A WSN ENERGY EFFICIENT LEACH PROTOCOL BASED ON MOBILE SENSORS

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Abstract:
In today's world, automation drastically alters our way of life. Fundamentally, automation is the result of sensors, which play a significant role in determining system behaviour. Wireless sensor networks are one type of system that collects various parameters from its surroundings. Wireless sensor networks are made up of many sensor nodes, each of which has its own CPU (Central Processing Unit), Memory Unit, Transceiver Unit, and Power Unit. The most difficult challenge in designing any sensor network is maximising the use of power units, which increases the network's lifetime. Many clustering-based routing algorithms have already been developed to optimise sensor node energy usage. The major issue in clustering-based algorithms is the selection of the cluster head who is in charge of data transmission towards the base station.
In this paper, we will discuss a clustering-based Energy Efficient Low Energy Adaptive Clustering Hierarchy Protocol (MEE-LEACH) based on mobile sensor nodes. Cluster Heads (CHs) are elected in this protocol in such a way that the stability period and network lifetime are extended. Clustering has been performed on the sensor node's current energy level, implying that a threshold has been set for each node to be a CH. In addition, some Mobile Sensor Nodes (MSNs) are deployed in the network to replace any nodes that go down unexpectedly.

Keywords: cluster head, clustering protocols, mobile sensor nodes, wireless sensor network

INTRODUCTION

Wireless sensor networks have grown at an exponential rate since the introduction of wireless sensor nodes. As such, such networks are extremely useful for monitoring a variety of parameters in their immediate vicinity. Sensor nodes are fundamentally the result of recent advancements in MEMS (Micro Electro Mechanical Systems) that enable these small-sized components to become a reality [1]. WSNs (Wireless Sensor Networks) have many applications, including environmental monitoring, battlefield surveillance, body sensor networks, traffic monitoring, and so on [2]. At the architectural level, a sensor node consists of a CPU for computing information, such as aggregation, a Memory Unit for storing routing protocol information, a Transceiver Unit for transmitting and receiving data, and a Power Unit for powering all hardware units. The most significant challenge that WSNs face is 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 thispaper.

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)

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

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.

MATHMATICAL MODEL OFMEE-LEACH

A. Radio Energy DissipationModel

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).

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

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".

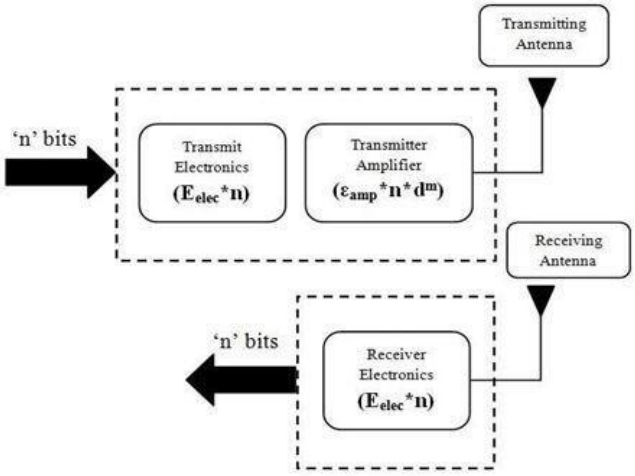

Fig. 1. Radio model

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

where, „Eelec" is the transmitter and receiver hardware energyexpenditureperbit,„åamp"istheenergyconsumption foramplificationinfreespace,„åfs"andmultipath,„åmp"„n" is message length in bits and „d" is the distance among transmitter and receiver. Energy consumption in reception given by(4)

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

B. Mobile SensorNodes

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)

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

wherethe„xm"and„ym"aretheco-ordinatesofdeadsensor node and „xmsn(i)" and „ymsn(i)" are the co-ordinates ofrandomly disseminated mobile sensor nodes. Themovable node having minimum value of distance „DistMSN" replaces the dead node when node failures happen.

C. Energy based Calculations for CHsSelection

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.

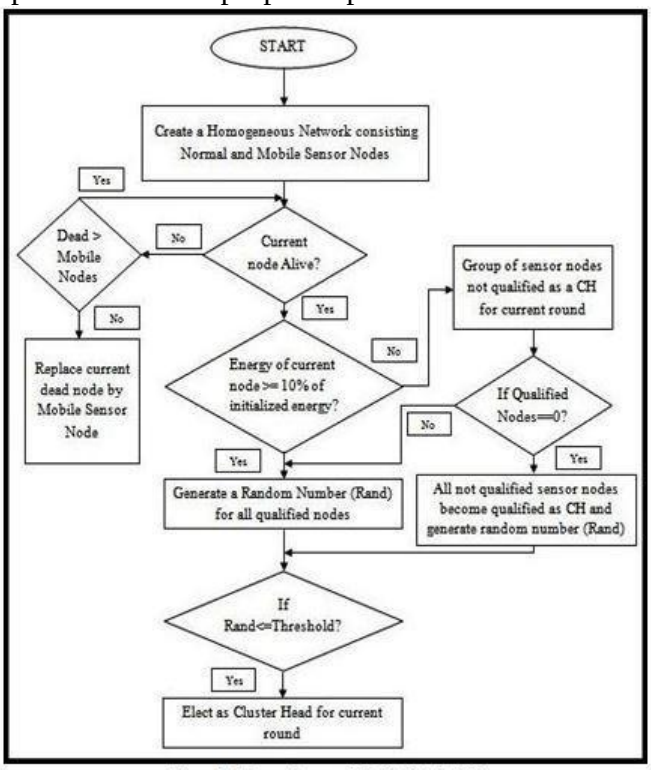

Fig. 2. Flow chart of MEE-LEACH

I. SIMULATIONRESULTS

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

A. SimulationEnvironment

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

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

ResultAnalysis

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.

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

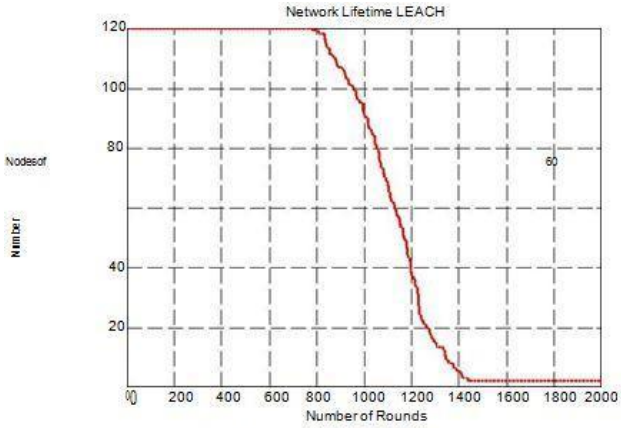

Fig. 5. Network Lifetime LEACH

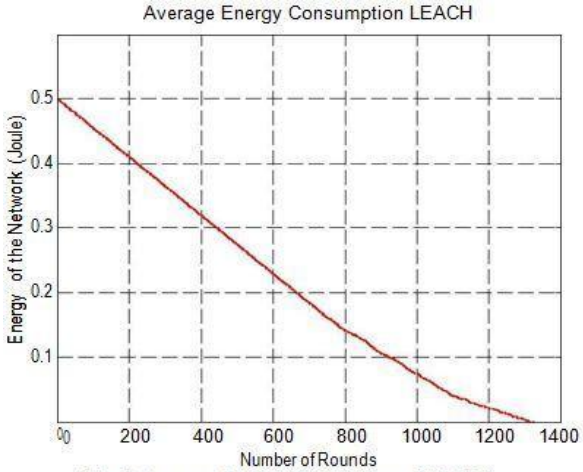

Fig. 6. Average Energy Consumption of LEACH

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

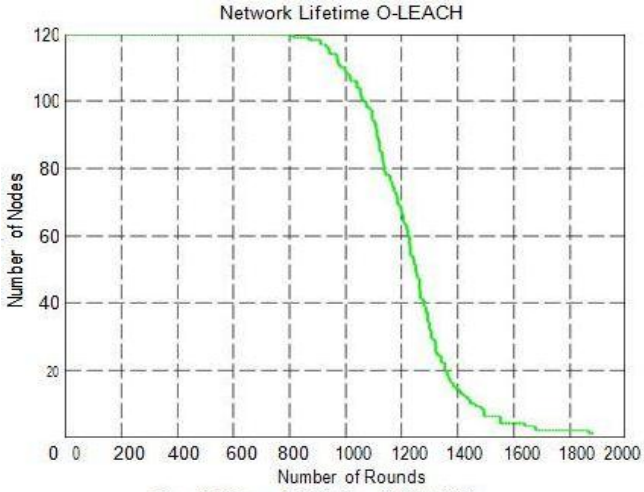

Fig. 7. Network Lifetime O-LEACH

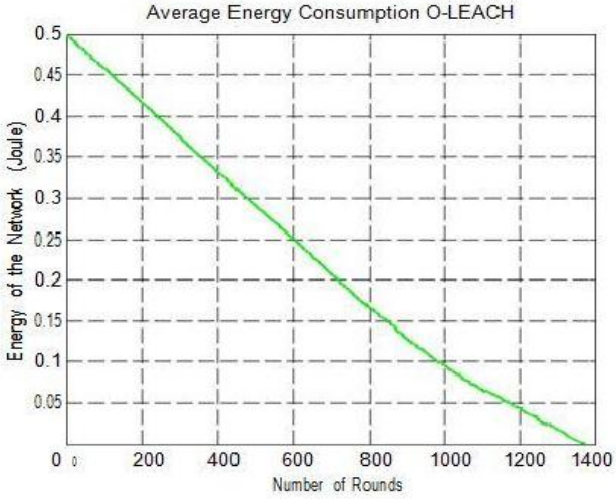

Fig. 8. Average Energy Consumption of O-LEACH

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

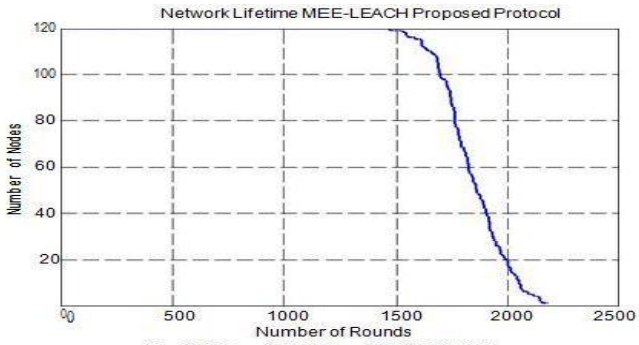

Fig. 9. Network Lifetime MEE-LEACH

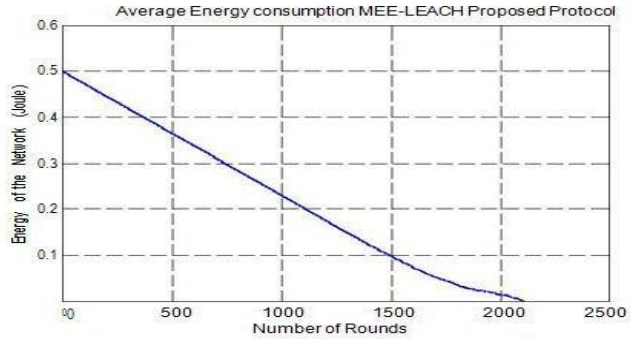

Fig. 10. Average Energy Consumption of MEE-LEACH

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.

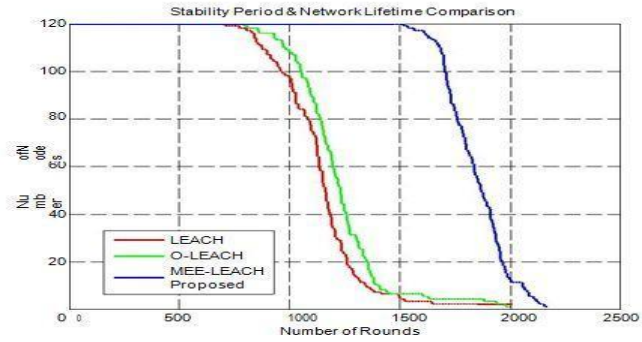

Fig. 11. Stability period and network lifetime comparison

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.

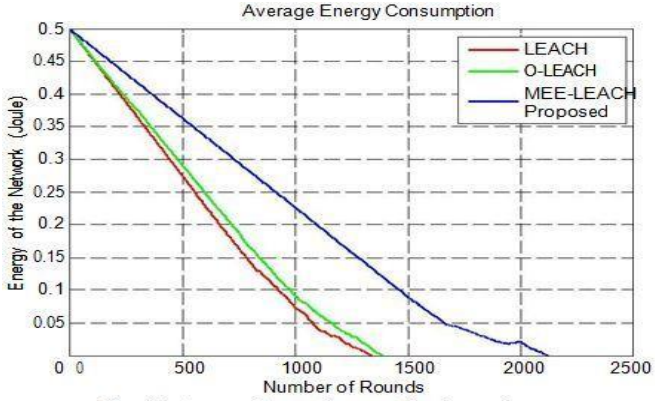

Fig. 12. Average Energy Consumption Comparison

II. CONCLUSION

Mobile sensor node based Energy Efficient LEACH (MEE-LEACH) was proposed in this work, which uses the concept of clustering based on residual energy of the node and for enhancing the lifetime of the network robot like feature instilled using mobile sensor nodes that replace dead nodes. This protocol improves stability period by 85.9 percent when compared to LEACH and by 81 percent when compared to O-LEACH, indicating a significant improvement factor. This protocol has only been tested in a homogeneous environment, but it can be tested in a heterogeneous environment with a change in network area and base station location.

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