VOL. 17, NO. 8, APRIL 2022 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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ENERGY EFFICIENT CLUSTER BASED APPROACH FOR LOAD BALANCING IN WSN

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ABSTRACT

During the last decade there has been a rapid growth of wireless sensor technology. Wireless sensor networks (WSNs) are widely deployed for a variety of applications. In WSN the sensor nodes are operating with limited battery power, so consumption of energy should be done very carefully to make the network long lasting. Therefore, efficient power utilization is a major concern for the researchers. This paper proposes an extended energy efficient clustering algorithm (EEECA) for load balancing in WSNs. It works in three phases, (i) initialization phase, (ii) setup phase, and (iii) transmission phase. In initialization phase, the network is splitted into number of clusters and for each cluster a cluster head (CH) is selected based on residual energy and mean distance. During setup phase, the base station (BS) sends routing information to all the sensor nodes informing about their CH. A sensor node knows the distance from any other node within the cluster and computes its transmission power. The base station allocates time division multiple access (TDMA) to the cluster nodes. In transmission phase, the sensor nodes in each cluster transmit data to cluster head as per the allocation of transmission time. The CH aggregates all the data and compresses it and sends it to the BS. The algorithm has been simulated using Java and Jung Simulator. Its performance has been estimated by the parameters like throughput, energy consumption, residual energy, and network energy. These results are also compared with the existing algorithms. It is found after analysis of the results that proposed algorithm shows better results in all the above parameters.

Keywords: wireless sensor network, load balancing, energy consumption, clustering, network lifetime.

1. INTRODUCTION

There has been a continuous demand for wireless sensor networks (WSNs) during the last two decades because it is used in a large number of applications. WSN consists of hundreds of minute sensor nodes to supervise bodily or ecological conditions such as humidity, temperature, clamminess, etc. Each sensor node can sense the data, compute, and communicate to the base station (BS). Within the WSN power efficiency plays an important role to limit the overhead through which the system lifetime can be increased. To increase the life of sensor nodes, energy consumption and routing algorithms need to be considered. Due to this reason, effective energy utilisation becomes an extreme issue in WSN. To address this issue Kacimi *et al.* [1] proposed a load balancing technique to maximize the lifetime of WSN by applying a heuristic mechanism and compared with shortest-path and equi-proportional routing. Sharmila *et al.* [2] suggested virtual scheduling backbone replacement to improve the lifetime of WSN by considering replacement of nodes based on energy. Zhao [3] proposed to increase the network lifetime by using the sleep scheduling technique known as virtual backbone scheduling. Low energy adaptive clustering hierarchy (LEACH) is a algorithm used by many researchers [4, 5, 6] by using localized coordination for getting robustness and scalability in adaptive networks. The LEACH working is organized in rounds that contain setup and transmission stage. In the setup stage, node organizes themselves into clusters among these nodes one node is chosen as Cluster head. During the transmission stage, the information is received from all other sensor nodes towards the cluster and sends information to the base station. Hierarchical energy efficient distributed routing (HEED) [4] grouping based protocol supports adaptable information aggregation. Clustering heads are probabilistically chosen based on their remaining energy and the power dimension of the detecting nodes. HEED convention is furnished in a distributive situation.

Guan *et al.* [5] presents a novel hierarchical clustering scheme for saving energy consumed by communication and balancing energy load in all sensor nodes. They proposed cluster based on the hop counts between sensor nodes and sink. The load can be balanced among clusters to a certain extent. While the author Chang *et al.* [6] proposed a saving energy clustering algorithm (SECA) centralized clustering architecture, efficient energy consumption and better network lifetime can be provided in the WSN. In this scheme Base Station received the information of residual energy and location for each sensing node and then average residual energy is calculated. When the remaining energy of sensing node is greater than the average remaining energy, the sensing node is selected as candidate of cluster head. Then modified k-means algorithm can be applied to make a perfect dispersion for sensor node clusters by utilizing the data of remaining energy and area for all sensor nodes the activity incorporates two stages: set-up stage and steady state stages. Randhawa *et al.* [7] suggested energy-efficient load balancing (EELB) technique for balancing load for two tier communication in WSNs, so as to adjust the general energy dissipation in node, balancing of load is required at two tiers/levels. In Tier1, the energy consumption of cluster and Base Station is reduced based on state-time block coding (STBC) approach over m-ary quadrature amplitude modulation (M-QAM) and binary phase shift keying (BPSK). In Tier2, First Come Serve approach is suggested for balancing load so that energy consumption within a cluster can be reduced for communication [7] [7].

Abusaimeh *et al*. [8] proposed a new energy aware mechanism to balance the number of sensing nodes in the clusters to increase the network lifetime by sending equal number of nodes in sleep mode in each cluster. The number of cluster-heads in the network will be chosen by the *k*-means clustering algorithm. Kim [9] proposed scheme managing sub-networks based on greedy growing algorithm and sets the maximized lifetime of the sensing nodes and networks. Azharuddin *et al*. [9] proposed particle swarm optimization (PSO) technique. PSO consists of a swarm of particles of a predefined size. Each particle provides a complete solution to a multidimensional optimization problem. A fitness function is used to evaluate each particle to judge its quality for the solution to the problem. In order to achieve the global best position, the particle follows its own best, i.e., personal best and the global best to update its own velocity and position. Sudha *et al*. [10] proposed multi-hop low energy adaptive clustering hierarchy (LEACH). Distributive cluster algorithm is added in LEACH. In every cluster, one node is considered as CH and the others as cluster members and this part is rotated at each round. More energy is utilized by CH over the cluster members. Selection of CH node is carried out repeatedly, since CH node dies quickly. There are two phases in each round (i) Set-up phase (ii) Steady state phase.

Akila *et al*. [11] divided sensor network into multiple zones based on their location of geographic coverage with respect to the sink node. The region of sensing is divided into geographic zones, which in turn divided into sub-zones of location. Cluster is formed of all sensor nodes present in a sub-zone, which is referred as geo-cluster. A primary cluster head is elected for each of these geo-clusters based on the residual energy of the nodes. Every zone is divided further into a number of sub-zones of equal size. Sensor nodes in a sub-zone form a geo-cluster. Palani *et al*. [12] developed a hybrid routing protocol and load balancing technique for the mobile data collectors. Instead of the shortest path tree, the hybrid routing protocol which is combination of reacting and pro-acting approach to enhance gradient based routing protocol is used for low power and lossy networks for efficiently handling movement of multiple sinks. To balance the load of sensor nodes, load balancing is applied over the multiple mobile elements. Anisi *et al*. [13] proposed harvesting energy technology that uses piezoelectric nano generators to nano sensor power supply; conventional energy harvesters are used for type of sensors that cannot be charged.

The author Dehghani *et al*. [14] used the cellular segmentation of network and genetic algorithm to determine the cluster heads and the K-means for clustering, This algorithm consists of three main phases: (i) cellular segmentation of network, (ii) clustering and (iii) data transmission. The author Bozorgi *et al*. [15] proposed a hybrid unequal energy efficiency clustering (HEEC) for WSN. Sensor nodes are distributed in an environment randomly. Each node can operate as a CH or a cluster member. All nodes and Base Station are stationary and can adjust transmission power considering distance. The author Lalwani *et al*. [16] proposed biogeography - based energy routing architecture (BERA) for WSNs. Biography based optimization (BBO) based cluster head selection algorithm with a new fitness function and efficient encoding scheme. BBO based multi-hop routing algorithm with a new fitness function and a novel encoding scheme. Kulshrestha *et al*. [17] used Mixed-hop routing in which each node switches between direct transmission mode, sending data directly to sink without using any relay node, and hop-by-hop transmission mode is forwarding or sending data to next-hop neighbors. By properly selecting between multi-hop and single-hop transmission, mixed-hop transmission balances the nodes energy and balances effectively the cnsumption of energy without involving any significant additional overhead or cost. The authors Rajeh *et al*. [18] propose a new cooperative balancing routing protocol (CBR) where each sensor node forward data to the sink by passing data to its neighbor node which has a minimum cost and high residual energy. Their protocol is based on three phases; the first phase is discovering the neighbors and establishment of neighboring table according to the hop counts between the sink and the sensor node. In the second phase, the source node sends data to the sink by selecting the best path depending on the calculated cost and the probability for each node exists in the neighboring table and their proposals node. Finally, update the neighboring table in nodes.

Arjuna *et al*. [19] proposed fuzzy logic based cluster construction and CH selection and Ant colony optimization based inter-cluster routing. Data transmission is carried out in hybrid manner i-e. Threshold based and periodic data transmission with longer time intervals. A routing strategy which exploits all possible paths. Haseeb *et al*. [20] proposed, adaptive energy aware cluster based routing (AECR) protocol produces distinct clusters that stay fixed all through the network life cycle. In like manner, diminishes clustering overheads and correspondence cost by avoiding re-clusters arrangement. Also, to cause less computational overheads and improving energy preservation, AECR starts the CH election mechanism inside the limit of clusters dependent on composite measurements.

The novelty of the Adhikary *et al*. [21] proposed methodology is that the cluster range of CHs' in the proposed approach is a function of nodes fitness and its distance to BS; with a decrease in fitness the cluster range dwindle as well. So, it ensures equality in load distribution and when combined with on demand clustering and fuzzy logic based CH selection, it provides an optimal structure for the clusters and conserves more energy. Wang *et al*. [22] begin with, planning a Trusted Module (TM), to improve the security of the system. Nonetheless, TM needs to expend additional energy. So they simply pick the cluster heads to introduce the TMs. Second, they proposed a grouping estimation named trust based energy efficient

VOL. 17, NO. 8, APRIL 2022 ISSN 1819-6608
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clustering (TEEC), which is used to pick reasonable nodes as the cluster takes off toward improving the energy adequacy of the framework. By then, they depicted the framework movement, which shows how the framework continues running from nodes sending to node passing. The framework movement contains the going with advances in clustering, TM-based CHs verification, TM-based CMs confirmation, and TM-based key foundation, information accumulation, and transmission. Ibrahim *et al.* [23] proposed an energy-efficient and load balancing cluster-based (ELC) routing algorithm for carrier sense multiple access (CSMA) in WSN. Specifically, both separation and remaining energy are thought about in building up the cluster head selection system. Moreover, notwithstanding separation, cluster measure is likewise utilized in figuring the cost function for cluster shaping so as to adjust load and energy utilization among the nodes, and subsequently, to improve the system lifetime. Also, ELC utilizes multi-hop inter-cluster routing dependent on a lowest cost path approach that thinks about both energy productivity and load balancing. Azharuddin *et al.* [24] proposed distributed fault clustering and routing algorithm (DFCR). The calculation of energy is proficient and fault tolerant. The DFCR utilizes a dispersed run time recovery of the sensor nodes because of abrupt failure of the clustering heads (CHs). It deals with the sensor nodes which include no CH inside their correspondence range. Mehra *et al.* [25] used re-clustering the system just when CH falls underneath a limit level. Repeated unnecessary clustering in each round exhausts the energy of the system more rapidly. By virtue of heterogeneity energy, lifetime of the system can be extended. A calculation is useful if the zone of interest is secured by dynamic nodes. The period for which the system is functional is termed as persistent period. Hyder *et al.* [26] proposed improving QoS parameter in WSN by TDMA and CSMA approach. Nandori *et al.* [27] has used clustering along with fuzzy logic modified K means algorithm to find the midpoint for improving lifetime in WSN. Umar *et al.* [28] used dynamic reclustering Leach protocol for calculating residual energy and performance of network. Dinesh *et al.* [29] proposed clustering algorithm for wireless body area network which uses trust based method. Avinash *et al.* [30] proposed a data transmission adaptive method in wsn which guaranteed and assured path for data transmission. Venkateswara *et al.* [31] worked on secure data transmission in WSN and worked on malicious packets using hyper elliptic curve cryptographic HECC algorithm. Avinash *et al.* [32] suggested that QoS parameter such as power efficiency can be improved by decreasing rate of data retransmission. Krishna *et al.* [33] has implemented smart irrigation using WSN based on IoT and has used sensor for soil moisture measurement, humidity and temperature. Kailas *et al.* [34] has done review on different localization techniques and put forth that sensor node location is important during data transmission without which sensor data is useless, hence the location of sensor must be known. Karthikeyan *et al.* [35] worked on how maximum data packets can be delivered to destination in wsn using clustering approach for this neighour based cluster location aware routing is used. Naidu *et al.* [36] has shown the impact of worm hole attack in WSN using location counter. Rajkumar *et al.* [37] proposed low power WSN localization and optimization problem in WSN using grey wolf optimization method. Regula *et al.* [38] proposed energy efficiency in wsn using multi level structured tree based routing.

2. RELATED WORK

2.1 LEACH Operates in Two Phases

a) Set up Phase

b) Steady state Phase

Using Leach protocol 30 nodes as a sample are randomly distributed

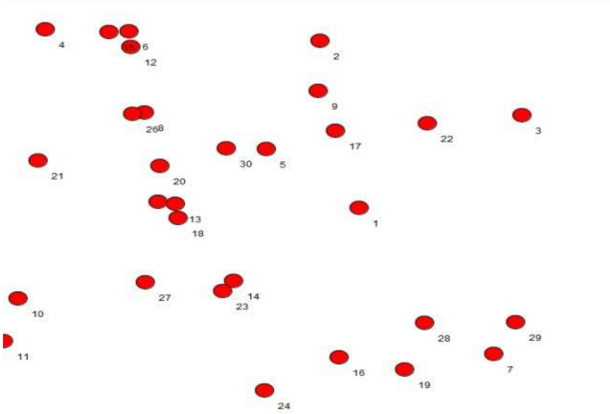

Figure-1. Nodes distributed randomly.

The first phase of LEACH is Set-up phase and it has three fundamental steps.

a) Cluster setup
b) Cluster head advertisement
c) Creation of transmission schedule using TDMA.

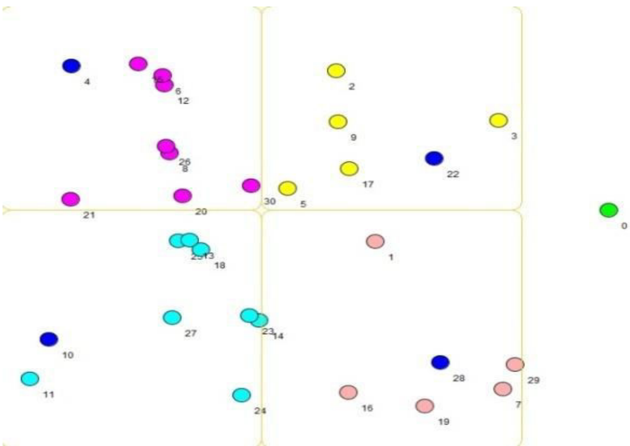

Figure-2. Clusters formation using Leach Protocol.

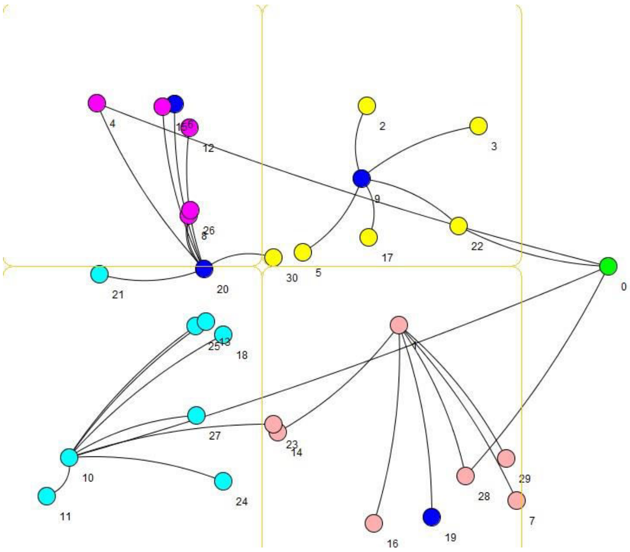

Figure-3. Cluster head formation and data sending using Leach Protocol.

Cluster Member 1: [20, 26, 8, 6, 4, 12, 15]
Cluster Member 2: [11, 10, 24, 27, 13, 18, 25,21]
Cluster Member 3: [14, 23, 16, 19, 28, 29, 7, 1]
Cluster Member 4: [30, 5, 17, 22, 9, 2, 3]
Non Cluster Member: []

Limitations of LEACH Algorithm

It offers no assurance about arrangement and additionally number of cluster head nodes in each round. Accordingly utilizing an incorporated central clustering algorithm would deliver better outcomes.

2.2 Hybrid Energy Efficient Distributed Clustering Protocol (HEED)

Algorithm

HEED protocol is a vitality productive grouping algorithm. It utilizes remaining energy as important parameter and node degree and separation to neighbors as optional parameter. It expands the fundamental plan of LEACH convention. The grouping cycle is separated into various iteration, and in every iteration node that are not secured by any cluster head; it duplicates the likelihood of turning into a cluster head.

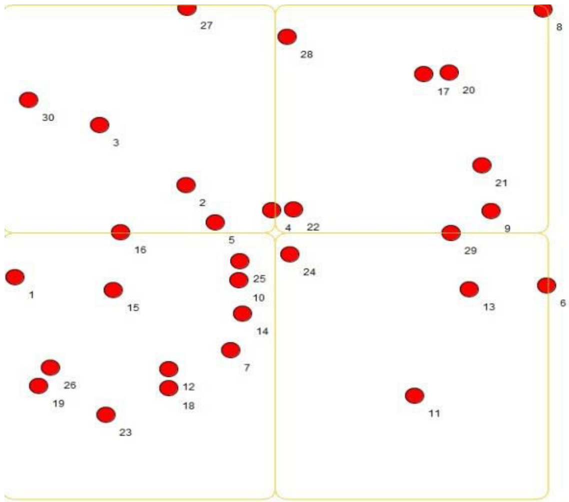

Figure-4. Cluster formation in HEED Protocol.

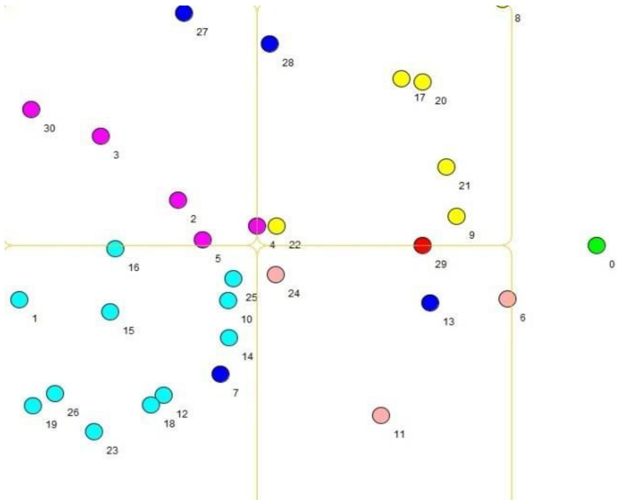

Figure-5. Cluster head formation in HEED Protocol.

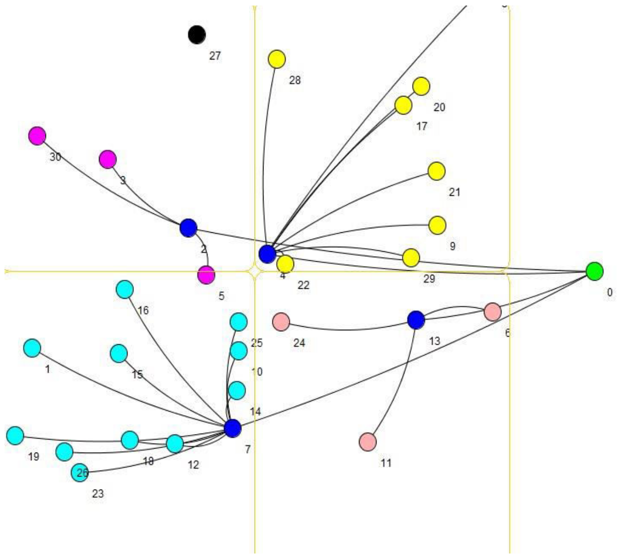

Figure-6. Cluster Head formation and data sending in HEED Protocol.

Cluster Member 1: [30,3,2,5]
Cluster Member 2: [25,10,14,7,16,15,1,19,18,12,26,23]
Cluster Member 3: [24,11,13,6,]
Cluster Member 4: [29,9,21,4,17,20,28,22]
Non Cluster Member: []

Limitations HEED Algorithm
Optimum cluster heads is not guaranteed.
Distributed Clustering,
No need of centralized Base Station.
Based on Residual Energy Cluster Head is Random selected.

2.3.1 Problem statement

Leach offers no guarantee about placement and/or number of cluster head nodes in every round. Therefore, using a centralized clustering algorithm would produce better results.

HEED cannot guarantee optimal elected set of cluster heads. Cluster Head is Random selected based on Residual Energy, to overcome these drawbacks we are proposing a Extended Energy Efficient Clustering Algorithm (EEECA) for the wireless sensor networks.
Finally, we proposed an Extended Energy Efficient Clustering Algorithm (EEECA) Cluster based method to reduce energy utilization by adjusting load in WSN.

- Main thought is to reduce data transmission distance of the sensor nodes in WSN with the help of uniform cluster formation.
- To make a perfect distribution of sensor node, we ascertain the average distance between sensor nodes and consider the remaining energy for choosing the best possible cluster head nodes.
- The proposed method presented an "Extended Energy Efficient Clustering Algorithm (EEECA) for remote sensor network".

Objectives and Scope

a) Reduce data transmission distance of sensor nodes using uniform clustering concepts.
b) Ideal distribution of sensor node, calculating the average distance between sensor nodes and considering the residual energy for selecting the proper cluster head nodes.
c) Balancing the load of WSN among the clusters.
d) Minimizing energy consumption in WSN.
e) Prolong the lifetime of WSN.

Table-1. Clustering algorithm techniques.

Clustering Algorithms				
Method	**Environment for Operation**	**Structure for Routing**	**Techniques**	**Need of Base station**
LEACH	Distributed	Cluster	Random	No
HEED	Distributed	Cluster	Random and Residual Energy	No
Proposed Algorithm EEECA	Centralized	Cluster	Residual Energy and Sensor position	Yes

3. PROPOSED EEEC ALGORITHM FOR LOAD BALANCING IN WSN

3.1 Algorithm for EEECA

The algorithm for proposed scheme is divided into three phases;

3.1.1 Phase A: Initialization Phase

a) Main objective of this phase is formation of Clusters and Selection of Cluster head (CH)

b) During this phase Base Station collects information of energy status and the position from all the nodes in network.

c) All nodes are fixed, obtain mean point and find out average distance nodes.

$$M = \sum_{i=1}^{s} \mathrm{D}i \,/S$$

Let M be the Mean point for all sensor nodes, if there are sensor nodes M calculated as, Where Di is the coordinate of sensor node i Average distance between M and all Sensor nodes Calculated by,

$$\mathrm{Davg} = \sum_{i=1}^{s} |\mathrm{D}i - M|/S$$

d) Find the nodes whose residual energy is more than average residual energy and select as a cluster head.

3.1.2 Phase B: Setup Phase

a) After formation of cluster head base station sends routing information to all sensor nodes.

VOL. 17, NO. 8, APRIL 2022 ISSN 1819-6608
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b) A sensor node knows the distance from any other node within the cluster so compute its transmission power.

c) TDMA allot time slot for cluster nodes.

3.1.3 Phase C: Communication Phase

a) The sensor nodes in cluster transmit data to cluster head as per the allocation of transmission time.

b) The cluster head aggregates all the data and compressed it and sent it to base station.

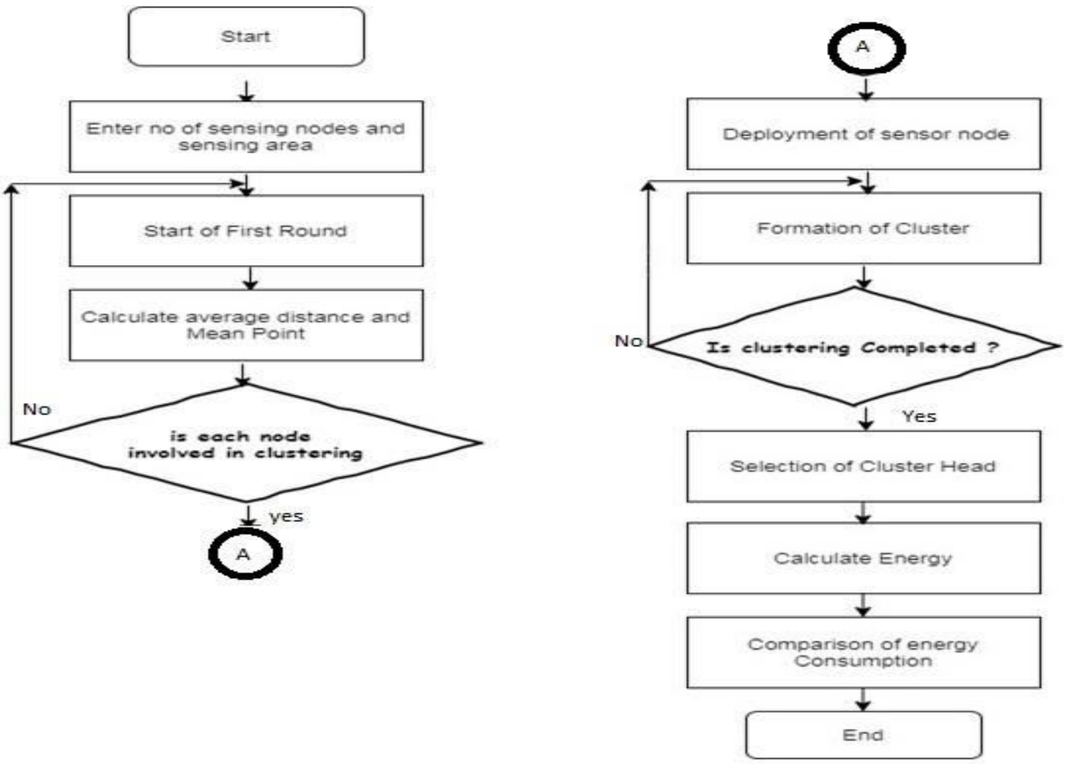

Figure-7. Flowchart for EEECA algorithm.

4. RESULTS AND DISCUSSIONS

To show expected results of our proposed extended energy efficient Clustering algorithm (EEECA) and existing LEACH and HEED algorithms the system is implemented in JAVA using JUNG Simulator.

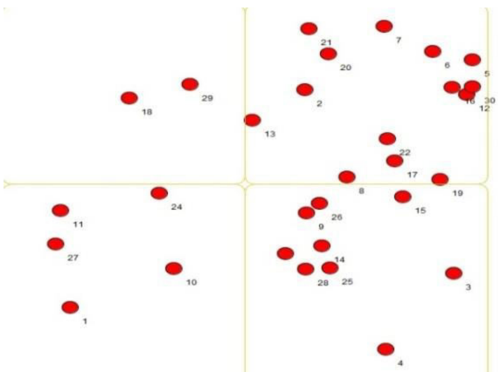

Figure-8. Clustering using our proposed EEECA Protocol.

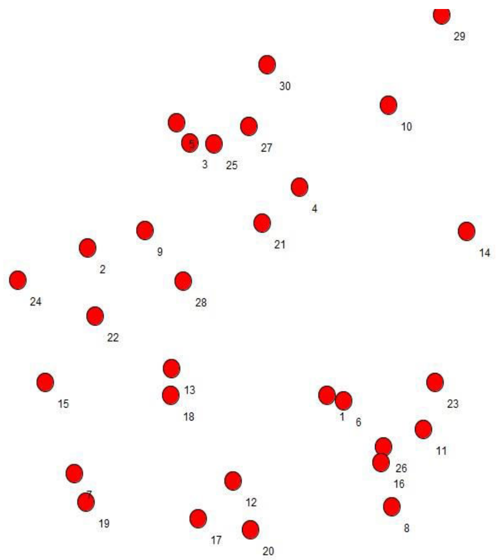

Figure-9. Ideal distribution of nodes in EEECA Protocol.

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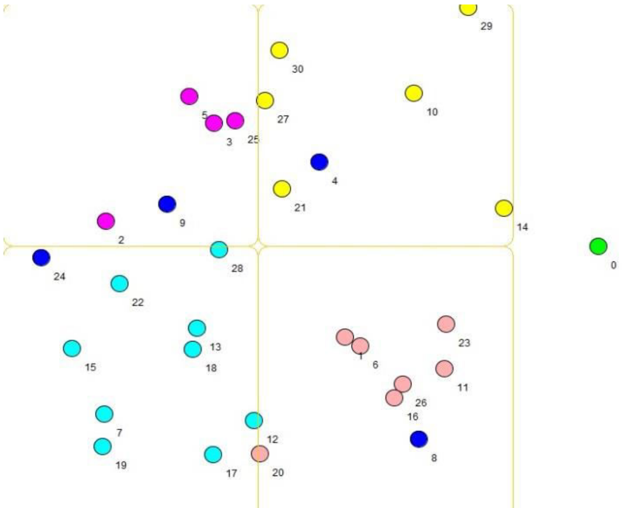

Figure-10. Cluster formation in EEECA Protocol.

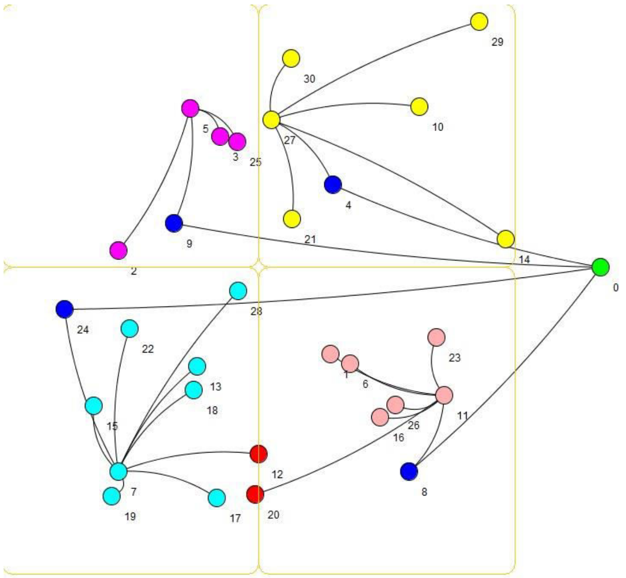

Figure-11. Cluster formation and sending data in EEECA Protocol.

Cluster Head 9,
Cluster Head 24,
Cluster Head 8,
Cluster Head 4.
Cluster Member 1: [9,2,5,3,25]
Cluster Member 2: [24,15,7,19,17,18,13,22,28]
Cluster Member 3: [8,20,12,16,26,1,6,23,11]
Cluster Member 4: [4,21,14,27,30,10,29]

Table-2. Comparison of data sent/received and packet loss between LEACH, HEED and EEECA protocol.

Comparison of data sent/received and packet loss between LEACH, HEED and EEECA protocol			
Algorithm	**Data Sent**	**Data Received**	**Packet loss**
LEACH	25	20	5
HEED	25	21	4
EEECA	25	24	1

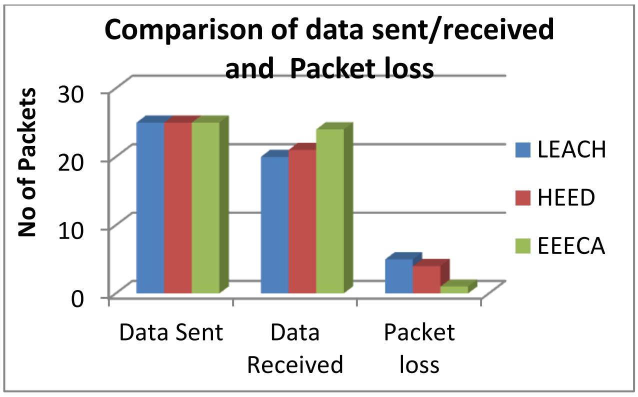

Figure-12. Comparison of data sent, received and packet loss between LEACH, HEED and EEECA protocol.

Table-3. Remaining energy in LEACH, HEED and EEECA Protocol.

Remaining energy in LEACH, HEED and EEECA Protocol.	
Algorithm	**Remaining Energy in joule**
LEACH Protocol	20000
HEED Protocol	25000
EEECA (Proposed) Protocol	165000

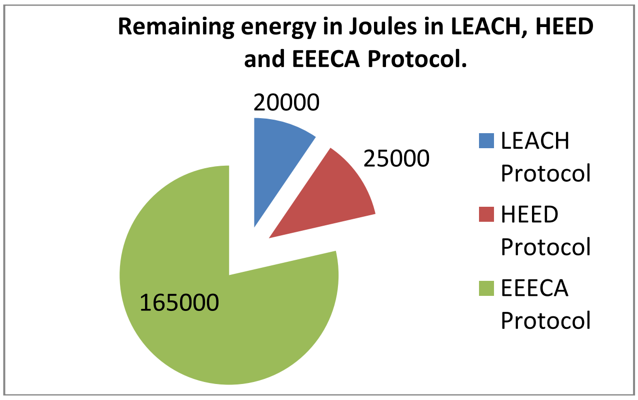

Figure-13. Remaining energy in LEACH, HEED and EEECA Protocol.

Total Number of Dead Nodes

In this section we analyze the performance of proposed EEECA algorithm using a simulation model,

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demonstrate the simulation results and compare with the LEACH and HEED. We design a simulation environment by using JUNG Simulator. Y axis denotes number of iterations and X axis having Algorithms. We check for 50 nodes and 100 nodes.

Table-4. No of dead nodes.

Algorithm used	Dead nodes/iterations
LEACH protocol	2
HEED Protocol	4
EEECA Proposed Protocol	1

No of Dead Nodes

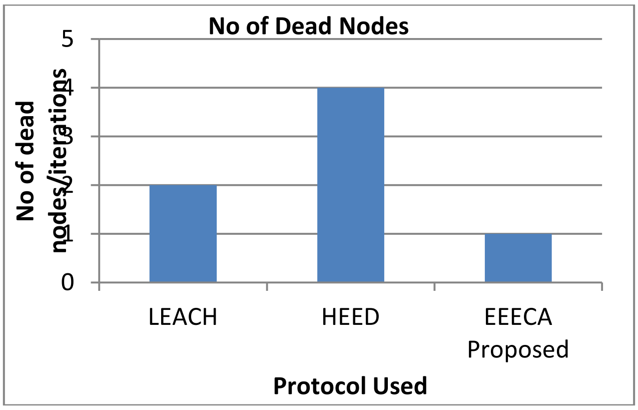

Figure-14. Number of dead nodes/iterations.

Energy Consumption

Figure shows that the total network energy when the number of sensor nodes are 50 and 100. Due to better energy efficiency method in proposed EEECA Algorithm, results show higher residual energy than the LEACH and HEED.

Table-5. Residual energy.

Algorithm	Remaining Energy in Joules
LEACH Protocol	50000
HEED protocol	100000
EEECA Proposed Protocol	400000

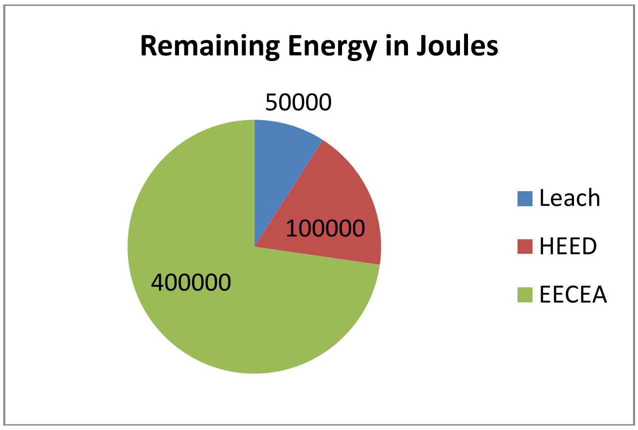

Figure-15. Residual energy.

Network Energy

Figure-17 shows the Network energy of the proposed extended energy efficient clustering algorithm. X axis represents required energy and Y axis represents rounds. As shown in figure the required energy for the network nodes after some rounds is more so our proposed algorithm is efficient.

Table-6. Total network energy.

Total Network Energy			
Round	LEACH Protocol	HEED Protocol	EEECA Protocol
0	20000	18000	15000
1	40000	36000	22000
2	60000	40000	30000
3	80000	60000	40000
4	100000	80000	50000
5	120000	100000	60000
6	140000	120000	70000
7	160000	140000	80000
8	180000	160000	90000
9	200000	180000	100000

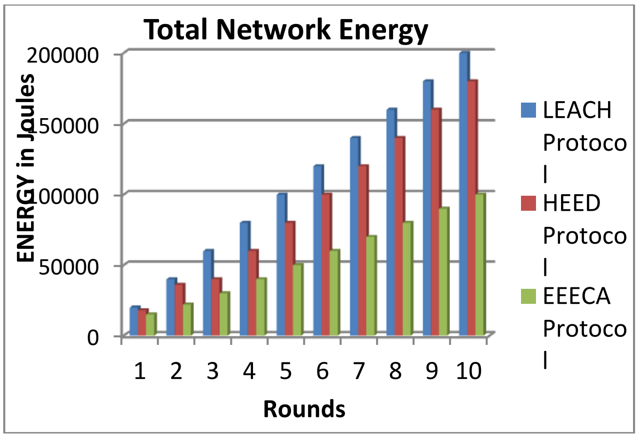

Figure-16. Total network energy.

Packet Ratio

Table shows the packet ratio of the proposed extended energy efficient clustering algorithm. X axis represents rounds and Y axis represents packets send, received and dropped. As shown in graph the less no of packets are dropped and maximum data sent and received with acknowledgment. Hence in the proposed scheme very less no nodes after some rounds are dead our proposed algorithm is energy efficient.

Table-7. Comparison of data sent/received and Packet Loss.

Algorithm	Data Sent	Data Received	Packet loss
LEACH	472	352	120
HEED	472	342	130
EEECA	472	400	72

Comparison of data sent/received and Packet Loss

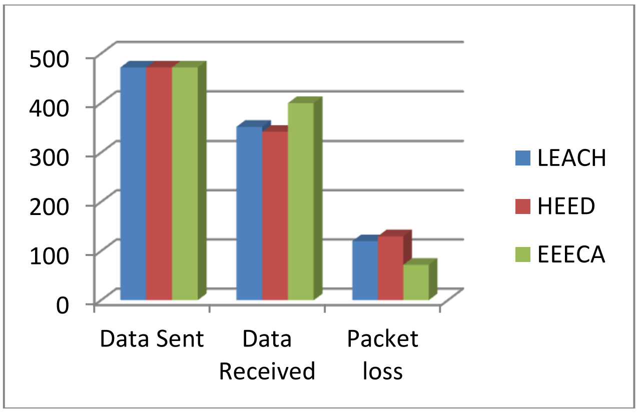

Figure-17. Packet sent, received and packet loss.

Total data collected in the proposed algorithm is more after no. of rounds as shown in Figure-18. X axis denotes no. of iterations and Y axis having algorithms. The transmission power of non-cluster head nodes is reduced. Also the distance among CH and n-CH is suitable using EEECA algorithm.

Table-8. Algorithm Vs total collected data.

Comparison of Energy Model	
Algorithm	**Total Collected Data**
EEECA Proposed	850
HEED	500
LEACH	50

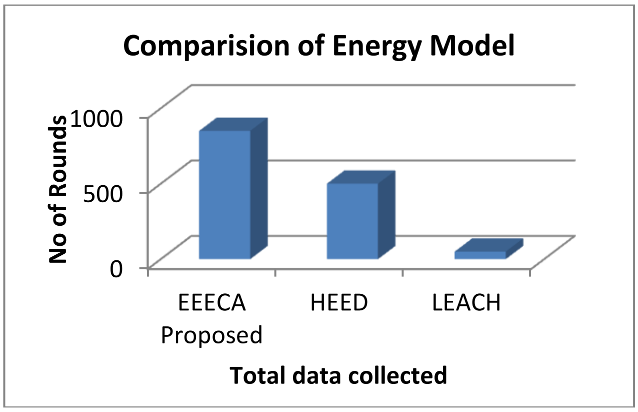

Figure-18. Comparison of energy model.

Figure-18 shows that the total network energy for the same amount of sensor nodes is less in our EEECA Algorithm. The proposed scheme results in higher residual energy than the LEACH and HEED.

Table-9. Comparison of energy model.

Radio Energy Model			
Energy	**LEACH**	**HEED**	**Proposed**
0	220	220	220
100	175	180	180
200	140	170	180
300	130	160	170
400	75	130	140
500	70	120	140
600	40	80	135
700	20	70	135
800	10	65	130
900	0	50	130

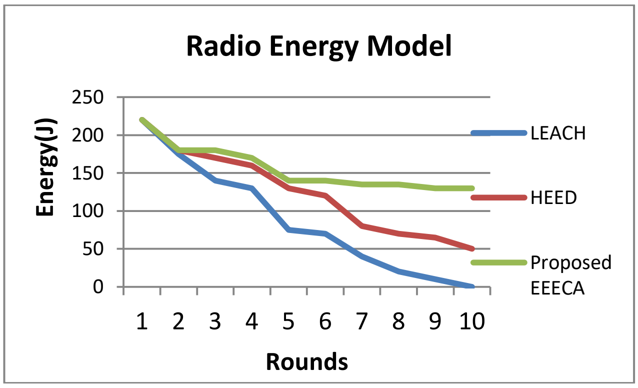

Figure-19. Radio energy model.

Figure-19 shows the Radio Energy consumed by LEACH, HEED and EEECA Algorithm. It is observed from Table-9 that proposed EEECA Algorithm is more radio energy efficient than the existing.

5. CONCLUSIONS

In this paper we have studied energy efficient load balancing clustering based technique choosing optimum path with minimum load towards the source node and sink node. Clustering reduces and balances the energy utilization and prolongs the lifetime as well as the scalability of the sensor network. Clustering is frequently used with a data aggregation method. In this way we can easily approach to minimum energy load in whole path, hence satisfying energy efficient using clustering based load balancing technique. The energy saving is a challenging issue in the wireless sensor networks. We introduced an Extended Energy Efficient Clustering algorithm which calculates the average distance between the sensor nodes and takes into account the residual energy for selecting the appropriate cluster head nodes. The lifetime of wireless sensor networks is extended by using the uniform cluster location and balancing the network load among the clusters. It considers the energy of the node as well as the distance of the node, it helps to produce best cluster. Proposed algorithm tries to change the cluster head of the nodes if the Cluster Head is running out of the energy which helps to decrease the dropped packets and also gives the improved performance in terms of throughput.

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