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MOBILE SENSOR NODES BASED ENERGY EFFICIENT LEACH PROTOCOL FOR WSN SYSTEMS (MEE-LEACH)

Vikram Singh Rathore[1], Suman[2]
[1]M.Tech Scholar, [2]Associate Professor, ECE Department SSIET Derabassi, Punjab, India

Abstract: In today's scenario automation abruptly changes our lifestyle. Fundamentally, automation is the result of sensors that plays a great role in deciding the behavior of the system. Wireless sensor networks are one kind of system used for collecting various parameters from its vicinity. Wireless sensor networks consists many sensor nodes which consist a CPU (Central Processing Unit), Memory Unit, Transceiver unit and Power Unit. The major challenge while designing any sensor network is the optimized use of power unit as this results in the enhancement of lifetime of the network. Many Clustering based routing algorithms have already been developed for optimizing usage of energy of sensor node. In clustering based algorithms the major issue is the selection of the cluster head that is responsible for data transmission towards the base station. In this paper, we will discuss a Mobile sensor nodes based Energy Efficient Low Energy Adaptive Clustering Hierarchy Protocol (MEE-LEACH) which is based on clustering mechanism. In this protocol, Cluster Heads (CHs) are elected in such a manner that results in prolongation of stability period and network lifetime. Clustering has been performed on the current energy level of the sensor node which means a threshold has been set for each node to be a CH. In addition to this, some Mobile Sensor Nodes (MSNs) are also deployed in the network which will replace that node which become dead immediately. The results for the proposed protocol had compared with LEACH, O-LEACH in terms of Network Lifetime and Energy Consumption.
Keywords: cluster head, clustering protocols, mobile sensor nodes, wireless sensor network

I. INTRODUCTION

Since the inception of wireless sensor nodes there is an exponential growth in the field of wireless sensors networks. As that kind of networks are very useful in monitoring various parameters from its vicinity. Fundamentally, sensor nodes are the result of recent advancement in MEMS (Micro Electro Mechanical Systems) that allow these small sized components to become reality [1]. The key applications of WSNs (Wireless Sensor Networks) are environment monitoring, battlefield surveillance, Body Sensor Networks, Traffic monitoring etc [2]. At architectural level, sensor node consist a CPU for performing computation on information such as aggregation, Memory Unit for storing routing protocol information, Transceiver unit for transmitting and receiving data and Power Unit for running all hardware units. The major challenge faced by WSNs is the depletion of energy of sensor node because once energy of sensor node depleted its functioning become stop. In most of the cases these nodes run using non-rechargeable batteries sources thus, there is a great need to utilize the energy resources available with sensor node in an optimized manner [3]. For achieving this goal, clustering is the best solution in which not all the sensor nodes communicate with Base Station (BS) which may be a large distance from sensing area where WSNs is deployed. In clustering, only a Cluster Head (CH) is responsible for transmitting sensed information to BS. For that, each time cluster head selection is the major issue. First time, Low Energy Adaptive Clustering Hierarchy (LEACH) introduced the concept of clustering protocol for information transmission as most of the energy is used by transceiver unit. In LEACH protocol complete network will divided into clusters provided with one cluster head (CH) that will communicate with BS and remaining sensor nodes act as cluster members which transmit information to their respective CHs [3]. LEACH protocol utilize probabilistic approach for CHs selection. In order to extend the lifetime of wireless sensor networks we use two approaches – use of (MSNs) Mobile Sensor Nodes for replacing dead nodes immediately and Cluster Heads are elected on the basis of their residual energy. Remaining paper is structured as follows. Section II includes the key researches associated to core of this article. Section III briefly introduced the mathematical analysis of proposed protocol. Section IV demonstrates the simulation of MEE-LEACH using MATLAB and compares the results with LEACH and O-LEACH in terms of Network Lifetime and Energy Consumption of the network. Finally, Section V concludes this paper.

II. RELATED WORK

In this section, most of the research articles that match with the core objectives of this paper are discussed. Fundamentally LEACH [4] was the first probabilistic hierarchical clustering protocol used for cluster head selection which results in the elongation of network lifetime as compared to single and multi-hop based communication models. LEACH elects CHs from a randomly distributed sensor nodes using a pre-calculated threshold and then rotate this progression to balance the energy consumption. The complete operation of LEACH consists two phases – first is SET-UP Phase and second is STEADY-STATE Phase. In setup segment cluster heads are chosen and in steady state segment information spreading takes place. The threshold value for CHs selection is given by (1)

$$T(n) = \begin{cases} \dfrac{p}{1 - p * (r * \mathrm{mod}(1/p))} & \text{if } n \in A \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where „p‟ is preferred percentage of CHs, „r‟ is present round and „A‟ is the group of sensor nodes that have not been cluster head in last 1/p rounds. After 1/p rounds all nodes become qualified to become cluster heads. After CHs selection each CHs transmit an advertisement and after receiving these advertisements, rest of the sensor nodes decide their relevant cluster head based on the acknowledged signal strength. Then, CHs form a Time Division Multiplexed Access (TDMA) frame for the preparation of every sensor node‟s broadcasting time. LEACH is a distributed approach which results in poor clustering. Further, the WSNs deployment is random which results in some CHs have more number of cluster members than others. Due to this, CHs far from BS and CHs having more number of cluster members exhaust their energy rapidly as compared to other CHs.

LEACH-C [5], is up gradation of LEACH as this approach is centralized instead of distributed like in LEACH. For the implementation of this protocol the sensor node must facilitates with Global Position System (GPS) because in LEACH-C only Base Station (BS) has rights to elect CHs by using some relevant information regarding sensor node like its position and energy level. Each sensor node transmits its existing position and energy stage to the base station through set up phase. Based upon the position and energy stage of nodes, CHs will be elected and remains are same as in LEACH.

S. el. Khedri et.al [6] describes a new approach for energy efficient clustering protocol named as O-LEACH. In this protocol cluster heads are elected on the basis of energy level of the sensor node. The threshold set in this work for the eligibility of a sensor node to be CH is 10% of initial energy level rest is same as LEACH protocol.

N. Mittal et.al [7] developed an improved version of LEACH using the concept of sub-cluster head. In this concept, during a round a CH has selected including a sub-CH which act as a CH when a CH become dead.

Pooja et.al [8] introduced improved version of O-LEACH. As compared to O-LEACH in this work instead of utilizing only residual energy level one more parameter has been considered for cluster head selection i.e distance of sensor node from base station which results in further enhancement in network lifetime as compared to standard protocol O-LEACH.

III. MATHMATICAL MODEL OF MEE-LEACH

A. Radio Energy Dissipation Model

First-order Radio Model used in LEACH [4] is used for the analysis of energy consumption in following modes of signal propagation – free space and multipath fading channel which is shown in Fig. 1. Free space and multipath fading nature of radio channel is based on crossover distance „d0‟ between transmitter and receiver given by (2).

$$do = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \qquad (2)$$

Where is amplification in free space and åmp is amplification in multipath scenario. Energy dissipation in first order energy model for transmission is given by (3) which based on the value of „d0‟.

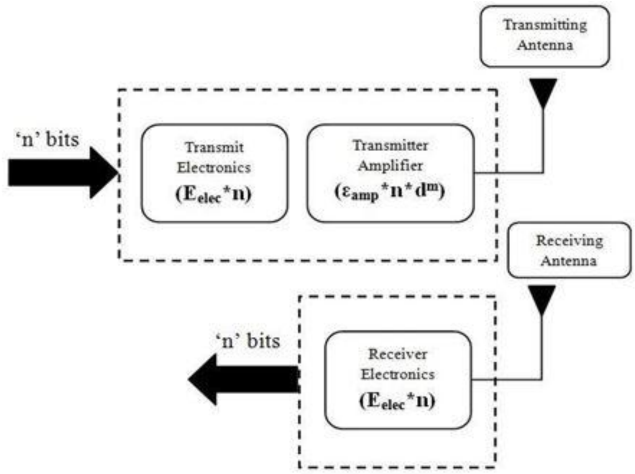

Fig. 1. Radio model

$$E_{Tx}(n,d) = \begin{cases} n*E_{elec} + n*\varepsilon_{fs}*d^2, & d < do \\ n*E_{elec} + n*\varepsilon_{mp}*d^4, & d \geq do \end{cases} \qquad (3)$$

where, „E_{elec}‟ is the transmitter and receiver hardware energy expenditure per bit, „$å_{amp}$‟ is the energy consumption for amplification in free space „$å_{fs}$‟ and multipath „$å_{mp}$‟, „n‟ is message length in bits and „d‟ is the distance among transmitter and receiver. Energy consumption in reception given by (4)

$$E_{Rx}(n) = n * E_{elec} \qquad (4)$$

B. Mobile Sensor Nodes

Mobile Sensor Nodes (MSNs) may be considered as robots in WSNs network which can move in the vicinity of the network. The main objective to use MSNs in this work is to enhance network lifetime and utilizing the concept of replacing a sensor node with a mobile node if sensor node get dead. This can be done by event dependent triggering for MSNs. For replacement coordinates of sensor nodes are important which can be easily find out in any two dimensional network and also the distance between mobile sensor node and normal sensor node can be easily calculated using distance formula given by (5)

$$Dist_{MSN} = \sqrt{(x_m - x_{msn}(i))^2 + (y_m - y_{msn}(i))^2} \qquad (5)$$

where the „x_m‟ and „y_m‟ are the co-ordinates of dead sensor node and „$x_{msn}(i)$‟ and „$y_{msn}(i)$‟ are the co-ordinates of randomly disseminated mobile sensor nodes. The movable node having minimum value of distance „$Dist_{MSN}$‟ replaces the dead node when node failures happen.

C. Energy based Calculations for CHs Selection

As mentioned earlier, in this proposed protocol CHs are elected based on a fixed threshold and this calculation is purely based on residual energy of the sensor node. Only those sensor nodes can participate in clustering process those are having remaining energy greater than the 10% of initialized energy level. Also, it is also considered if none of the sensor node having energy greater than the 10% of initialized energy level then all nodes become eligible for clustering process. This complete scenario is clearly shown in Fig. 2 which is flow chart for the implementation of proposed protocol.

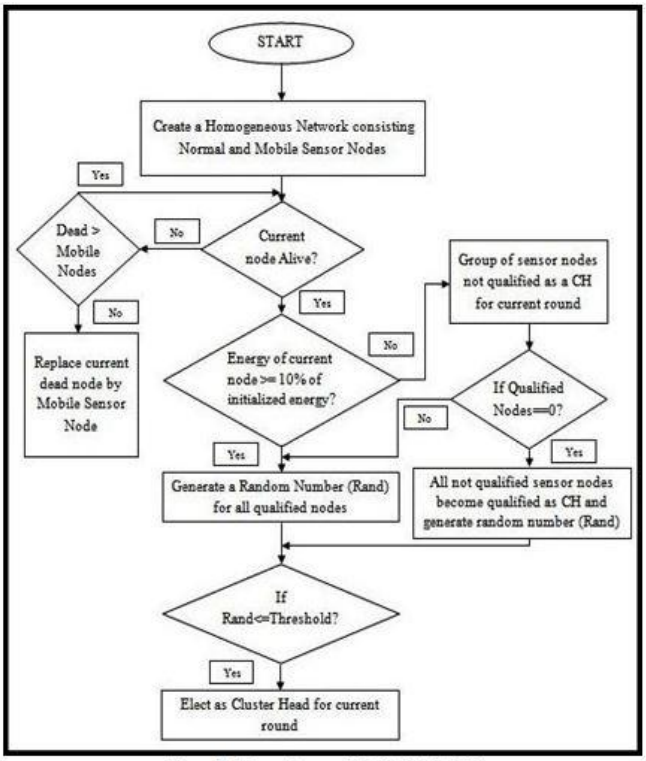

Fig. 2. Flow chart of MEE-LEACH

IV. SIMULATION RESULTS

In this section, simulation results and comparative analysis of MEE-LEACH with LEACH and O-LEACH has been demonstrated.

A. Simulation Environment

To demonstrate the performance of MEE-LEACH and its comparison with LEACH and O-LEACH the simulation is conducted using MATLAB version R2013a (8.1.0.604). The considered simulation parameters listed in Table I.

TABLE I: SIMULATION PARAMETERS

Description	Value
Simulation Area	120m x 120m
Total nodes in the network, n	120
Base station position	(50, 50)
Initial energy of normal nodes, E_0	0.5J
Initial energy of MSNs	0.5 J
Energy consumed by transmitter or receiver circuit, E_{elec}	50 nJ/bit
Amplification circuit energy in free space, $å_{fs}$	10 pJ/bit/m^2
Amplification circuit energy in multipath, $å_{mp}$	0.0013 pJ/bit/m^4

The created network for simulation and cluster formation is shown in Fig. 3 and Fig. 4 respectively.

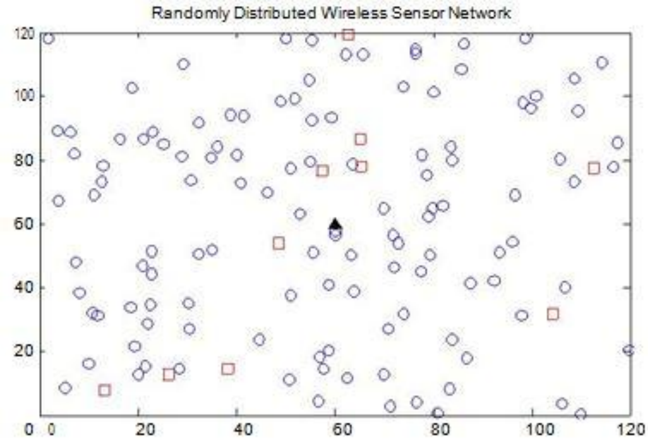

Fig. 3. Assumed network for simulation

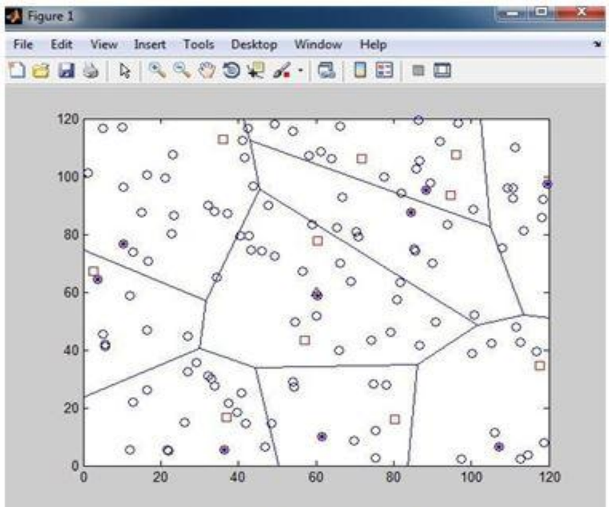

Fig. 4. Cluster formation

B. Result Analysis

The simulation results of LEACH, O-LEACH and MEE-LEACH are compared on the basis of Stability period, Network Lifetime and Average Energy Consumption of the network. The simulation of LEACH is shown in Fig. 5 for Network Lifetime and Fig. 6 for Average Energy Consumption of the network.

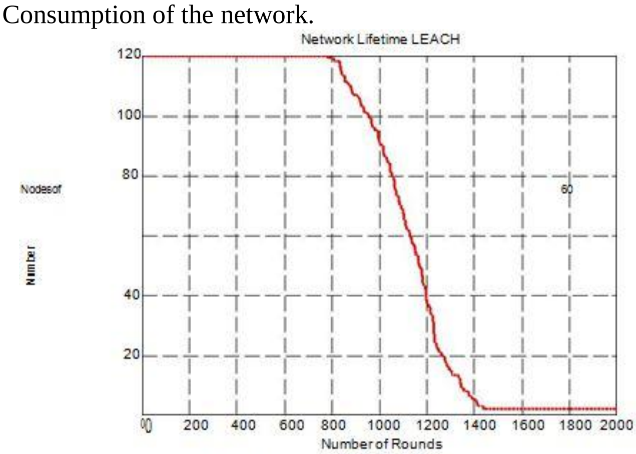

Fig. 5. Network Lifetime LEACH

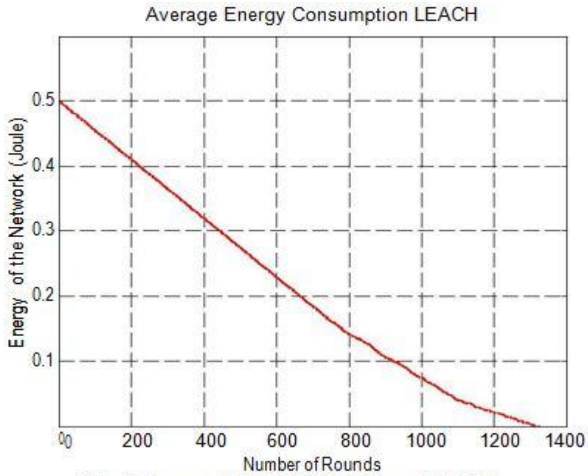

Fig. 6. Average Energy Consumption of LEACH

The results of O-LEACH are shown in Fig. 7 for Network Lifetime and Fig. 8 for Average Energy Consumption of the network.

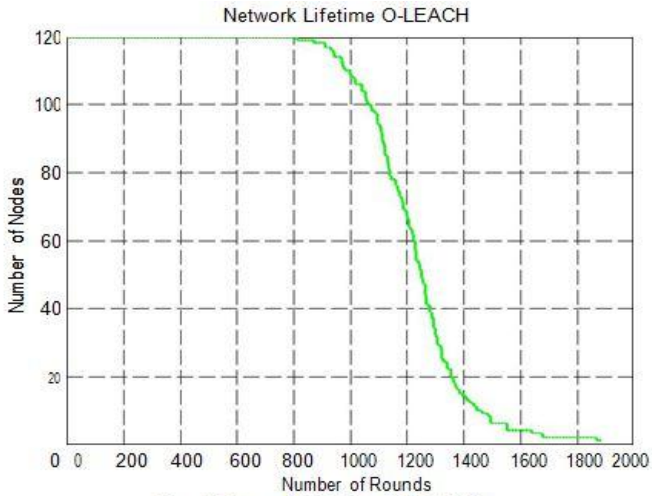

Fig. 7. Network Lifetime O-LEACH

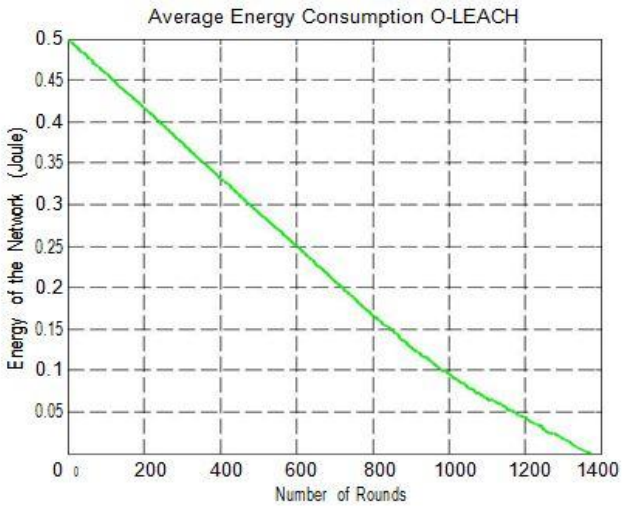

Fig. 8. Average Energy Consumption of O-LEACH

The simulation results of MEE-LEACH are shown in Fig. 9 for Network Lifetime and Fig. 10 for Average Energy Consumption of the network.

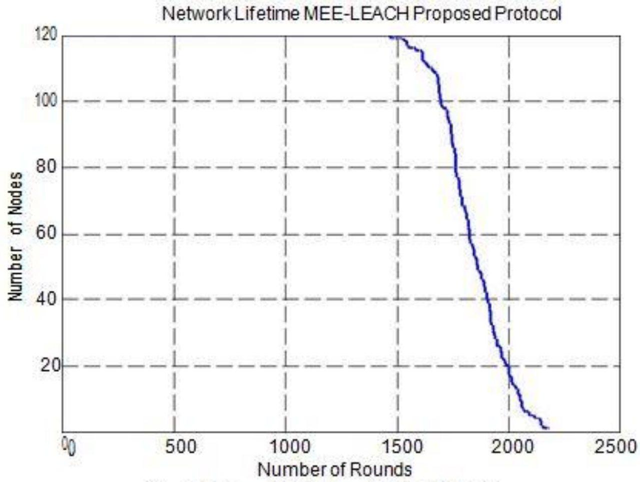

Fig. 9. Network Lifetime MEE-LEACH

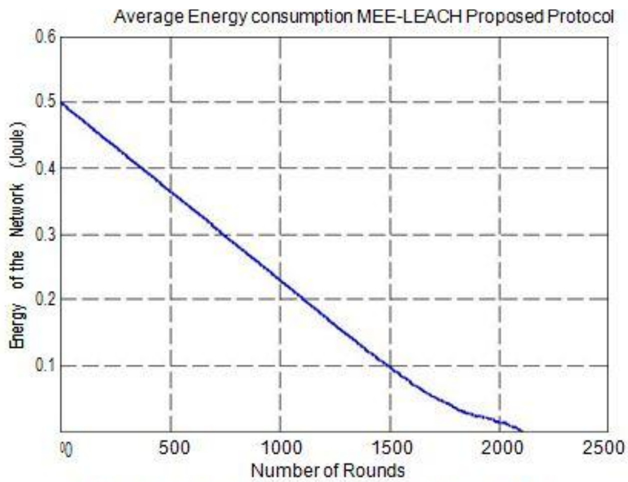

Fig. 10. Average Energy Consumption of MEE-LEACH

The comparative result that shows that proposed MEE-LEACH protocol provide better results is shown in Fig. 11 for Stability period and network lifetime while Fig. 12 for Average Energy Consumption of the network.

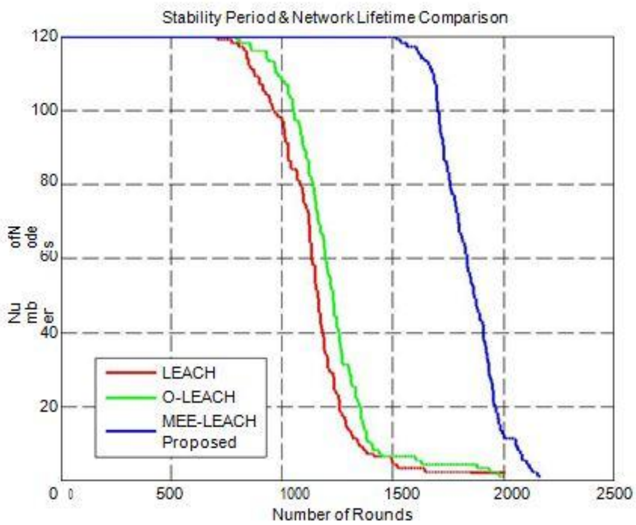

Fig. 11. Stability period and network lifetime comparison

From Fig. 11 it is clearly indicated that proposed protocol‟s stability period i.e round at which first sensor node get dead and network lifetime are improved as compare to LEACH and O-LEACH. The first dead node round for LEACH, O-LEACH and MEE-LEACH are 790, 811 and 1469 respectively.

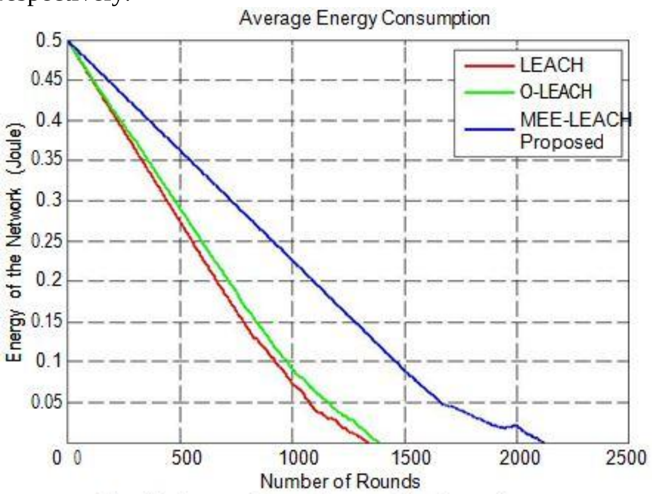

Fig. 12. Average Energy Consumption Comparison

V. CONCLUSION

In this work, Mobile sensor node based Energy Efficient LEACH (MEE-LEACH) had proposed which utilize the concept of clustering based on residual energy of the node and for enhancing lifetime of the network robot like feature inculcated using mobile sensor nodes that replaces dead nodes. This protocol enhance stability period as compare to LEACH by 85.9% and as compare to O-LEACH by 81% which signifies a great improvement factor. This protocol is only tested for homogeneous environment and can be tested for heterogeneous environment with change in network area and location of the base station.

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