few disadvantages as well as. In first, CHs of random rotation may be lead to many sun-optimal period of the communication. Due to inadequate nodes could be selected as the CHs in periods. Secondly, the CHs distance in network isn't uniform, therefore few CHs would be send the data at longer distances than the others. These disadvantages are accounted for their protocol whereas the CHs are selected with the help of residual battery levels of devices. Furthermore, DT (Data Transmission) to BS is assumed as a cooperative effect by the help of entire CHs in network. The route of EE including all CHs, which is computed for the data of eventual transmission. In [27], FCM is known as another clustering based routing protocol. FCM introduces minimization based clustering for the Euclidean device's distance from the base of the clusters from their places. This is performed to develop a balance of energy between cluster's nodes of sensor. Head of the cluster within FCM are selected with respect to levels of residual energy. Head of the cluster takes the average of the data collected from all devices within the network and send it to the BS. While formation of the cluster, the capacity of the generation of the data is not considered by FCM. Thus if many devices that generate long messages and rapidly sense huge amount of information than others are combined into single cluster, then the selected head of the cluster of this group will suffer more energy cost than the others within the networks. At the same time, current cluster may have shortage of battery power before than others. This disadvantage is compensated for our protocol and also we assume three device features for formation of the cluster: location of the nodes from BS, amount of data generated by the sensor nodes within single communication epoch, and message length produced by the devices. Our implemented routing protocol is executed and compared with FCM and LEACH in section-V. We will be seeing that our implemented protocol's performance is better compared to LEACH and FCM with respect of few metrics. Investigation has also added into network deployment schemes' development to gain green IoT. This type of scheme is introduced in [28]. It is a static scheme for network deployment that uses two types of nodes, relay nodes and sensor nodes. Relay nodes are assumed having high computational when compared to sensor nodes and are utilized to handle sensor nodes' cluster. The network is designed into three levels in hierarchy way. Here sensor nodes do the lowest level, relay nodes are the middle level and the top level is the BS. Huang et al have implemented communication conditions between nodes within the network that is based on hierarchy node levels. The writer shows the cost and energy optimization's issue as a routing issue. Algorithm named Steiner tree is utilized to resolve this optimization issue of computing the amount and location of relays within the network.

The fault of this method is that it is a static scheme of deployment and places many conditions on how the way the network is been designed.

In our technique, this issue is ameliorated, as there is dynamic hierarchy among various nodes, the complete method is simplistic in behavior and can be selected to consume energy in any type of application of sensor network. As said before, scheduling for sleeping is the best way to give energy conservation within IoT networks. In [29] an mechanism of energy balancing scheduling for sleep is introduced for WSNs that is dependent on optimization of Particle Swarm. In this article, we use scheduling for sleep technique related by GA (Genetic-Algorithm) and OPS (Optimization-of-Particle-Swarm) evolutionary techniques and represented as OGS (Optimization-of-Genetic-Swarm). The implemented protocol's performance is differentiated to three various scheduling for sleep methodologies: GA, OPS and ECCA [30]. The outcome from the execution represents that the implemented protocol's results are much better than OGS. We have validated the performance of the implemented algorithm of minimum-Energy (MINEN) with and without help of scheduling for sleep, as scheduling for sleep can cause more difficulties.

III. PROPOSED METHODOLOGY

Network Model

Let's consider any model where the X number of sensor nodes are placed in the given area of $Y\ X\ Y$. Initially it is assumed that each and every sensor node is aware of the current location. Hence, it becomes a lot more easier to compute the distance between the each sensor nodes. Every node is represented using the unique ID and has certain communication range.

Energy model

In any WSN model it is essential to design the energy model as the energy consumption plays one of the eminent role, the less the energy consumption the better the model is. In this research work we design an energy model which is dependent on the distance, equation 1 shows the energy transmitted and it matches the criteria of ε_f and ε_m. Here $Eng_{TR}(cd, l)$ is the energy consumed while transmission and while receiving the b bit data. Eng_{ec} is the energy required to process the circuit. cd_0 and cd_1 are the lowest and highest threshold distance in the circuit respectively.

$$Eng_{TR}(cd, b) = \begin{cases} b\left(Eng_{ec} + \varepsilon_f cd_0^2\right), & if\ cd \le cd_0 \\ b\left(Eng_{ec} + \varepsilon_f cd^2\right), & if\ cd < cd < cd_1 \\ b(Eng_{ec} + \varepsilon_m cd^4), & if cd \ge cd_1 \end{cases} \quad (1)$$

$$Eng_{Rc}(b) = bEng_{ec} \quad (2)$$

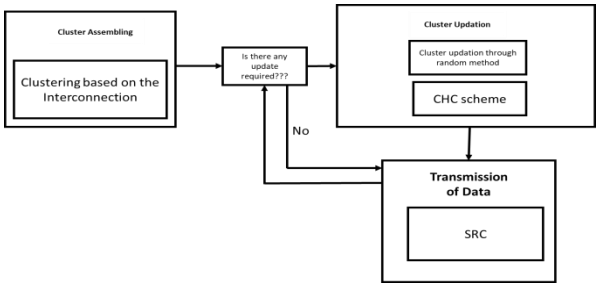


Figure 2 Proposed flow work of EE-CRI

The above diagram shows the proposed flow work, the above diagram has three blocks; first block is cluster assembling, where the clustering is formed based on the distributed interconnection algorithm. In cluster updation the initial clusters are updated through random updation method. Meanwhile the cluster heads are selected through the combination of CHC and random updation scheme, this in terms helps in saving the network energy. Similarly, in transmission phase the proposed algorithm holds the sample rate for improvising the transmission efficiently.

Proposed work

Our methodology is parted into two distinctive part, first part is Cluster Assembling (CA) and second part is Clusters Updation (CU).

CA (Cluster Assembling)

At first, the network is parted into the initial clustering**;** In here we consider **the** amount of data transmitted and the distance in order to make the efficient clustering. CA phase is divided into three distinctive stage, first stage is known as the set up phase, Selection phase and formation phase.

Let us consider a network $N = \{x_i | i = 1,2,3 \ldots., X\}$ with X sensor nodes, let the neighbor set be XN_i considered as the node set in the given communication range C then the node in the neighbor set is $|XN_i|$. Moreover let P be the center node and Q represent the neighbor and these both are denoted as $P_k = \{p_1, p_2, \ldots \ldots \ldots p_n\}$ and $Q_k = \{q_1, q_2, q_3 \ldots\ldots\ldots q_n\}$. Moreover, the Q can be reconstructed using P based on the locally available information. Hence, the data rate transmission is calculated as:

TR= TR_1+ TR_2 >= Ent(Q|P) + Ent(P)=Ent(P,Q)

Here the entropy ent (p) is computed through the below equation. Entropy is calculated in order to explore the correlation characteristics.

$$Ent(p) = \sum_i prob(p_k)\, logprob(p_k)$$

Set up phase

In this phase at first, each and every node broadcasts the sensed data, the broadcasting of data is done so that the remaining nodes can compute the average entropy, once the AE is computed then set of nodes are initialized.

Step1: start

Step2: for each node x_k

Step3: {location of the n_i node within RR (Radio Range)}-XN_i

Step4: $SRLN_i \leftarrow \phi$, $SURLN_i \leftarrow \phi$

Step5:$Avgent_p \leftarrow$

$$\sum_{l \in XN_i} \frac{(1-0.5\rho_{kl})(ent(P_k)+(Q)_l)-ent(P_k)}{|NS_i|}$$

Step6: For each given node $x_l \in XN_k$

Step7: if ($|ent(Q_l|Q_l)| - Avgent_k \leq \varepsilon$) go to step 8

Step8: $ton_{kl} = 1$ and $RLN_i \leftarrow x_l$

Else, go to step 9.

Step9: $ton_{kl} = 0$ and $URLN_i \leftarrow x_l$

Step10: end of for loop

Step11: $CDG_k = |RS_i|$

Step12: Active state

Step13: end of for loop

Moreover the related nodes in the NS_i is combined with the RS_i and Unrelated nodes are combined with the US_i. If the above scenario is satisfied then entire network is set to the active state.

Selection phase

Step1: start

Step2: for each node x_i

Step3: send exchange_msg (NID, $Avgent_k CDG_k$) to the each node $x_l \in XN_k$

Step4: End of for loop

Step5: for (each node x_l)

Step6: MIN {all received$Avgent_k$} $\rightarrow Avgent_{min}$

Step7: CH→ status and $x_l \rightarrow$ G

Step8: else if ($Avgent_{min} = Avgent_k$)

Step9: MAX {all receivedCDG_l} $\rightarrow CDG_{max}$

Step10: if ($CDG_{max} \leq CDG_k$)

Step11: CH→ status

Step12: $x_l \rightarrow G$

Step13: end of for loop

Evolution phase
Sub-algorithm 1

Step1: For each node $x_l \in G$

Step2: send CH_notifications_msg (NID) to every node $x_l \in XN_k$

Step3: End of for loop

Sub-algorithm 2

Step1: for each node n_i

Step2: If (CH≠ $status$)

Step3: receive n messages from every node $x_l \in XN_k$

Step4: if (n=1) join the cluster G_l

Step5: $CM \rightarrow status$

Step6: else if (x >= 2 && message i.e. received are from the UN nodes)

Step7: CH→ status

Step 8: $x_k \rightarrow C$

Step9: End of for loop

Sub-algorithm 3

Step1: for each node x_k

Step2: If (CM= status)

Step3: send join_msg (NID) to the CH node.

Step4: If (CH=status)

Step5: adding the x_l to its CM (Cluster Member) table list.

Step6: acknowledgement ack_msg (NID) is sent

Step7: End for loop

Moreover, Evolution phase algorithm is divided into three sub algorithm, In sub-algorithm1 the Cluster head broadcast the particular message , in sub-algorithm 2 the every other nodes receives the messages It contains two scenario

A) In case if x=1, node integrates with the cluster Head node and the status is set as "CM".
B) In case if x>= 2 and there exist minimum one message from the related node.

Then it combines with the cluster, which constitutes the shortest path among them and set the status as Cluster member. However, if the number of messages are from the unrelated nodes the status of the nodes are set to "Cluster head". Moreover in sub-algorithm 3 all the cluster member request the CH for joining i.e. join message, later the table is modified and acknowledgment is sent, this leads to the formation of topology.

CU (Cluster Updation)

This part describes how the clusters are updated; this is divided into various parts,

which is discuss later in the same section.

RODC (Rate of Data Change) : In this paper we use the RODC to understand the sensor node activation. Moreover, if the data is unchanged then the uncertainty of the sensor is very low, this leads to differ in entropy. Here the RODC is tanh, tanh helps in activating the neural networks.
The standard form of tanh is given as in the below equation i.e.

$$g(h) = \frac{1}{1 + (\frac{1}{e^h})}, \qquad h \in (-\infty, +\infty) \tag{5}$$

The RODC is defined as:

$$RODC = \frac{1}{1 + e^{-(u\Delta ent + v)}} \tag{6}$$

$$\Delta ent = \left(ent_{tl2}(P) - ent_{tl1}(P)\right) \tag{7}$$

Here $ent_{tl1}(P)$ represents the entropy at given time $tl1$ nad $ent_{tl2}(P)$ presents he entropy at given time $tl2$, similalry transform constant are denoted as u and v, Δent is the difference entropy difference between the $tl1$ and $tl2$, these values lies from 0 to 1.

RU (Random Updation)

Moreover, for reduction in energy consumption RU (Random updation) method takes place, this adopts the dynamic topologies in the WSNs. Here, we update the frequency these frequencies are determined through the data.
Once the cluster assembling is done, then data transmission phase gets activated. Moreover the time reaches to Δtl, the cluster member nodes notifies the respective cluster head nodes using the RODC and piggybacking.
Moreover the CH nodes is updated using the Random updation, the probability of the random is given using the below equations.

$$prob = \begin{cases} \frac{g}{cm}, & if\ g < \sigma cm \\ 1, & otherwise \end{cases} \tag{8}$$

Here, the total cluster members are depicted through m constant in percentage is given by σ. After the updation the cycle τ.

$$\tau = \frac{2\Delta tl}{1 + RODC'}$$
$$RODC' = \max_{1 \le k \le cm} RODC_i \tag{9}$$

Δtl is cycle predefined and τ is newly updated cycle, the random updation helps in optimizing the energy consumption it also minimizes the time complexity, hence the energy consumption is minimized.

Steps involved in RU

Step1: start

Step2: All the nodes detects the RODC and gives acknowledgment to the CH.

Step2: If the time reaches for Cycle updation.

Step3: Random updation according to the probablity

Step4: update cycle refresh

Step5: Updation required go to step2

Step6: local updation of clusters

Step7: transmission of Data

Step8: Stop

CHC Cycle: Once the random updation is done, the cluster architecture remains in the same position; hence the cluster adjustment takes place locally. Moreover, with the time, there doesn't exist CH re-election system and this might cause the unbalance in energy. Hence, CH cycling scheme is introduced to get rid of such issue. The probability of CH being selected is presented in the below equation.

$$CH\_selction_{prob} = \frac{Eng_{rem} prob}{cm(1 - RODC_{prob}) Eng_{max}} \tag{10}$$

Here, residual energy of the node is given by Eng_{remain}, whereas initial energy is denoted by Eng_{max},Hence the cluster head selection is done based on the residual energy, one with the highest residual energy can be considered as the Cluster Head. Moreover proposed algorithm integrates random updation along with the CH cycle, this not only helps in balancing the network energy distribution but also minimizes the data size.

Lifetime Analysis:

In any given network which consists of X nodes, let us assume that the lifetime of the network using the re-clustering scheme be TL_1 and the lifetime of the network after using the RU be TL_2. Hence, the relation between them could be defined in the following equations.

$$TL_2 > TL_1 \tag{11}$$

IV. PERFORMANCE EVALUATION

In this section, the algorithm evaluation takes place. These evaluations are performed using the Windows10 operating system packed with 2 GB Nvidia graphics and 8 GB Ram. The programming language used is .Net and the platform used visual basic version of 2017.

Network parameter

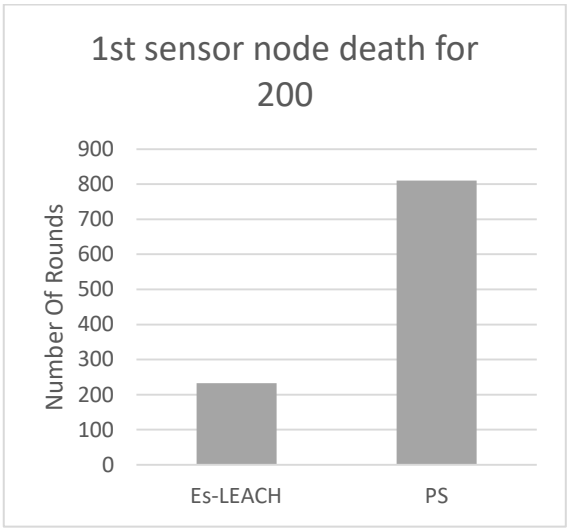
In here we have consider the area of network as 50m* 50m with 2 base station along with the initial energy 0.2J an transmission speed of 100 bit per sec. Moreover, we have performed the evaluation on four different number of node in order to observe the variety in results i.e. 200N, 400N, 600N and 800N. N indicates the number of nodes.

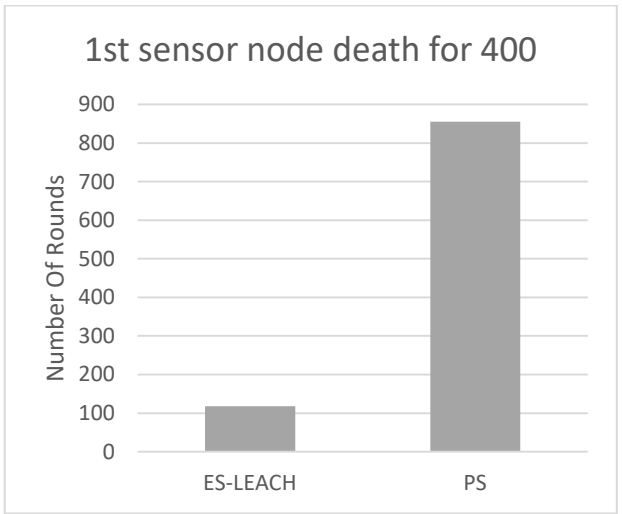
Network energy

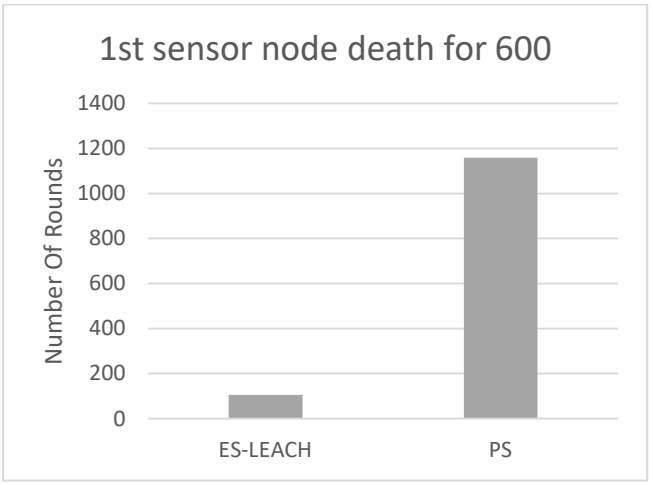
Energy consumption is defined as the amount of energy required to perform the particular task and in the generalized version, energy is defined as the capacity of any physical system to perform the particular task.

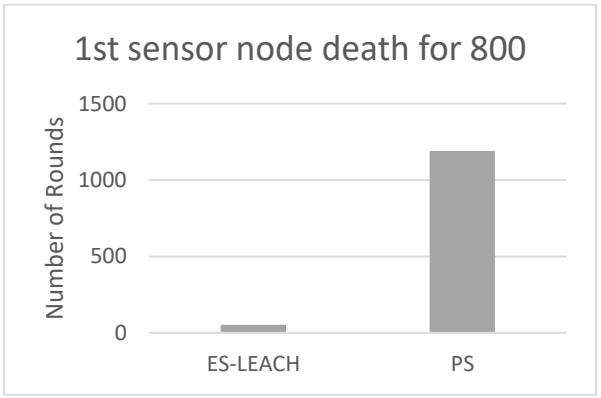
Death of first sensor node

This is consider to be one of the constraint for evaluating the particular algorithm, the below graph shows the performance of existing and proposed algorithm with various number of nodes, i.e. 200, 400, 600and 800. Here the evaluation is done when the first sensor node is dead. When we observe the below graph we see that when the 200 nodes are induced the existing algorithm performs only 233 rounds whereas the proposed system performs the 810 rounds. Similarly in case of 400 nodes, the number of rounds performed are 118 rounds and 855 rounds respectively, when proposed and existing methodology is compared, the result shows that existing methodology performs the 105 rounds whereas proposed methodology performs 1159 rounds. At last we have evaluated our algorithm on 800 nodes, in this scenario the existing methods performs only 54 rounds whereas proposed method performs the 1159 rounds.



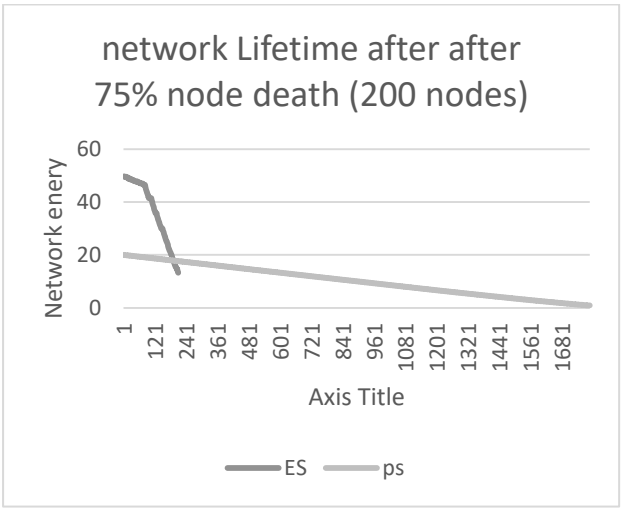


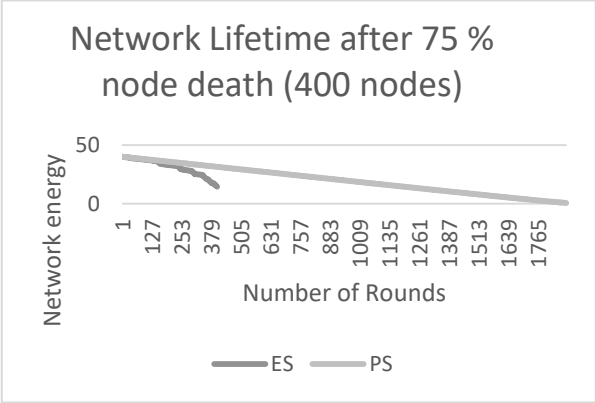


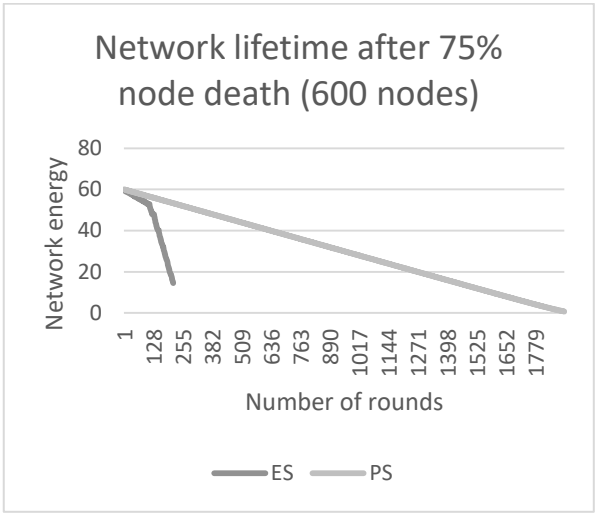


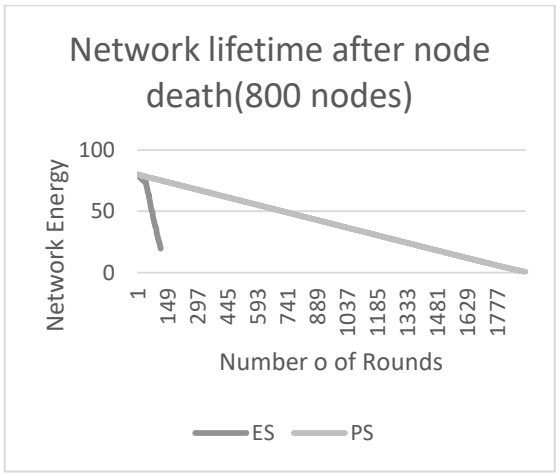
75 % node death

This is considered to be one of the constraints, meanwhile we have evaluated our algorithm by taking the constraints that the performance of existing and proposed algorithm based on the event that when 75 % of node is dead,. we observe that in case of different node scenario here it is 200, 400 , 600 and 800 the proposed system possesses 210, 402, 210 , 115 rounds whereas proposed system possesses 1788, 1886, 1903, 1918 rounds respectively. The outcomes clearly shows that proposed algorithm simply outperforms the Leach method.



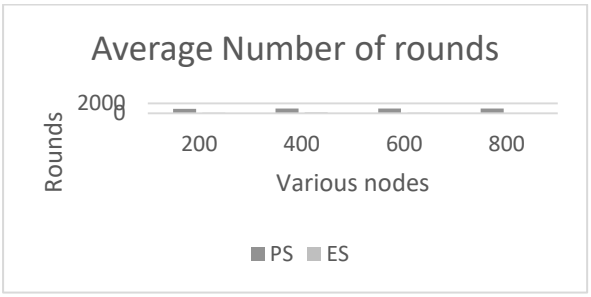






Average number of rounds

The below graphs shows the average number of rounds performed by existing system and proposed system, more number of rounds directly shows that increase in lifetime of network. Moreover evaluation is done on 200, 400 , 600 and 800 nodes, we observe that when compared to the proposed methodology existing system i.e. LEACH performs very poor. In the below graph we see that the average number of rounds performed is 105 in case of LEACH methodology whereas proposed method performs nearly 895 rounds. Similarly, in case of 400 nodes the number of rounds performed by existing system is only 202 rounds and proposed nearly goes around 944 rounds. In case of 600 nodes, the number of rounds reduces and reaches to 107 rounds whereas proposed system performs 953 rounds. In case of 800 nodes, the existing methodology reduces when it is applied on 800 nodes whereas our proposed methodology gives the 960 rounds. The result analysis shows the network lifetime of the network and our methodology simply governs when compared with the existing LEACH method.



V. CONCLUSION

Clustering methods are proposed for reducing the energy consumption while transmitting the data, LEACH is one of the basic methodology, which is used for communication routing and sensor clustering. In this research work, we have proposed a methodology using Interconnection and random updation. In EECI we have proposed the CHC scheme and RU (Random Updation) in order to achieve maximum efficiency, later for the transmission of data sample are reduced. In order to evaluate our proposed algorithm we have considered LEACH as the existing model and EECI as proposed model. Several constraints were considered while evaluating the EECI algorithm such as 1st sensor node death and certain percentage death of nodes. Moreover, we have considered the 75 % death from the whole node. The result analysis shows that EECI simply outperforms the LEACH protocol. Moreover, in future we have to see how the methodology performs when other constraint are induced, henceforth this research work can be considered for the further research in WSN.

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