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# Energy Efficient Routing Protocol for Wireless Sensor Network - LEACH

Kanika Bindal<sup>1\*</sup> and Shalley Raina<sup>1</sup>

<sup>1</sup>Department of Electronics and Communication, Swami Parmanand College Lalru, Punjab Technical University, India.

### Authors' contributions

This work was carried out in collaboration between both authors. Author KB did the statistical analysis and simulated the structures in MATLAB, comparison between various network's efficiency methods have been calculated. Author SR reviewed the paper related to the analysis done. Both authors read and approved the final manuscript.

### Article Information

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## ABSTRACT

**Aim:** Wireless Sensor Network is spatially distributed autonomous sensor to monitor physical and environmental conditions. Energy is the scarcest resource of WSN nodes, and it determines the lifetime of WSNs. For this reason, algorithms and protocols need to address the issues such as increased lifespan, fault tolerance and energy efficiency. For energy efficiency we have various routing protocol.

One of them is HEEMCP Protocol which has been discussed in the below paper along with other protocols.

**Study Design:** MATLAB is being used for simulating the networks.

**Place and Duration of Study:** Swami Parmanand College Lalru, between Jan 2017 to June 2017.

**Methodology:** It included following steps:-

- Survey of the literature related to the proposed work.
- Implementation /simulation of cluster using MATLAB.

\*Corresponding author: E-mail: Kanika.bindal91@gmail.com;

- Implementation/simulation of LEACH, Hetero-LEACH, SEP and EEHC protocols using MATLAB.
- Implementation/simulation of the HEEMCP using MATLAB.
- Comparison of LEACH and HEEMCP.

**Results:** "Table 1: Comparison between Various Energy Efficiency Protocol" discussed below clearly states that HEEMCP is 5 times more energy efficient as compared to other protocols discussed such as EEHC,SEP,LEACH

**Conclusion:** HEEMCP Protocol is more energy efficient as compared to other protocols discussed.

*Keywords: Stable Election Protocol (SEP); Energy Efficient Hierarchical Clustering (EEHC); Heterogeneous Energy Efficient Mobile Clustering Protocol (HEEMCP).*

## 1. INTRODUCTION

Wireless Sensor Network needs various energy efficient protocols, which is of great importance. The major limiting factor for sensors is fading. They hinder a lot to the performance of sensor.

For a network to sustain for a longer time it shall have energy efficiency.

To reduce the energy consumption of a network few protocols have been developed one of them is LEACH. The main advantage of LEACH over other protocols is the dynamicity of LEACH protocol.

LEACH protocol has various energy efficient routing algorithm. In below paper we have tried to simulate the results for this protocol using MATLAB and tried to compare the energy efficiency.

A Wireless Sensor Network is built of nodes where each node is connected to one sensor.

Each sensor has a transreciever with internal antenna. A sensor node's size may vary. WSN collects the information and forwards it to the base station.

As they are deployed very densely so there is a need to design some protocol to achieve fault tolerance which will in turn minimizes the energy consumption. Channel bandwidth which is shared by all sensor networks is also a limiting factor. Nodes join together to complete a common task. As capability of each sensor network is limited, so there shall be some aggregate power which is being provided to the entire network.

LEACH is one such protocol whose main goal is to increase energy efficiency of the network. LEACH stands for Low-Energy adaptive clustering hierarchy. WSN is considered as clustering method which is dynamic in nature.

When battery dies node in the network will not be useful. This protocol helps us to estimate the lifespan of the node, which allows it to do minimum job required to transmit data. The LEACH Network comprises of nodes, of which few are cluster heads. Cluster Head collects the data from nearby nodes and passes to base station.

## 2. EXPERIMENTAL DETAILS

Research has been done regarding this energy efficiency in network and "Heinzelman et al. [1]" presented LEACH protocol for WSN energy efficiency.

LEACH forms clusters based on the signal strength received and use cluster heads as the routers to the base station. Transmission of data to base station consumes more energy, so cluster heads are rotated so that energy. Since data transmission to base station consumes more energy, so rotation of cluster head is done to balance the energy consumption of all the nodes. The conclusion of using in such a manner came by the analysis from threshold equation. Heinzelman et al. [1] also proposed LEACH-C.

**LEACH-C:-** Homogenous sensor network configuration is being used by all of them. LEACH is being used as a reference for homogenous network, and a network with two types of nodes is used as a reference for heterogeneous network.

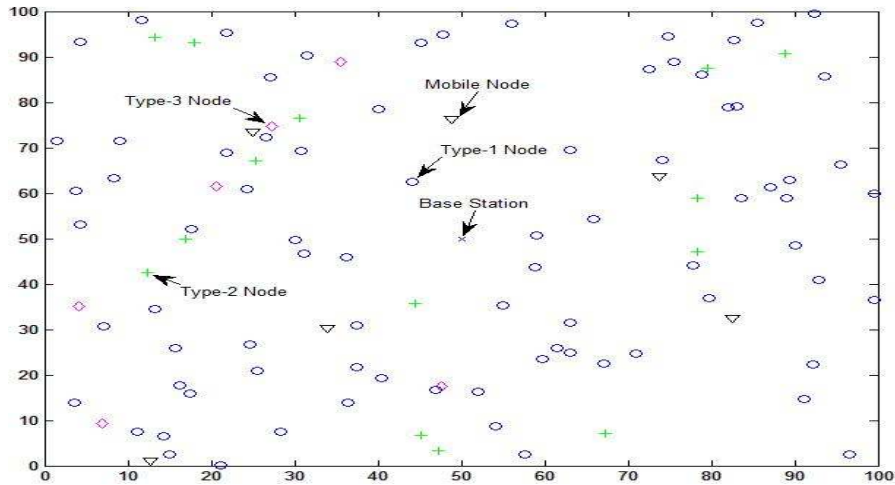
**SEP:-** SEP protocol was proposed by Smaragdakis et al. [2] for heterogeneous network. They are made up of two types of node having different energy at initial points and nodes. This technique helps for increasing the stability period.

**EEHC:-** EEHC is a heterogeneous clustering scheme for wireless sensor network based on weighted election probabilities of each node to

become a cluster head as per the residual energy in node.

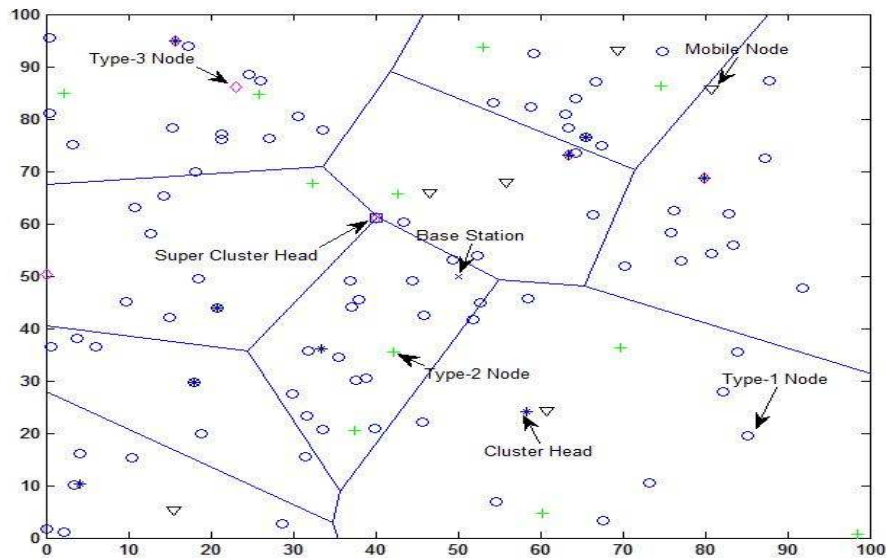
**HEEMCP:-** HEEMCP is also a heterogeneous clustering scheme which focuses on formation of clusters and increase the scalability and lifetime of the network.

DEEC a distributed clustering scheme for heterogeneous WSN network was proposed by Smaragdakis et al. [2]. Cluster heads are calculated using probability based on the ratio of residual energy of each node and total energy of network.



(a)

**Fig. 1 (a).** Illustrates the different type of nodes like Mobile Node, Base Stations, Type-1 Node, Type-2 Node, Type-3 Node



(b)

**Fig. 1(b).** Illustrates the formation of different types of cluster formation with different type of nodes

**Fig. 1. (a) Test network model (b) Formation of cluster**

Along with the mobile nodes, sensor nodes have also been deployed which is of great use as they have capability to self deploy, repair the network and track the event. This paper proposes the architecture of mobile sensor network and simulation results show how hierarchical mobile sensor networks can effectively reduce the energy consumption of sensor nodes.

Mhatre et al. [3] made comparative study on homogenous and heterogeneous network for single hop communication. For homogenous networks LEACH was used as the representative and for heterogeneous networks, a network with two types of nodes was used. A method to estimate the optimal distribution among different type of sensor nodes was proposed. The case of multi-hop routing was also studied within each cluster. For multi-hop homogeneous network, a multi-hop variant of LEACH called M-LEACH was proposed and analyzed. Results show that M-LEACH had better energy efficiency than LEACH in many cases. A comparison based on cost was also done between multi-hop homogenous network M-LEACH and multi-hop sensor network with two types of nodes.

Manik Gupta et al. [4] presented a framework which will help in fault revoking and distributing sensor nodes randomly, which helps clusters to consume equal energy.

M. O. Farooq et al. [5] presented a Multi-hop routing protocol, which consists of partitioning the network in different layers of cluster head, which collaborates with the nearby layers and saves the energy.

T. Qiang et al. [6] presented Multi-hop routing protocol as well in order to minimize the total energy consumed by the wireless sensor network. The algorithm which was proposed optimizes the distribution of Cluster Heads.

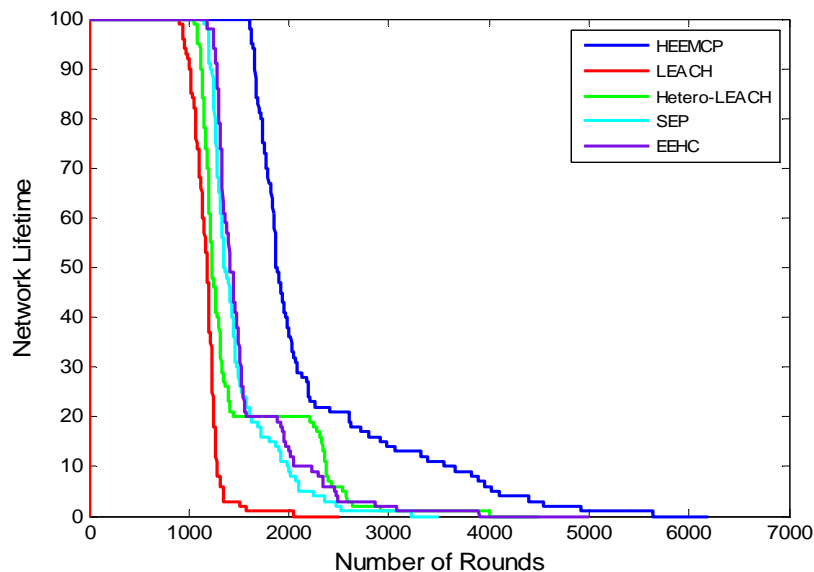
### 3. RESULTS AND DISCUSSION

Comparison is shown between HEEMCP with LEACH. Fig. 2 shows the comparison result for network lifetime of HEEMCP with LEACH, Hetero-LEACH, SEP and EEHC protocol.

**Simulation models used:-** Channel Propagation Model, Radio Energy Model.

**Simulation parameter:-** Crossover distance for free space and two-ray ground attenuation model, Radio Electronics Energy, Energy for Beam Forming, Radio Amplifier Energy, Antenna Gain Factor, Antenna height above the ground, Bit Rate.

It shows the comparison between various protocols based on the network lifetime, and Fig. 2 clearly states that LEACH protocol has higher lifetime as compared to other protocols.



**Fig. 2. Network lifetime comparison of HEEMCP with LEACH, Hetero-LEACH, SEP and EEHC**

In LEACH we have used heterogeneous sensor network as compared to homogenous sensor network, which will increase the total energy efficiency of the network.

Mobile Nodes have also been used as backup nodes for cluster head which again increase the total energy efficiency of network.

So the total network lifetime of HEEMCP is compared with other protocols in terms of the ratio of percentage increase in network lifetime to the percentage increase in total network energy.

Let the Ratio be:-

$$R = \frac{\text{Improvement in Network Lifetime}}{\text{Increase in Total network Energy}}$$

There is 26% increase in the energy efficiency for HEEMCP than EEHC protocol.

Network Lifetime is improved by 44.64%

Total Energy of network for HEEMCP is 20% increase in comparison between SEP and HEEMCP. So network lifetime is improved by 75%.

$$R = \frac{75}{20} = 3.75$$

This proves that there is 3.75 times increase in total energy for HEEMCP.

Now when we compare between HEEMCP and Heterogeneous LEACH, network energy is increased by 20% and lifetime by 46.6%.

$$R = \frac{46.6}{20} = 2.03$$

So there is 2.03 times increase in network efficiency for HEEMCP and Heterogeneous LEACH.

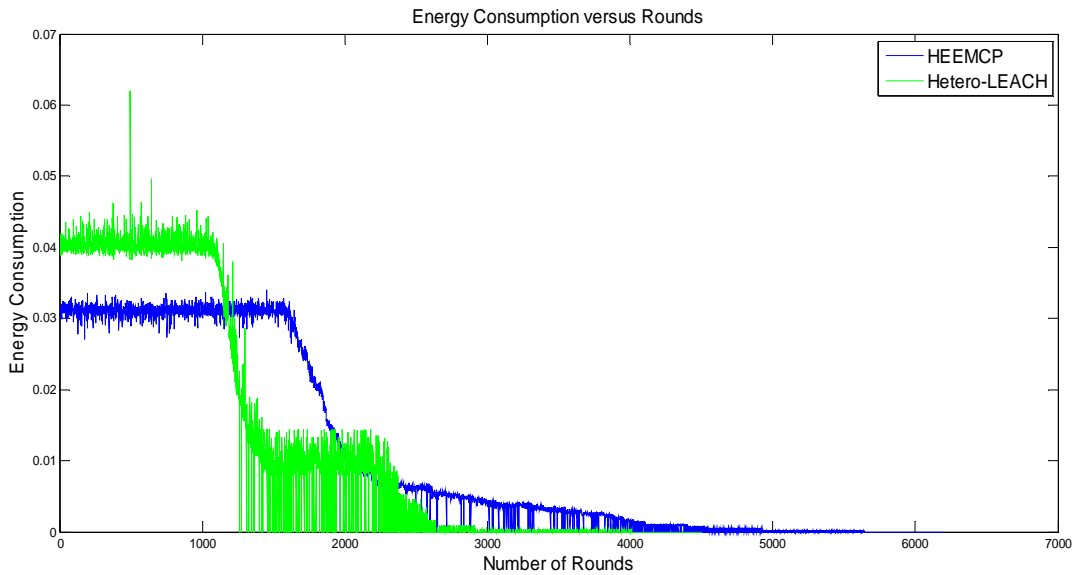
Due to large unstable there is less improvement in case of Heterogeneous LEACH.

While we compare LEACH and HEEMCP, there is significant increase in total network energy. The reason behind it is that LEACH uses homogenous network setting and HEEMCP uses heterogeneous network setting. There is 35% increase in total network energy which gives overall improvement of 176% in network lifetime.

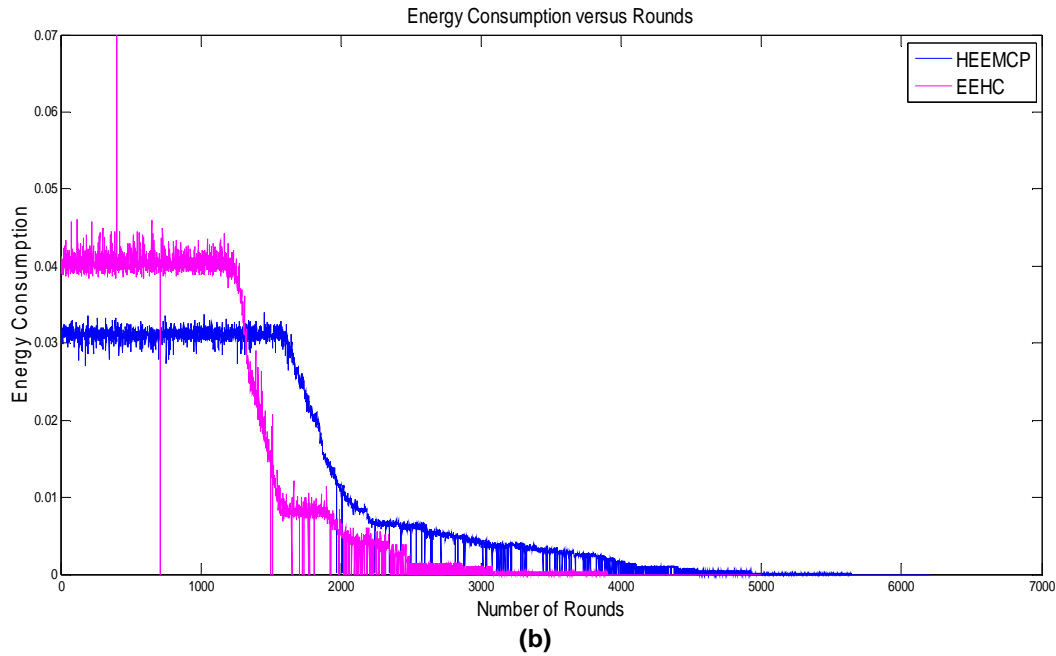
$$R = \frac{176}{35} = 5.02$$

This proves that there is 5 times improvement in network lifetime as compared to the total energy.

Fig. 3 shows the comparison of energy consumption in prospect with number of rounds for HEEMPCP with Hetro-Leach and HEEMCP with EEHC protocol which proves that HEEMCP has better energy consumption.



(a)



**Fig. 3. Comparison of energy consumption per round of HEEMCP with (a) Hetero-LEACH and (b) EEHC protocol**

Below table gives us the overview of various protocol’s energy efficiency where.

Ratio is defined as Improvement in Network Lifetime /Increase in Total network Energy.

**Table 1. Comparison between various energy efficiency protocols**

Protocols	Ratio
HEEMCP in comparison with EEHC	1.71
HEEMCP in comparison with SEP	3.75
Heterogeneous LEACH in comparison with HEEMCP	2.03
HEEMCP in comparison with LEACH	5.02

Above result proves that HEEMCP has 5 times more network lifetime as compared to total energy between LEACH and HEEMCP.

**4. CONCLUSION**

So various protocols have been discussed in this paper related how to improve the performance of battery for sensor nodes.

All the factors discussed above make network reliable and stable. These include energy and sensing.

These protocols are used in many application of wireless sensor network.

As per Table 1, it proves that HEEMCP is more energy efficient than other protocols discussed above.

**5. FUTURE SCOPE**

The following areas briefly outlined in this section are open research issues that could be explored further for future work:

- Following HEEMCP, sensor nodes can be made solar energy dependent. This will further improve the network lifetime.
- Replacement of dead node with mobile node can be done on the basis of geographical routing, that is, nearest mobile node near the dead node, replaces the dead node.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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