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Load Balancing in Heterogeneous Wireless Sensor Network

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Abstract

In Wireless Sensor Networks (WSNs), one of most important and daunting problems is reducing energy usage in order to extend life of WSN networks.The main aim of the project is to develop a clustering technique through which the lifetime of nodes and throughput of network should be increased. Network throughput and lifetime may be increased when the energy of sensor nodes is retained for a long time. To increase lifetime of nodes residual energy of nodes should be considered. Residual energy includes many factors like nodes weight. We have developed an algorithm including nodes residual energy that will definitely increase lifetime and throughput of the network. Using DEEC formula with heterogeneous network based on average and residual energy. Then here we have compared with LEACH (Low Energy Adaptive ClusteringHierarchy), DEEC (Distributed Energy Efficient Clustering) and proposed load balancing clustering algorithm.

Keywords: Wireless sensor networks, Clustering,Heterogeneity, Network lifetime,Load Balancing, Residual energy.

1. Introduction

A WSN (Wireless Sensor Networks) is a series of sensor nodes connected by wireless connections which are located in a physical location. Four sensing, touch, processing and power supply modules are primarily composed of a sensor node. There are several problems with wireless sensor networks. Maximizing network reliability and lifespan (WSN), which is intensely based on large-scale convergence and energy efficiency (energy consumption), is the greatest challenge (energy consumption). It is feasible to secure valuable sensor-node resources through energy-efficient solutions. This is one of WSNs' most critical problems, which plays a fundamental role in deciding the lifespan of network. While there are several WSN protocols, clustering-based hierarchical routing protocols are conferredmore importance due to their improved scalability. Currently, sensors are battery-powered, often restricting available space, which is not able changein most cases. One of most common energy-efficiency sensor network protocols is the Low Energy Adaptive Clustering Hierarchy (LEACH) as a source, and DEECH is the other approach (Distributed Energy Efficient Clustering). But it is not possible for WSN for replacementof batteries of hundreds or more of sensor nodes since deployment. In the sensor network, clustering sensor nodes into the cluster is known as clustering. Any cluster is having a

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leader named the cluster's head. The cluster members may pre-assign or nominate a president of cluster. A cluster head accumulates and transfers information from cluster nodes to destination (base station) of the cluster (base station).Segmenting the network into clusters [1] is one of techniques utilizedfor reducing energy consumption and contributes to WSN's prolonged network life. Clustering technology has a range of advantages, as it affixes more scalability, reduces load and reduces energy consumption, in comparison to WSN flat routing protocols. For CHs nodes only, scalability as data transmission is responsible, so size of routing table at individual sensor node is reduced. Consequently, in the Clustering algorithm CH node aggregation, sensor node can produce redundant data using the data aggregation mechanism that in turn helps to minimize redundant data and thereby reducing size of the data packets, hence saving energy [2, 3]. In clustering mechanisms, there are primarily two important stages. In first stage, few nodes are categorized as CHs and form various clusters, while on second stageare usually correlated with data collecting and forwarding. In each cluster, entire member nodes transmit their sensory data to their respective CHs, which conduct further processing (i.e. compression, aggregation and resource planning and allocation) and transmit their member data to the sink node. As CHs are responsible for several tasks, compared to ordinary nodes, more energy is thus expended [4]. Consequently, selection of CH plays a key role and has major effect on the lifespan of the network [5]. However, much of the cluster phase randomly selects the CH without considering significant parameters, which can result in the selection of deficient node by the CH. Other clustering approaches are centered on a centralized approach that can impact the scalability of the network by the use of the base station as nodes need to send their parameters, like resources, the number of neighbors to BS that in turn tends to increase the overhead network. This manuscript therefore proposes, based on a distributed approach, a clustering scheme for energy efficient, better throughput and load balancing.

2. Literature Review

Owing to their possible applications and related challenges, the WSNs have attracted many researchers. They have many applications, including military, environmental, health, science exploration applications, systematic health monitoring and area monitoring, and so on. They have several challenges at the same time, such as simplicity, scalability,coverage, usability, robustness, security, fault tolerance, energy efficiency, and so on. One of the most significant tasks is to extend longevity of network so that the control area for object operations can be controlled for a long time. Ultimately, the life cycle of the network is linked to the efficient use of the resources of the network. Consequently, several methods, including different protocols, have been developed. Heinzelman et al.[6] addressed the very first protocol to increase the life span of WSNs in 2000, termed as the Low Energy Adaptive Clustering Hierarchy (LEACH) protocol. The Low Energy Adaptive Clustering Hierarchy (LEACH) was introduced in[7] and is established as the LEACH protocol. The goal of LEACH was to confer a way of tackling WSN's energy use and to prolong life of network. A probabilistic approach called single-hop is both distributed and dependent on LEACH. It structures network, based on frequency of receiving signals, into clusters. The nodes in LEACH are either ordinary SNs or CHs. Any SN sends its CH with its sensing data. The CHs server, however, serves as BS's node. Initially, in the LEACH

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protocol, a node produces a randomly generated number between 0 to 1 to determine which node is a CH, and a threshold value is determined to do this. Usually, for electricity use, LEACH offers a reasonable model. It also was suggested to shape a sensor node chain that starts from farthest node to nearest node towards the base station in the proposed in Sensor Information Systems, power effective collection [8] to minimize energy consumption (PEGASIS). One of each node transmits and receives information about its neighbors and switches to the base station or destination of the transmission chief. However, with a rise in chain or network size, such a mechanism may produce high transmission delays.

WSNs have concentrated primarily on technology solutions focused on WSNs that are homogeneous for the past few years, where entire nodes have the same resources for the system. Heterogeneous networks of wireless sensors have become more and more prevalent lately. Research [9,10] demonstrates that, without dramatically increasing cost, heterogeneous nodes are eligible of extending network lifetime and increase network performance. For filtering, merging, and transporting data, heterogeneous nodes are more effective, but more costly than homogeneous nodes. One or more heterogeneous resource types, such as increased energy capacity or communication capabilities, may occur with a heterogeneous node. They may be equipped with more efficient microprocessor or extra memory, or both, as compared with standard nodes. Via a long-distance and high-bandwidth network, they can also connect with the base station. Implementing heterogeneous nodes increases resources of network and thus the life cycle of network. Some works discussing heterogeneous network models have been written. Smaragdakis et al. have introduced the secure election protocol (SEP)[11] that utilizes heterogeneity, a LEACH extension. This is first protocol to discuss about heterogeneity. In this protocol, on the basis of the weighted elective likelihood, the anode becomes the cluster head, which utilizes the remaining node energy function to ensure the uniform use of node energy. Two degrees of heterogeneity, consisting of two node groups, known as standard and advanced nodes, are taken into account by the SEP's underlying network. Because of the increased cost factor, Li et al., energy of advanced node is greater than normal nodes and their number is lower than of normal nodes. Discuss distributed energy-efficient clustering (DEEC)[12] protocol when considering heterogeneous WSNs at 2 and multilevel. The benefits and drawbacks of the previous algorithm are given below.

2.1 Low-Energy Adaptive Clustering Hierarchy (LEACH)

They are grouped into clusters within these sensors and randomly pick some nodes as a cluster head along with a specificpossibility of being a cluster head per round. Between nodes, the role of becoming a cluster head is shifted. The dissipation of network nodes energy [13, 14] is balanced by the rotation position. LEACH is a distributed algorithm, but the number of clusters per epoch per round is not fixed (cluster head). By choosing a random number [15], because of the distributed algorithm, each node is able to pick itself as cluster head. Because of the randomness property of the random number generator, there is a possibility for each node to choose the same number for selectingcluster head. Hence, the amount of cluster heads varies in every round [16].

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The Advantages of the LEACH protocol are:

1. It's one of algorithms most widely utilized for hierarchical routing in sensor networks.

2. The LEACH protocol segments entire wireless sensors network in several clusters. It is not possible to select any node which acts as CH in current round as a CH yetagain, almost every node can exchange the very same load imposed mostly on heads of the cluster [17].

3. The Cluster Head Node ispicked at random and likelihood that each node is picked as cluster head is uniformly attributable to overall network's average energy consumption [18]. The network life cycle would therefore be enhanced by LEACH.

Issues within LEACH's protocol:

1) In LEACH protocol, cluster head node is chosen at random [19]. There are few limitations that can be attributed to the likelihood that, because the cluster head is the same, each node is selected. The node having greater residual energy and node having smaller residual energy contain same probability of being selected after multiple rounds as cluster head. The energy will run out and die faster if the node having lower residual energy is pickedas the cluster head, causing the robustness of network to be influenced and the life of the network to get short.

2) The normal LEACH protocol randomly splits clusters, simply leading to an uneven distribution of clusters [20]. Finally, it may be that the split clusters are not the simplest or the best. For instance, few clusters have a huge number of nodes, whilst few clusters containlesser nodes. Few cluster heads can be reasonably central to clusters, while at the edge of the clusters, some cluster heads may be far from the members. These events will increase energy consumption and have a severe influence on network's overall performance.

3) The cluster head usually directly transmits data to sink or base station in a steady state. Mostly, cluster head that is further away from sink spends a lot of energy directly communicating with the sink. So, it will crash repeatedly as anoutcome of it running out of the energy. These impacts have a serious impact on life of network, especially in the midst of the extension of the network dimensions.

2.2Distributed Energetic Efficient Clustering Protocol (DEEC)

In the course of 2006 Q. Li, and Z. And Qingxin, W. Mingwen's suggested DEEC Protocol [21]. The DEEC mechanism is the cluster-based approach for heterogeneous wireless sensor networks with multi-level and 2-level energy. The probability of cluster heads is selected in this scheme depending upon ratio of the residual energy of every node to overall energy of network. According to their original and residual energy, age of cluster-heads for nodes is extremely distinct. In contrast to low energy nodes, nodes with largeoriginaland residual energy contain higher opportunityfor becoming cluster heads.

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DEEC's Advantages:

1. DEEC doesn't really necessitate any essential awareness of energy within that election round.

2. DEEC will perform well on a heterogeneous wireless multi-level network, unlike SEP and LEACH.

DEEC's drawbacks:

1. Enhanced nodes are always punishable in DEEC, mostly when residual energy decreases and when they arrive within the standard range for node. Especially in comparison with others, advanced nodes inevitably die throughout this position.

3. Methodology

This model represents the wireless sensor network which contains three kinds of sensor nodes, on basis of energy levels. These nodes are the normal node, the intermediate, and the advanced node. Either node becomes either cluster head for current round or cluster head member following network formation. Clustering is a technique for network load balancing. The clustering schemes have some features. Such features can be associated with the inner structure of cluster or how it refers to others. The parameters for cluster head selection are the original energy, remaining energy, consumption rate and energy consumed of network. Here, all nodes are used for heterogeneous networks and the flowchart of the proposed work is given in Figure 1.

The network consists of all information regarding the nodes and communication medium. So that network formation is started. The network model utilized in this system is totally based on certain hypotheses that are given below.

N no. of the nodes are distributed within the square zone. And a unique ID is assigned to every node.

Base station is located at certain location. Entire nodes possess identical communication capacities, except in case of heterotaxia, in terms of energy, they're different.

After deployment, nodes are left unattended, which means that recharging the battery is not possible.

There is only one BS with a constant power supply located in the centre of the network, so there are no energy, memory, and computing limitations.

Each node is having ability for aggregating data; it is therefore possible to compress multiple data packets as single packet.

You can measure the distance between nodes on the basic principle of received signal strength (RSS).

Nodes withcapability to control power transmission as per distance of collecting nodes and only because of energy depletion is the failure of the node considered.

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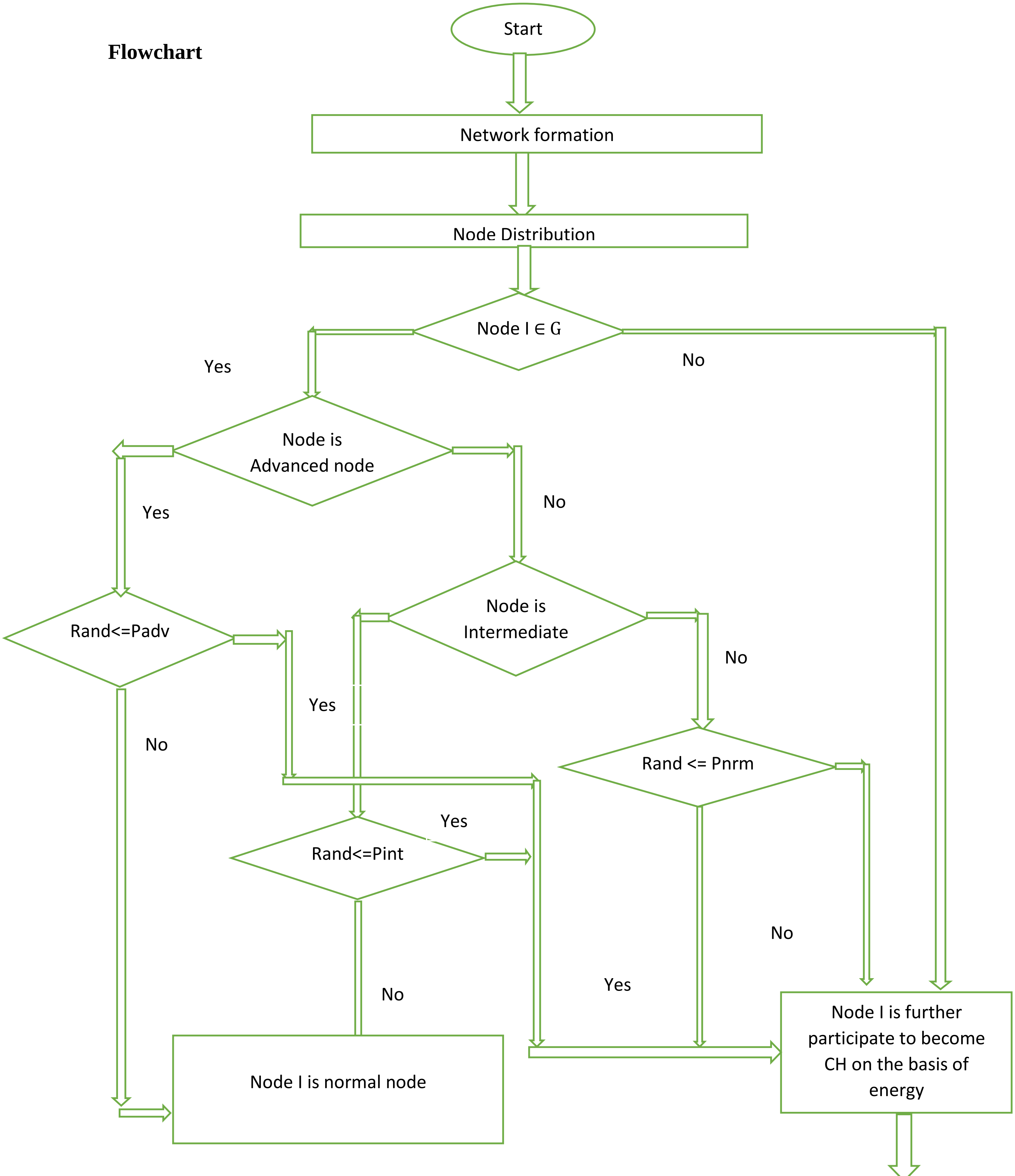
Flowchart



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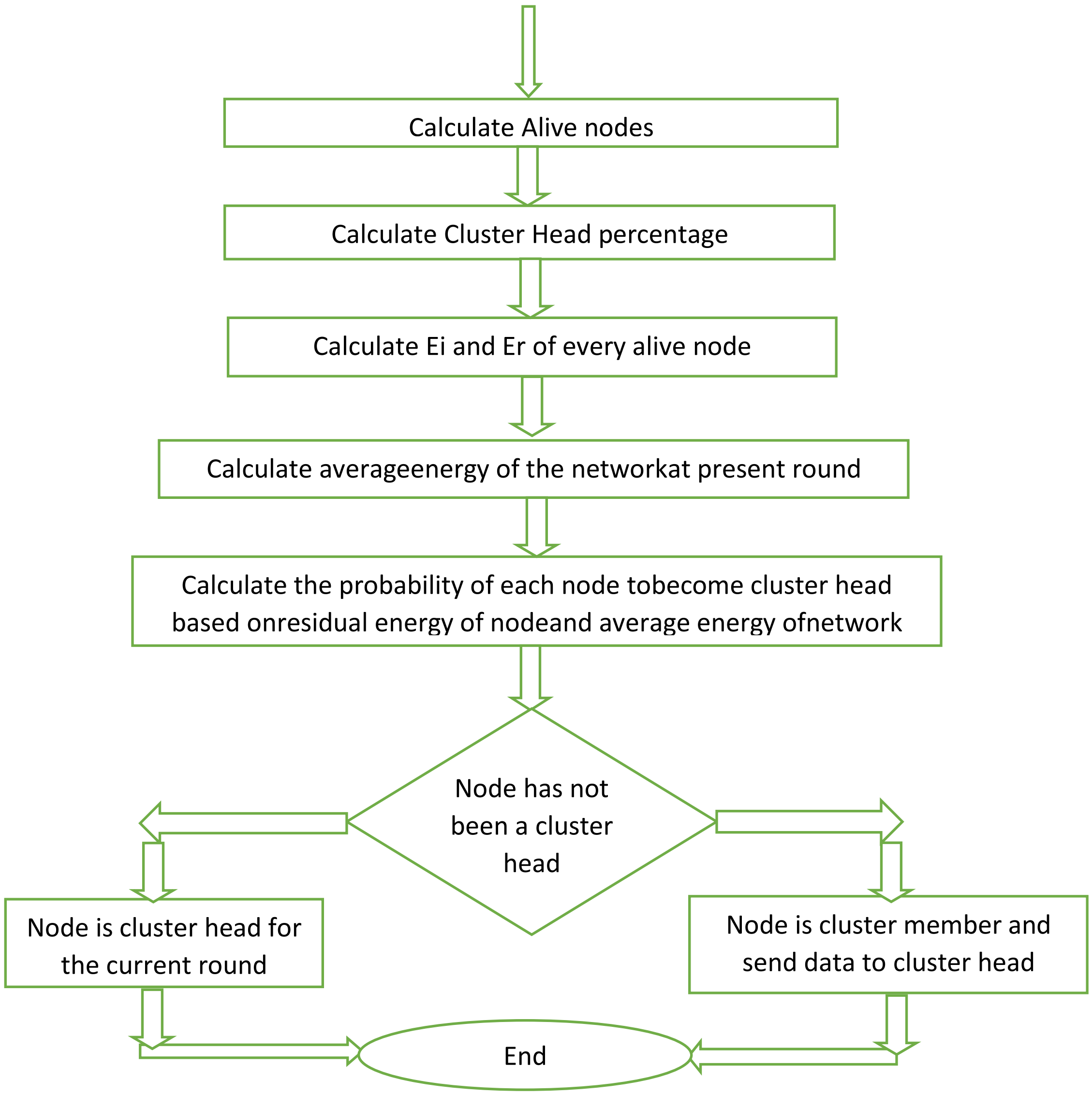

Figure 1: Flow chart for the proposed work

Using the following equations, essentialenergy to transmit and receive'l'bits around a distance‘d’ is computed.

$$E_T(k,d) = \begin{cases} E_{elec}\ k + E_{fs}\ kd^2 & d < d_0 \\ E_{elec}\ k + E_{mp}\ kd^4 & d > d_0 \end{cases} \qquad (1)$$

$$E_R(k) = E_{R-elec}(k) = E_{elec}\ k \qquad (2)$$

Where E_{elec} is energy used to transmit/receive a bit, E_{fs} is free spacepower of transmitter amplifier, E_{mp} is multi-pathpowerof transmitter amplifier energy.

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The node residual energy is E_r; and total residual energy is En; andenergy referencefactor is E_{ref}.

$$E_{ref} = 2 * e^{-(E_r - \frac{E_n}{n})} \qquad (3)$$

Here for the node distribution if node I is subset of G the if this condition is no then Node I is further participate to become CH (Cluster Head) on the basis of energy, but if condition is yes then node is advanced. But advanced node is divided in two nodes that is normal node and intermediate nodes and the energy state of these nodes is defined in equation no (4) and (5) respectively. After calculating the normal node, intermediate node and advanced node we move to find the initial energy of the nodes that depend on battery power of sensor distance of sensor from the communicating object, and the initial energy is calculated by equation (1).

After the network formation, the node distribution stars. In the proposed work for heterogeneity, known as original, intermediate and advanced nodes, three types of nodes are included. The energy of even an advanced node is greater than those of a normal node because of the increased cost factor, and their amount is lower than normal nodes. Let number of sensor nodes deployed in a monitoring area be N. Suppose E_0 is initial energy of the normal node and m is fraction of advanced node with an alpha (α) times more energy than a normal node than initial energy of the normal node = Eo and advanced nodes.

$Eadv$= (1+α). (4)

Supposefor intermediatenodes, $Eint$= (1 + μ)o. (5)

We write:

$$\mu = \alpha/2$$

The probability setting $popt$ has same value. Yet, by introducing of intermediate and advanced nodes, system entire initial energy is increased:

$$n.E_0 (1 - m - b) + n.m.\ E_0 (1 + \alpha) + n.b.\ (1 + \mu)E_0 = n.E_0 (1 + m.\alpha + b.\mu) \quad (6)$$

Where n= number of nodes, m = advanced nodes to total nodes ratio; with energy higher than remaining nodes and b = part of intermediate nodes.

For the probity manner after getting the cluster head, we calculate the alive node which are used during the round or complete cycle. Then calculate the cluster head percentage. Then calculate the Ei and Er by the equation (1) and (3) for the alive node. By introducing the intermediate node and advanced node the initial energy also increased that is shown in equation (6).

The network entire energy is increased by a part of $(1 + m.\alpha + b.\mu)$ and system new epochmust be

$$Popt: (1 + m.\alpha + b.\mu) \qquad (7)$$

$$P_{nrm} = P/Popt * E_{ref} \quad (8)$$

$$P_{int} = (P) * (1 + \mu)/Popt * E_{ref} \quad (9)$$

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$$P_{adv} = P * (1 + \alpha)/Popt * E_{ref} \quad (10)$$

Where Popt is thepredetermined percentage of clusters.Our approach assigns weights for each type of node in order to obtain optimal probability. In the equations (8) and (9) for clustering in proposed mode of heterogeneous network, the total increased energy in heterogeneous networks is shown in (10). When we obtain the knowledge of living node, and then calculate average power of network at current round.

Calculate probability that each node, focused on node residual energy and network average power, will become a CH.

$P_{\_nrm} = P_{nrm}$ *n*(1+α)*E/(n+A)*(Ea); (11)
$P_{\_int} = P_{int}$ *n*(1+α)*E/(n+A)*(Ea); (12)
$P_{\_adv} = P_{adv}$ *n*(1+α)*E/(n+A)*(Ea); (13)

Where:

A= fraction of advanced enhancement of node energy.
n= total number of nodes ; $\alpha =$ The energy of nodes with advanced alpha times is greater than normal nodes.
For selection of cluster head, the likelihood is computed as below.

$$T(P_{\_nrm}) = \begin{cases} \frac{P_{\_nrm}}{1-P_{\_nrm}\,[r \text{ x } mod\,(1/P_{\_nrm})]} & if\ P_{\_nrm} \in G' \\ 0 & otherwise \end{cases} \quad (14)$$

Whereas G' = normal nodes sets

$$T(P_{\_int}) = \begin{cases} \frac{P_{\_int}}{1-P_{\_int}\,[r \text{ x } mod\,(1/P_{\_int})]} & if\ P_{\_int} \in G'' \\ 0 & otherwise \end{cases} \quad (15)$$

Where G'' = set of intermediate nodes

$$T\ (P_{\_adv}) = \begin{cases} \frac{P_{\_adv}}{1 - P_{\_adv}\,[r \text{ x } mod\ (1/P_{\_adv})]} & if\ P_{\_adv} \in G''' \\ 0 & otherwise \end{cases} \quad (16)$$

Where G''' = set of advanced nodes
Where G'; G'' and G''' are group of normal, intermediate, and advance nodes in last rounds that haven't even become cluster heads. We have estimated weighted election estimates and thresholds to effective selection of cluster heads so as to enhance network life and throughput for the proposed algorithm. We will now describeoutcomes of simulations of one's heterogeneous prototype of network and start comparing with current network models like LEECH and DEEC.

4. Results and Discussion

In this portion, results of LEECH, DEEC and proposed algorithm are discussed and the performance of proposed algorithm is evaluated by comparing to that of LEECH and DEEC. Our

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simulations consider the 200 sensor nodes random deployment in a square area with dimension of 100 M x 100 M. In sense of rounds, network lifetime plus throughput, the results of the current and proposed algorithm are compared with heterogeneous network models.

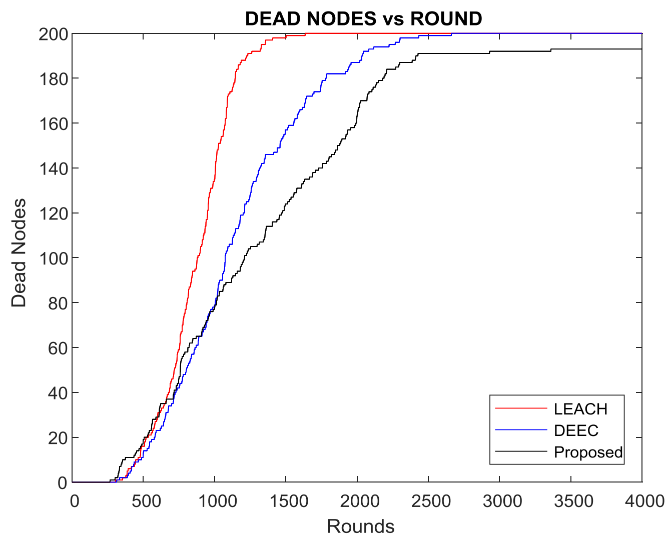

Figure 2: Number of nodes with the dead sensor vs. number of rounds

Figure 2 shows that the proposed model provides a longer lifetime than the LEECH and DEEC because the nodes die slow as compared to LEECH and DEEC in the proposed model.So that in 4000 rounds for the proposed model still nearly 10 nodes have the energy to perform or 10nodes are still alive but for the LEECH all nodes are dead till only 2500 rounds and in DEEC all nodes are dead till 2600 rounds.

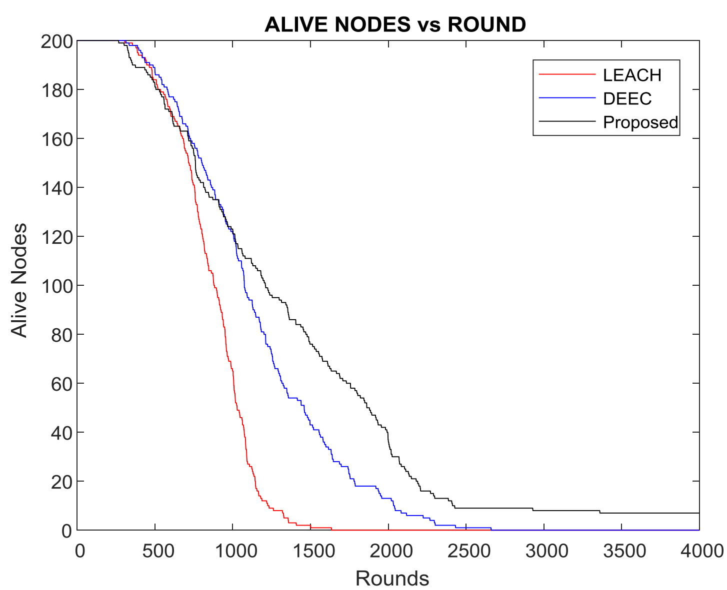

Figure 3: Number of nodes of living sensor vs. number of rounds

Figure 3 shows number of live nodes for LEECH, DEEC and proposed model with addition to amount of rounds. In order to do a performance comparison in contrast of heterogeneity, we have

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associated graphs for LEECH and DEEC. This is the completely inverse plot of figure 2. In the beginning all 200 nodes are alive, but the proposed model till all 4000 rounds nearly 10 nodes are alive compare to LECCH and DEEC. In the LEECH nodes are alive till only 1500 round then all the nodes are dead. In DEEC the nodes are alive till 2500 round only.

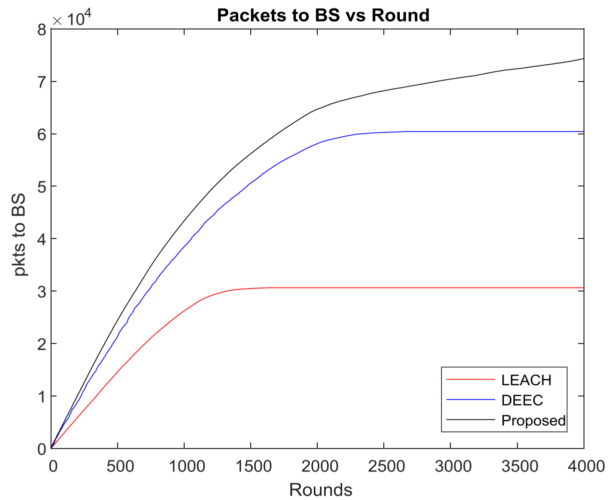

Figure 4: Base station packets vs. the number of rounds

The amount of packets transmitted to base station is shown in Figure 4 with regard to number of rounds for LEECH, DEEC and the model proposed. This evaluation relates to the quantity of information gathered from sensor field by the network and sent to base station. Compared to LEECH and DEEC, the proposed model sends the maximum amount of packets to base station.

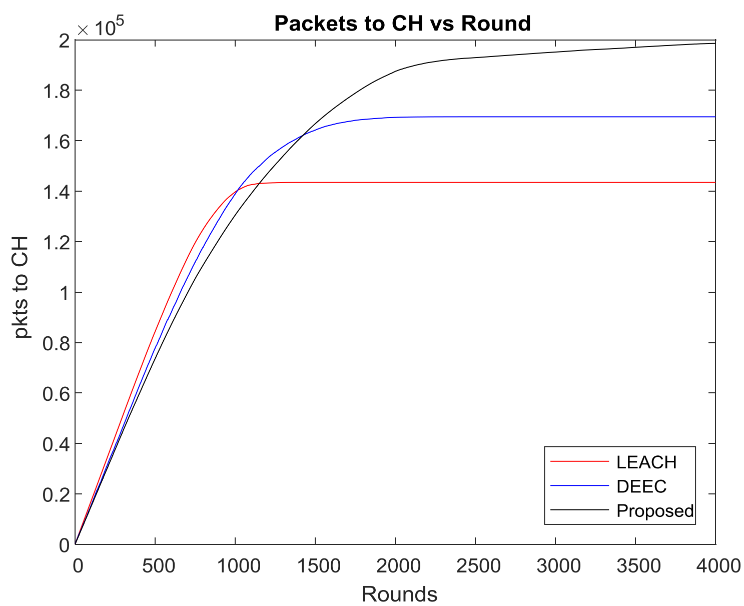

Figure 5: Packets to Cluster head vs. number of rounds

The figure 5 shows packets send to cluster head with respect to the rounds. Here shows the graph for proposed model, LEACH and DEEC. The information send by the proposed model is much high for all the rounds but in LEACH and DEEC is less.

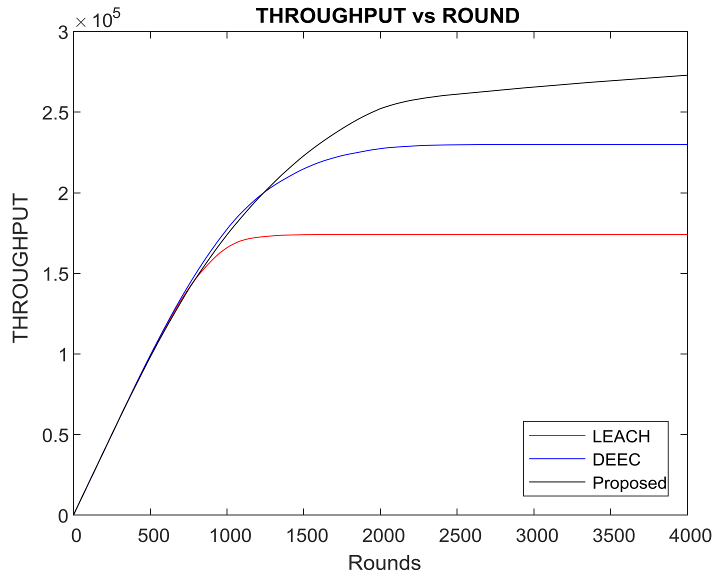

Figure 6: Throughput vs. number of rounds

The figure 6 shows throughput ((size of packets x delivered number of data packets)/ time) for the proposed model, LEACH and DEEC. Here it is shown that the throughput is better for the proposed model compare to LEACH and DEEC.

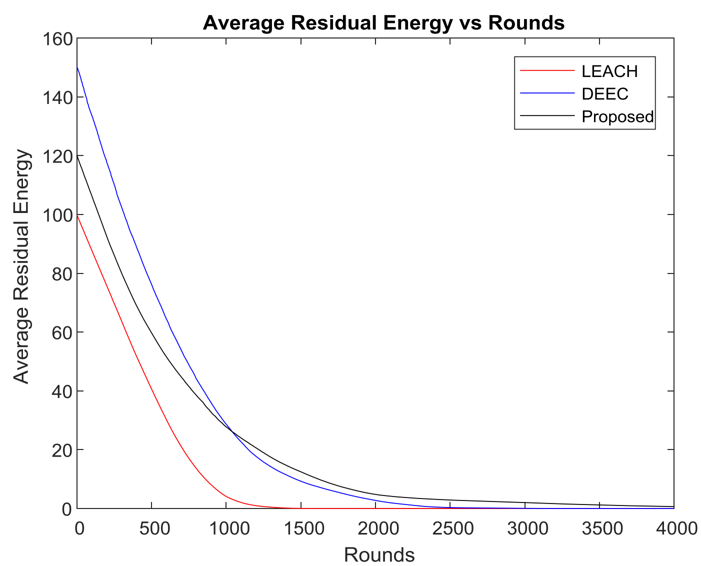

Figure 7: Average residual energy vs. number of rounds

Figure 7 depicts average residual power with addition to rounds. This is depends on the battery life of the sensors. For the proposed model the energy is at high level and till all the rounds energy is left due to the alive nodes, but in LEACH energy is lost till 1500 rounds and in DEEC energy is lost till 2500 rounds.

5. Conclusion

An approach to load balancing within wireless sensor network is suggested in this paper. Algorithms are proposed for cluster head collection, cluster creation, intra-cluster communication and wireless sensor network inter-cluster communication. With regard to amount of rounds and the dead nodes, performance of algorithm is compared with original LEACH algorithm DEEC algorithm using the parameter as the energy dissipation in each round per node. The findings show that the approach proposed is effective in prolonging lifetime of network. Figure 2 and 3 shows number of dead nodes and number of alive nodes that shows energy efficiency of the proposed model that's why some nodes are alive till the last round. Figure 6 shows the throughput of the proposed model that is more information can be transferred with this proposed model. The figure 7 depicts the average energy of model that is energy is also left till the last rounds. So that the proposed model have better life time and throughput with compared to LEACH and DEEC.

Declaration of Interest:

All the authors wish to confirm that there are no known conflicts of interest associated with this publication.

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