International Journal of Advanced Research in Engineering and Applied Sciences

ISSN: 2278-6252
Impact Factor: 4.817

ENERGY PREDICTION BASED HETEROGENEOUS MOBILE CLUSTERING PROTOCOL FOR WIRELESS SENSOR NETWORKS

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Abstract: *Wireless sensor networks (WSNs) facilitate new applications and require non-conventional paradigms for protocol design due to several constraints. One of the limitations of wireless sensor nodes is their inherent limited energy source. In Wireless Sensor Networks (WSNs) hundred or more sensor nodes are present for sensing purpose. These sensor nodes have limited battery life and their recharging is difficult. Thus, to stretch out the lifetime of wireless sensor networks many optimization techniques had been introduced. Clustering is an admired proposal for enhancing the lifespan of the network. Low Energy Adaptive Clustering Hierarchy (LEACH) was the first hierarchical based clustering algorithm in which cluster heads are determined using probabilistic approach in a distributed manner. After that protocol many other protocols had been introduced which utilize selecting the cluster heads and rotating them to balance the energy usage, but none of these protocol consider predicted residual energy, the energy of a sensor node which is left behind after selecting as a cluster head and run a complete round. Thus, in this work fuzzy based prediction has been utilized for appropriate clustering and heterogeneity will be added to the network so as to prolong the lifetime of the network. A further enhancement in network lifetime will be done by introducing mobile sensors into the network. The main responsibility of these mobile sensors is to replace any dead node in the network so that stable region will increased. The simulation results of proposed protocol shows a significant improvement in terms of FND (First Node Dead), HND (Half Node Dead) compared to LEACH, Energy Efficient Hierarchical Clustering (EEHC) and LEACH–Expected Residual Energy (LEACH-ERE).*

Keywords: *WSN; Energy Efficient WSN ; Clustering; Heterogeneity; Fuzzy Logic; Energy Predication*

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I. INTRODUCTION

Wireless Sensor Networks (WSNs) had gained worldwide attention in latest years, particularly with the proliferation in Micro Electro Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors. These sensors are small in size, with limited computing and processing resources, and they are economical as compared to traditional sensors. These sensor nodes can sense, evaluate, and collect information from the environment and based on some local evaluation process, they can transmit the sensed data to the user [1] and [2]. Wireless sensor network are one of the category that belongs to ad-hoc networks. Here actually the node has a specific name that is “Sensor” because these nodes are equipped with smart sensors [3]. A sensor node is a device that converts a sensed characteristic like vibrations, temperature & pressure into a form recognize by the users. The Wireless sensor networks nodes are less mobile than ad-hoc networks. So, the mobility in case of ad-hoc is more. In wireless sensor network data are requested depending upon certain A sensor consists of a transducer, small memory unit, an embedded processor and a wireless transceiver and all these devices run on the power supplied by an attached battery [3]. Figure 1 shows an example of wireless sensor network in which many sensor nodes are deployed in a random manner and their sensed data is transmitted to the user that is far away from sensing location. The well-known IEEE 802.11 family of standards was introduced in 1997 and is the most common wireless networking technology for mobile communication systems. It uses the different frequency bands, for example, 2.4-GHz band is used by IEEE 802.11b & IEEE 802.11g, while the IEEE 802.11a protocol uses 5-GHz frequency band. IEEE 802.11 was frequently used in early wireless sensor networks and can still be found in current networks when bandwidth demands are high (e.g., for multimedia sensors).

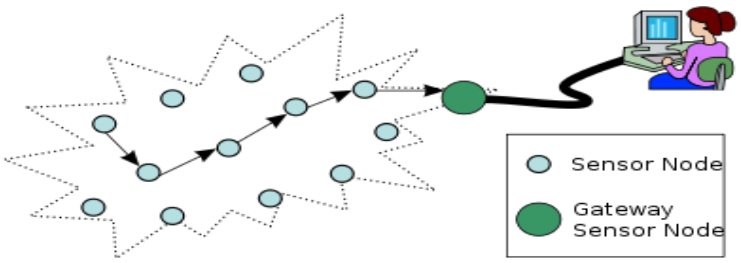

Figure 1: Wireless Sensor Network

However, the high-energy overhead of IEEE 802.11 based networks makes this standard unsuitable for low-power sensor networks. The data rate requirements in sensor networks

are comparable to the bandwidths provided by dial-up modems, therefore the data rate provided by IEEE 802.11 are typically much higher than needed. This has resulted to the development of a variety of protocols that better satisfy the networks' needs for low power consumption and low data rates. For example, the protocol IEEE 802.15.4, has been designed specifically for short range communications in low-power sensor networks and is supported by most academic and commercial sensor nodes. When the transmission range of the radios of all sensor nodes are large enough and the sensors can transmit their data directly to the base station, they can form a star topology .In this topology, each sensor node communicates directly with the base station using a single hop. However, sensor networks often cover large geographic areas and radio transmission power should be kept at a minimum in order to conserve energy consequently multi-hop communication is the more common case for sensor networks. In this mesh topology, sensor nodes must not only capture and disseminate their own data, but also serve as relays for other sensor nodes, that is, they must collaborate to propagate sensor data towards the base station. This routing problem, that is, the task of finding a multi-hop path from a sensor node to the base station, which is one of the most important challenges and has received immense attention from the research community [4].

The proposed algorithm investigates the below mentioned issues related to energy efficiency of WSN.

- Sustaining the energy of wireless sensor nodes in wireless sensor networks using fuzzy logic based clustering that consider predicted residual energy.
- Introducing heterogeneous sensor nodes in the network to protracting the lifetime of sensor network.
- Utilizing MSNs (Mobile Sensor Nodes) to further extend the lifetime of sensor network by immediately replacing a dead node with a mobile node.

The algorithm focuses on adaptive energy conservation and optimization in the wireless sensors networks. The main aim of this research is to develop a Predictive Energy Efficient Heterogeneous Mobile Sensor Node Clustering Protocol (PEEHMCP) for wireless sensor networks. Objectives of this research paper include:

- As the problem is based on energy efficient protocol LEACH which is developed by Heinzelman et al. in [5], therefore, this protocol will be simulated in MATLAB followed by SEP [6] and LEACH-ERE [7] protocols.
- Then PEEHMCP, the proposed protocol will be simulated in MATLAB.
- Existing energy efficient protocols such as LEACH, SEP and LEACH-ERE will be compared with proposed protocol to show the results of improvement.

II. RELATED WORK

Heinzelman et al. [5] LEACH is a well-known cluster-head election approach that constitutes a basis for many other approaches as stated in literature. It is the first significant protocol that aims to minimize the overall energy used in data gathering operations in wireless sensor networks. **Lee et al.** [7] proposed a framework for energy prediction in wireless sensor networks based on fuzzy logic. This proposed protocol is named as LEACH-ERE (LEACH Expected Residual Energy) Energy Prediction methodology in clustering using fuzzy logic with input fuzzy descriptors as residual energy and expected residual energy. Other than this protocol, the energy of a sensor node after selecting as a CH and run a full round has never been discussed. So this approach outperforms LEACH and CHEF (Cluster Head Election using Fuzzy Logic) [8]. LEACH-ERE is more efficient than LEACH about 42.61%. **Gupta et al.** [9] first time introduced fuzzy logic in the field of wireless sensor networks. It is based on LEACH protocol. As in LEACH cluster heads are elected using a fixed threshold value but in this proposed approach fuzzy logic used for CH selection process to eliminate the problems face by pure probabilistic approaches like poor clustering. In this scheme fuzzy logic control is implemented using three fuzzy descriptors such as energy, concentration and centrality for improving clustering process. **Smaragdakis et al.** [6] proposed an energy-aware protocol for heterogeneous wireless sensor networks. SEP or Stable Election Protocol is used for electing cluster heads in two-level hierarchical wireless sensor networks. This protocol is based on weighted election probabilities of each node to become cluster head according to the residual energy in each node. SEP improved the stable region of the clustering hierarchy process using the fraction of advanced nodes. Since advanced nodes had more energy than the normal nodes, so advanced nodes were become cluster heads more frequently than the normal nodes.

III. PROPOSED APPROACH

This research is based upon [7], it introduces and developed the LEACH-ERE algorithm in order to optimize the energy of wireless sensor networks using fuzzy logic based energy prediction analysis. This research developed a new contributed algorithm that saves energy in percent better than LEACH-ERE, with some other benefits. In this research an improved protocol had designed and implemented for WSNs that optimize energy dissipation and lengthened lifetime.

The main contributions of the proposed research are:

- Increases the energy saving and lifetime than existing energy efficient protocols.
- Provide a better cluster head selection scheme based on energy prediction mechanism using fuzzy logic.
- Increases stability period of the network which results in good throughput

The proposed protocol is a distributed clustering algorithm in which all sensor nodes decide whether to be a CH or not independently using fuzzy logic. In LEACH all sensor nodes are eligible for CH selection process those have energy greater than zero, but in proposed protocol predicted residual energy is considered which indicate whether a node after performing as a CH can run a round successfully or not. This will improve the stable region of the sensor network in which the entire nodes are alive.

IV. EXPERIMENTAL RESULTS

In this work, total of 100 sensor nodes with the dimensions of network as 100m x 100m and the location of base station considered at (50, 50) which is center of sensing region is considered

The proposed protocol is an energy efficient clustering protocol based on fuzzy logic for the heterogeneous WSNs including mobile sensor nodes. In this protocol fuzzy logic based energy prediction is proposed for the enhancing the lifetime of wireless sensor networks. Two input parameters are used in this protocol as residual energy and predicted residual energy. The test network for proposed protocol is as shown in Figure 2.

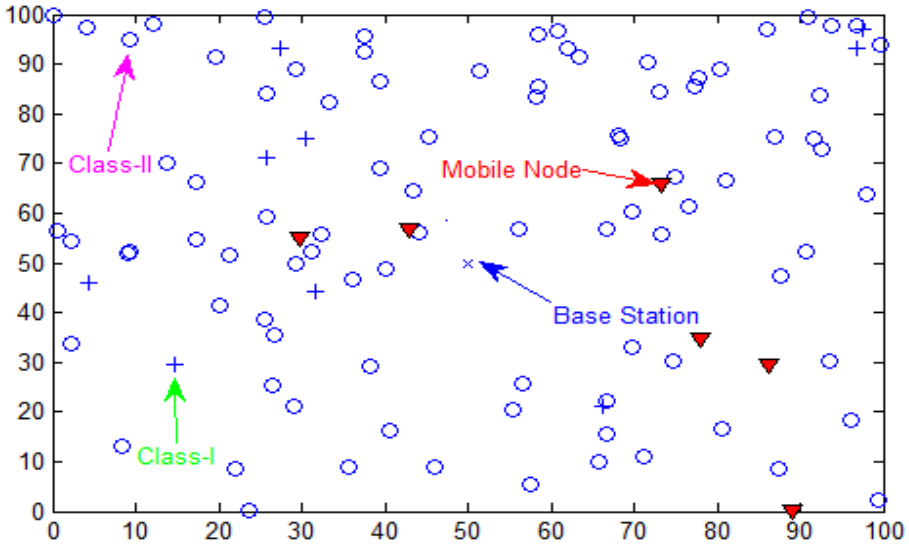

Figure 2: Test Network for PEEHMCP

In PEEHMCP mobile sensor nodes are introduced to replace immediately whenever any sensor nodes gets deplete its energy as shown in Figure 3. The purpose of these MSNs in wireless sensor network is to use as a back-up for the prolongation of the lifetime of the network. The heterogeneity parameters in proposed system are A=0.1 and x=1.

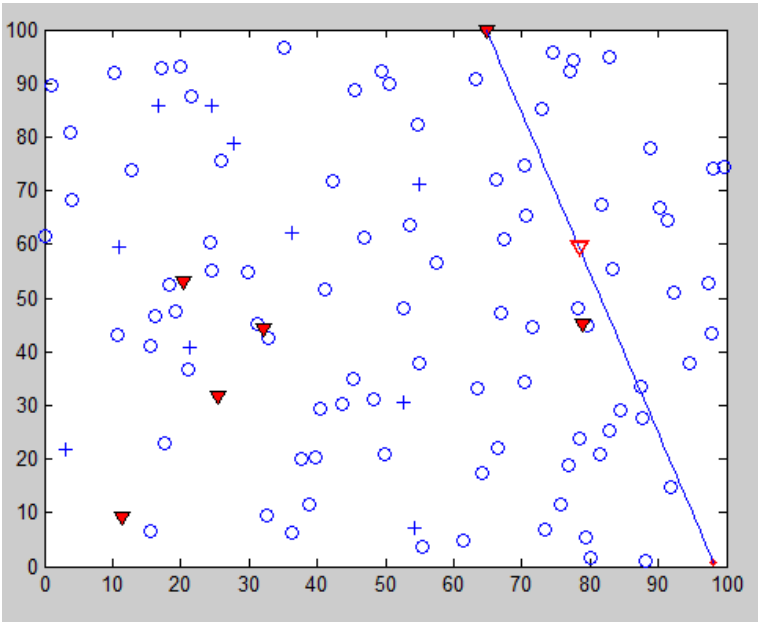

Figure 3: Mobile node moves to replace a dead node

Performance Analysis of PEEHMCP

Figure 4 shows the number of alive nodes with respect to number of rounds. In proposed protocol the FND occur at round 790, HND occur at 900 and total network lifetime is more

than 5000 rounds. The performance of LEACH-ERE clearly indicate a significant improvement over LEACH.

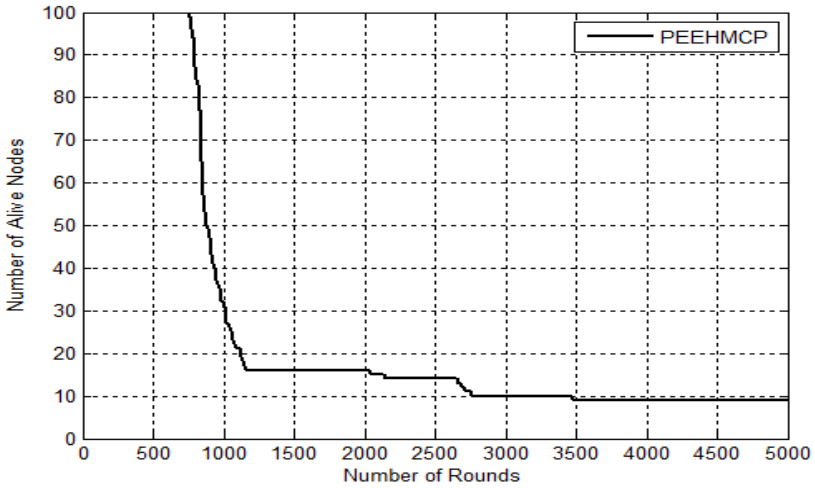

Figure 4: PEEHMCP Performance Curve

V. CONCLUSION & FUTURE SCOPE

The PEEHMCP improved the stability period or FND (First Node Dead) period by a factor of 151% compared to LEACH that is more than double performance provided by LEACH. This improvement is credited to the fact that proposed protocol used two input parameters such as Residual Energy (RE) and Predicted Residual Energy (PRE) using fuzzy logic in cluster formation compared to LEACH [10] that uses only one. Relying on one parameter is not suitable to produce good clustering. It has further been analyzed that the performance of proposed protocol with LEACH, SEP and LEACH-ERE in terms of FND and HND performance matrices. Simulation results in MATLAB shown that there is an improvement in FND of proposed protocol by 151% LEACH, 104% SEP and 14.49% LEACH-ERE. In terms of HND the improvement achieved by proposed protocol is 89.47% LEACH, 76.12% SEP and 12.5% LEACH-ERE. Improved results for total network lifetime are also obtained. In future, some extensions of the PEEHMCP approach can be applied. The following areas are briefly outlined in this section are open research issues that could be explored for future work.

- 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.
- Finding the optimized value of mobile sensor nodes for a network, mathematically.

ACKNOWLEDGEMENT

I would like to give my sincere gratitude to our guide Er. Vivek Pant who encouraged and guided me throughout this paper. I am especially grateful to Er. Manpreet Singh for his valuable guidance and encouragement.

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