**How to Cite**:
Sakthivel, K., Ganesan, R., Devi, G. T., & Sowmya, M. (2022). Modified distributed energy efficient clustering protocol for lifetime maximization in wireless sensor networks. *International Journal of Health Sciences*, *6*(S6), 9481–9490. https://doi.org/10.53730/ijhs.v6nS6.12459

# Modified distributed energy efficient clustering protocol for lifetime maximization in wireless sensor networks

**Karthikeyan Sakthivel**
Department of Electronics and Communication Engineering, School of Electrical and Electronics Engineering, Sastra Deemed to be University, Thanjavur, India

**Rajkumar Ganesan**
Department of Electronics and Communication Engineering, School of Electrical and Electronics Engineering, Sastra Deemed to be University, Thanjavur, India
*Corresponding author email: grkumar@ece.sastra.edu

**Gayathri Devi T.**
Department of Electronics and Communication Engineering, Srinivasa Ramanujan centre, Sastra Deemed to be University, Kumbakonam, India

**Sowmya M.**
Department of Electronics and Communication Engineering, School of Electrical and Electronics Engineering, Sastra Deemed to be University, Thanjavur, India

***Abstract***---A wireless sensor network is a combination of tiny sensing nodes with minimal energy capabilities. The sensors are installed across field to monitor parameters such as noise, temperature etc for long time. WSN has wide range of applications such as military, health care industry etc. It has advantages such as easy deploying, lower cost and fault tolerance. Since the energy capabilities are minimal, we can take some measures to improve network capabilities. To overcome the issue, we need to concentrate on the performance of the routing protocol while designing the architecture. The aim of WSN is to transfer data by increasing the lifetime of the network, throughput, and number of Cluster Heads (CH). We take DEEC protocol in comparison with the proposed design of M-DEEC which helps in minimizing the energy consumption of the nodes in network and maximize the network lifetime. In M-DEEC is a modified energy distribution algorithm which uses energy aware adaptive clustering protocol in heterogeneous WSN. Each node will carry over a remaining energy over the network which can be further used as reference to increase the lifetime. WSN is being used in diabetic retinopathy to check and monitor the eyesight of diabetic patients which helps in

International Journal of Health Sciences ISSN 2550-6978 E-ISSN 2550-696X © 2022.
*Manuscript submitted: 9 May 2022, Manuscript revised: 18 July 2022, Accepted for publication: 27 August 2022*

overcoming the early sight loss. Hence the proposed M- DEEC protocol helps in producing improved results compared to DEEC model. The results generated are stimulated using MATLAB.

***Keywords***---wireless sensor network, network lifetime, throughput, number of clusterheads, residual energy, base station, modified distributed energy efficient clustering.

## Introduction

A wireless sensor network is a group of sensors which are dedicated for monitor and save the conditions of the environment. It has ability to collect data and communicate through many sensor nodes. The data which contains the conditions of the environment are saved in a sensor node, then the data is stored at the base for final processing. Operations of WSN is combined as sensing, computation, and communication, it is achieved by mesh networking protocols, this mechanism will exploit the path used for communication by data hops from one node to another. Device capability are defined to be limited; However, the composition of multiple devices gives us exposure to multiple technologies. The use of WSN has rapidly increased in today's world for various applications like transportation traffic monitoring, surveillance. In

WSN, the nodes present act as a sensor and router due to which its transmission ability is limited. Each cluster has a dedicated cluster head with pre-defined tasks of collecting data from nodes within and to transfer them to destination. This method is used widely to increase the lifetime and scalability. There are various clustering techniques which can be used to reduce the path cost within a network. Clustering protocols needs to be created in a hierarchical method so that path cost is reduced while communicating within the base station. Fig.1 represents the WSN architecture.

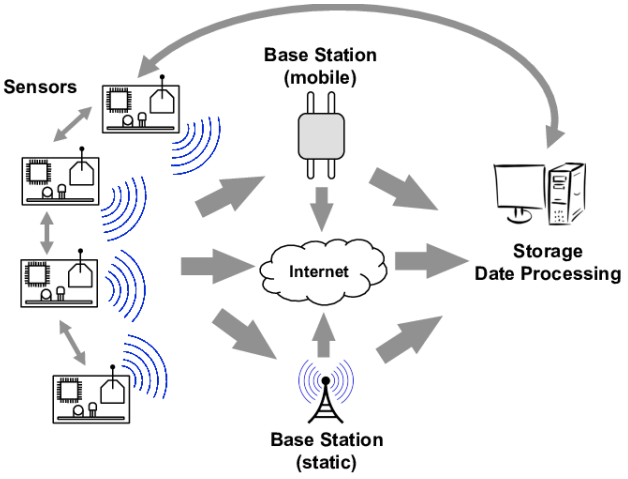


Fig 1. Wireless Sensor Network Architecture

**Related Works**

Energy efficient and an optimal architecture compromising the model is important factor of WSN.A new strategy LEACH-B is used to identify the cluster heads [10] and modify their election frequency. This method of choosing the cluster heads helps in optimal energy usage. Classifying the routing protocols [7] based on their applications wise help in reduced battery usage and they are classified into flat, hierarchical and location based. Energy efficient clustering protocol with improved priority queue [1] is used by increasing the number of data sent to base station when priority queue is used the ratio of packet drop is highly reduced. This can be further processed and improved in future design as well by implying other clustering protocols like SEP and DEEC etc. By further making modifications to DEEC protocol another new variant M-DEEC [3], this is used for three different segregations are used to improve stability and lifetime of the network which in return helps in energy efficiency.

Multi hop routing within each cluster M-LEACH [9] helps in use of using the powerful nodes as the cluster heads this reduces the time taken to from node to node for selecting the cluster head. This improve in less energy use and the modifications can be done as per the requirement. Multilevel HEED protocol [2] is used for large deployment of multilevel models where WSN can be used. Various dimensions can be defined in each level and various protocols can be applied to each model which provides us extension of energy efficient model Novel energy efficient clustering protocol [4] technique is used for choosing the cluster heads in an optimal way with an option to adjust sensing range and data aggregation using chaining approach. This is sorted by classifying data's with and without aggregations. This approach helps in avoiding redundant data transmission which improves network lifetime. Reliable energy efficient and structure free data aggregation protocol ESDAD [6] is used to efficient energy use by dividing the sensing regions into multiple subregions and with different reliability requirements.

The use of efficient selection of node helps in improving spatial and convergence for data aggregations. Multilevel heterogeneous network mode [5] is used in WSN where up to seven level of heterogeneous can be achieved where multiple parameters can be optimized. This can be applied to clustering protocols as distance and distance between base station and sensor, node density and residual energy. Energy efficient clustering Scheme [8] is used with more residue energy through local radio communications, the transmission of energy used between nodes and cluster heads and from cluster heads to base station is traded off and increases the requirement of global knowledge of distances between cluster heads and base station. A hierarchical cluster method is used for the need of asymmetric communication and energy saving in sensor networks. The energy saved in between can be used for selecting the cluster head selection. This method of scaling coordination in sensor networks optimize the efficient use of energy.

## Materials and Methods

### Wireless Sensor Network

WSN has the ability to collect data from various nodes for monitoring and saving the physical conditions of the environment. These data must be sent and received between the nodes in the network. In this network, it consists of large number of sensors for collecting data from various environments Figure 1. Since the sensors are operated on battery power, it is challenging to design energy efficient routing protocols. In general, WSN has two types of nodes a sensor node and a sink node, both these nodes have limited power resources. These nodes also have properties of collecting data automatically and sharing them between each other. To increase the lifetime of WSN, there are some considerations for improvements on how power of nodes is consumed, how the routing protocols are managed and energy can be minimized.

### Parameters Considered for WSN

- **Stability of WSN**: Stability is total time duration interval; maximum duration refers to the network stability
- **Throughput** is the average of the network bandwidth where it is calculated by taking the packet size and the packet start and end time
- **Packets delivered to Base Station (BS):** It is defined as the number of cluster head packets which are sent to station base
- **Packets delivered to Cluster Heads (CH):** It is defined as the number of sensor node packets which are sent to cluster heads
- **Data Aggregation:** It is an addition of data from a multiple source points, which is used to save energy and data transfer
- **Residual Energy:** The energy absorbed by the network is determined by the residual energy and it deals with the leftover energy of the sensor node per round in the network. The lifespan of WSN depends on the residual energy.

### WSN Challenges

While designing an architecture for an WSN, we face various constraints and challenges are listed below.

- **Routing**: While implementing WSN for a big environment, challenge would be to design adaptive routing schemes to transmit information from one sensor to another. This may occur due to limited energy and poor sensors.
- **Algorithms:** To overcome limited energy availability each node needs to be fed with simple and efficient algorithm so that minimal energy is consumed. Commonly an architecture is carried over with a centralized algorithm, so it is challenging problem to design suitable algorithms for various environments.
- **Topology Control:** With the increasing number of sensors, it is challenging to provide efficient network connectivity with dynamic topologies
- **Security**: WSN is widely used across in commercial and military purposes, in such cases it is important to safeguard the privacy and safety of millions

of users. There is always possibility of attacks from internal or external, due to which the nodes may collect false information and transmit them which creates unnecessary confusions leading to incorrect decisions

**Applications of WSN**

WSN are used in various applications and is mentioned in Fig. 2.

- **Health Monitoring Applications:** WSN helps in supporting patient monitoring, administering drugs and tracking doctors and patients inside hospital**.**
- **Environmental Sensing:** WSN is widely deployedto help science research by monitoring and sensing Volcanoes, oceans and forests. This also extends to monitoring pollution, disasters etc.
- **Industry and Structural Sensing:** In industries WSN is deployed as Condition based maintenance and helps majorly in cost savings as wired systems would incur major expense in installation. While implementing major structures like bridges and flyover monitoring these progresses in person would incur huge cost, WSN helps in practicing remote monitoring.
- **Greenhouse Monitoring:** Temperature, leakage of any harmful substance, weather and soil can be monitored with the help of WSN by preprogramming microcontrollers with reference preset value and it is presented through a interface which is easy to access.
- **Defense Application:** Since military services and applications are entitled to be work on large area and it include multiple officials and person on field, any normal alert or emergency would need to be highlighted to officials in surveillanceso that required actions can be taken on time. WSN can be used to capture these data's by effectively deploying nodes across the field.
- **Home Application**: In home applications nodes inside each device would interact with each other and internet so that devices can be operated remotely.

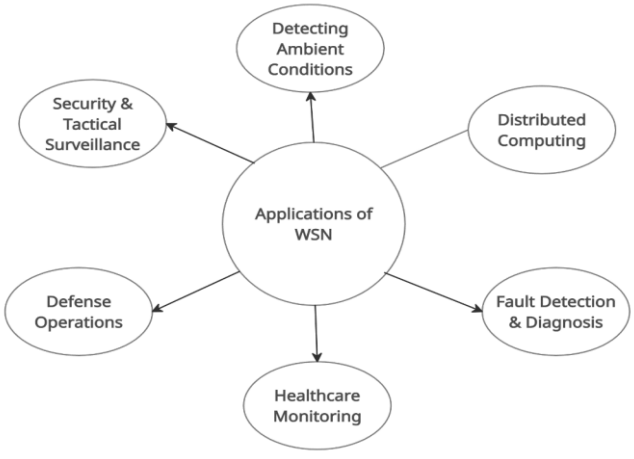


Fig 2. Applications of WSN

**Proposed Work**

The assumptions for the WSN in our model are as follows: Post deployment, all the Base Station (BS) and sensor nodes are stationary. They can be identified with a unique ID reference. In terms of capability all the nodes are defined in same way, however during heterogeneity their energy varies. In this setup there is no issues with memory, compute and energy. Since the BS is deployed at the center of the network where power supply is constant. Data aggregation is possible, hence multiple nodes can be added andcombined as a packet. Power transmission can be controlled and monitored by the nodes. All the nodes are capable of sending data during transfer. Metadata of the nodes are copied and stored on their cluster array. Consumption of energy from node 1 to 2 and vice versa is always same since the radio links are symmetric. The initial energy transmitted across network is sameand this can be setup as a predefined condition to evaluate if the network is capable of handling the energy until the end Fig. 3. For each round the Advanced Node (AN) that is the node with more energy and costlier in a cluster is chosen as the Cluster Head (CH) and the Normal Node (NN) that is the node with less energy and cheaper is chosen as its cluster members.

Thevalue of nodes that are alive and dead are executed and available at the end of each round. Same node cannot be assigned as CH for multiple times. The data from nodes are sent to CH as a single hop, this being added into packets are further sent to BS on a single hop. As the simulation progress, the AN gets weak and starts dying slowly. The value of dead and active nodes, data sent across to BS and energy consumed are represented across various figures. Thework using Modified Distributed Energy Efficient Clustering(M-DEEC) involves deployment of 100 nodes. Creation of the topography. Deployment of sink node. Cluster head election is based on the residual energy in M-DEEC. Estimation of average energy of network. MATLAB code written for the network stability, network lifetime, network throughput and number of cluster heads.

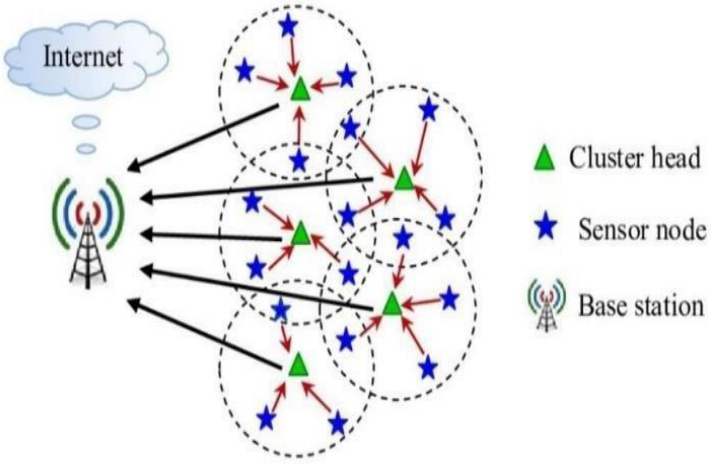


Fig 3. WSN Model

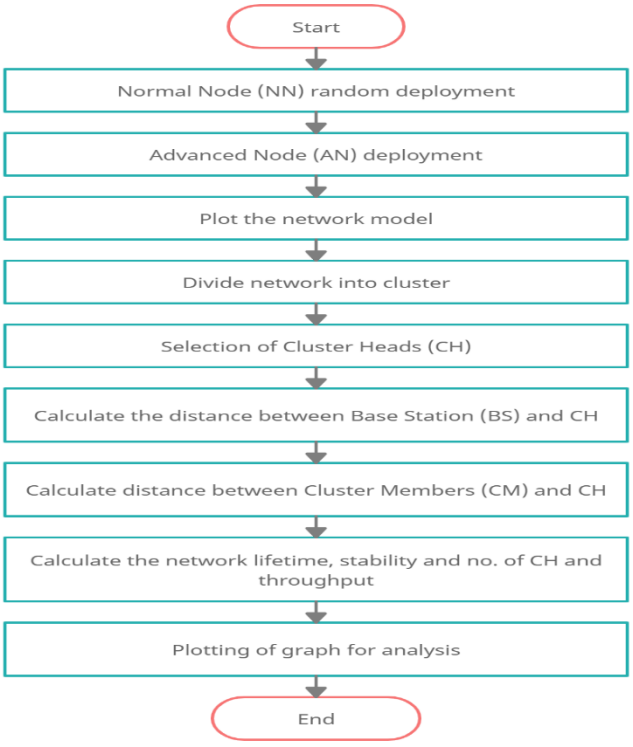


Fig 4. Flowchart of proposed methodology

Table 1
Network metrics required of proposed WSN model

| Parameter | Value |
|---|---|
| Network Size | 100*100 |
| Initial Nodes | 100 |
| Maximum Number of Rounds | 8000 |
| Packet Size | 4000 bits/500 bytes |
| Sink Location | $0.5*x_m$; $0.5*y_m$ |
| Optimal Probability | 0.1 |
| Initial Energy | 0.5 Joules |
| Cluster Head Election Energy | 5 nJ/bit |
| Transmission Energy | 36.1 nJ/bit |
| Receive Energy | 16.7 nJ/bit |

**Simulation and Results**

**Network Stability**

In the Fig 5 we can see that in the existing design the number of dead nodes start to increase from 1274 rounds and reach maximum value at 3145 rounds. However, in proposed we could see dead nodes starts increasing only from 2164

rounds and reach max value at 4628th round. We can clearly see the achievement is 38.35% in the new M-DEEC.

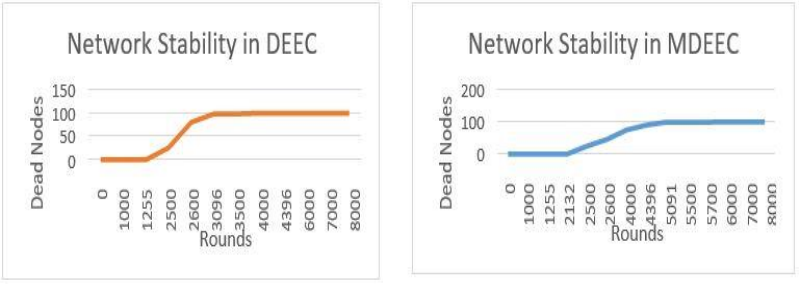


Fig 5. Network Stability DEEC vs M-DEEC

**Network Lifetime**

In Fig. 6 the number of alive nodes starts decreasing at 1275 rounds and the dead nodes are generated from 3174 round. However, in proposed method the alive nodes start decreasing at 2165 and dead nodes are generated after 4632 nodes. Network lifetime is highly increased by 65.51 % in M-DEEC

**Network Throughput**

In Fig. 7 the number of packets in a network starts increasing and reach a stable value at 3071 rounds. However, in the proposed design we can see that maximum value is attained at 4661 rounds. Hence, we see an improvement of 39.80% between DEEC and M-DEEC.

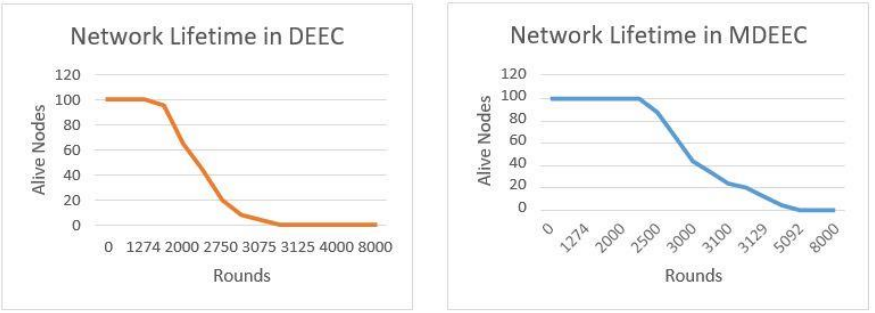


Fig 6. Network Lifetime DEEC vs M-DEEC


Fig 7. Network Throughput DEEC vs M-DEEC

**Number of Cluster Heads**

In Fig 8 the number of CH in DEEC reach maximum value at 1090 round, however in M- DEEC it is achieved in 1650 and the CH becomes minimum at 5416, providing an increase of 39.79%.

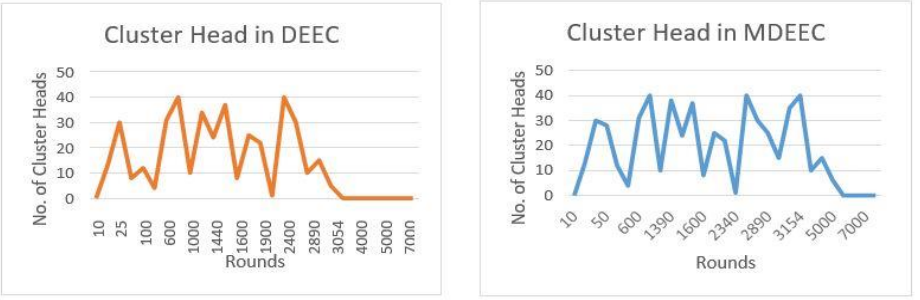


Fig 8. Number of Cluster Heads DEEC vs M-DEEC

The performance comparison between DEEC and M-DEEC is represented in Table 2.

Table 2
Comparison Between DEEC and M-DEEC based on the Simulation Results

| Performance Metrics | DEEC | M-DEEC | Enhancement (%) |
|---|---|---|---|
| Network Stability (more dead nodes at) | 3096 | 5091 | 64.43 |
| Network Lifetime (alive nodes starts decreasing at) | 1274 | 2102 | 64.99 |
| Network Throughput (packet received becomes stable from) | 3080 | 4511 | 46.46 |
| Number of Cluster Heads (becomes zero at) | 3154 | 5185 | 64.39 |

**Future Work**

In this proposed work multiple parameters like stability, lifetime, throughput ofthe network and count of cluster heads is optimized. The results are generated and stimulated using MATLAB, these are compared with existing DEEC protocol. Results convey the optimized QoS values from M-DEEC protocol are much better and suited compared to normalized Qos parameters in WSN. The Quality-of-Service parameters need to be further optimized for better performance of heterogeneous Wireless Sensor Network (WSN) is left as future work.

**References**


1. A. Depedri, A. Zanella, R. Verdone, **"**An energy efficient protocol for wireless sensor networks", Autonomous Intelligent Networks and Systems (AINS 2003), June 30–July 1, 2003.
2. A.El Aalaoui and A.Hajraoui **,** **"**Analysis of energy efficiency for the extended WSN using a multilevel HEED protocol", International Journal of Advanced Research in Science, Engineering and Technology ,vol. 6, no.3,pp.8541-8551,2019.
3. Aisyah, S. (2015). Computer networking company in business area. International Research Journal of Management, IT and Social Sciences, 2(7), 1-4. Retrieved from https://sloap.org/journals/index.php/irjmis/article/view/311
4. Amee Vishwakarma and Prof. Papiya Dutta, "Improved &Modified DEEC protocol for Energy Efficient Clustering in WSN's", International journal of trend in scientific research anddevelopment, vol.1, no.6, pp.206-216,2017.
5. Komalpreet Kaur and Er. Shivani Sharma**,** **"**Enhanced Distributed Energy Efficient Clustering Protocol", International Conference on Computer Communication and Informatics(ICCCI -2020), Jan 22 – 24, 2020.
6. M. Ye, C. Li, G. Chen, J. Wu**,** "EECS: an energy efficient cluster scheme in wireless sensor networks", Performance, Computing and Communications Conference, April 7-9,2005.
7. Padmanabhan and Kamala Kannan, P, **"**A study on energy efficient routing protocols in wireless sensor networks", European Journal of Scientific Research, vol.60, no.4, pp.499- 511,2011 .
8. Prabhudutta Mohanty and Manas Ranjan Kabat, "Energy efficient structure-free data aggregation and delivery in WSN", Egyptian Informatics Journal, vol. 17,no.3, pp.273-284 ,2016.
9. S. Singh, S. Chand and B. Kumar, **"**Multilevel Heterogeneous Network Model for Wireless Sensor Networks", Telecommunication Systems Modelling, Analysis, Design and Management,vol.64, no.2, pp.259-277,2016.
10. S. Singh, S. Chand and R. Kumar**,** **"**NEECP: novel energy efficient clustering protocol for prolonging lifetime of WSNs", IET Wireless Sensor Systems, vol.6, no.5, pp.151-157,2016.
11. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2021). Health and treatment of diabetes mellitus. *International Journal of Health Sciences*, *5*(1), i-v. https://doi.org/10.53730/ijhs.v5n1.2864
12. V. Mhatre, C. Rosenberg**,** **"**Design guidelines for wireless sensor networks: communication, clustering and aggregation", Ad Hoc Networks,vol.2,no.1,pp.45-63 ,2004.
13. Widana, I. K., Sumetri, N. W., & Sutapa, I. K. (2018). Effect of improvement on work attitudes and work environment on decreasing occupational pain. International Journal of Life Sciences, 2(3), 86–97. https://doi.org/10.29332/ijls.v2n3.209