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Research Article

Energy Efficiency in Wireless Sensor Network

Neha Rani†* and Prateek Singh†

†Computer Science and Information Technology, SHIATS, Allahabad, India

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Abstract

In recent years, many routing protocols have been proposed to improve the lifetime, energy efficiency, deployment of nodes, latency, fault tolerance, robustness, and reliability of Wireless Sensor Networks (WSN). The energy constraints and prolonging the lifetime of the WSN is very important role of routing protocols. Different cluster based routing protocol have proposed to improve the conventional protocols i.e. direct transmission, multi-hop routing, static clustering and minimum-transmission-energy. Among all cluster based protocols, Low-Energy Adaptive Clustering Hierarchy (LEACH) is the most prominent WSN protocol. In this project, we have tried to expand the LEACH by adding different features in LEACH for homogeneous and heterogeneous environments. We have proposed SEA LEACH (Special energy advanced node) by introducing proficient cluster head selection scheme and different transmitting power levels for LEACH in homogeneous environment. But, energy saving scheme of homogeneous environment is not suitable for heterogeneous environment. Stable Election Protocol (SEP) is the dynamic heterogeneous routing protocol. SEP is based on weighted election probabilities of each node to become the cluster head according to the remaining energy in each node. We propose advanced node LEACH by applying different ways of communication (between CH to sink) for advanced and normal nodes. By showing simulation, we prove that advanced node LEACH is more energy efficient and has longer lifetime of network than LEACH in homogeneous and heterogeneous environments.

Keywords: *heterogeneous system, homogeneous system, distributed system, data aggregation, dynamic cluster head rotation, threshold value concept, SEP, LEACH, SEA.*

Introduction

Energy efficiency is an important issue in system design and operation of WSNs. As Wireless sensor networks (WSNs) are characterized by limited amount of energy supply at sensor nodes. Sensor nodes are generally battery-powered devices; the critical aspects to face concern how to reduce the energy consumption of nodes, so that the network lifetime can be extended to reasonable times. In wireless sensor networks, sensors consume energy both in sensing data and in transmitting the sensed data to a base station. Consequently, the communication in wireless sensor networks lacks the required reliability, and often exhibits long communication delays. Hence some techniques are applied through which the energy associated with each node can be conserved. Energy conservation can be done by controlling the transmission power of each node. So here we study about cluster based routing protocol i.e LEACH which is prominent wireless sensor network protocol. The goal of LEACH is to lower the energy consumption required to create and maintain clusters in order to improve the life time of WSNs. We take into account the setup costs and analyse the energy-efficiency and the useful lifetime of the system. Wireless sensor networks are comprised of small, low-cost, resource-restricted devices that have the capability to communicate and interact with their environment, either only passively by sensing certain parameters, or also actively by triggering actuators. The advancements in wireless communication technologies enabled large scale wireless sensor networks (WSNs) deployment. Due to the feature of ease of deployment of sensor nodes, wireless sensor networks (WSNs) have a vast range of applications such as monitoring of environment and rescue missions.

WSN protocols for Heterogeneous system:

LEACH, which is a WSN protocol for homogeneous systems, is not suitable for heterogeneous systems. Putting few heterogeneous nodes in a Wireless Sensor Network is an effective way to increase the network's stability and lifetime. The energy saving schemes used for homogeneous WSNs does not work efficiently when used for heterogeneous WSNs. Thus, a new energy

*Corresponding author: **Neha Rani** is a M.Tech Scholars and **Prateek Singh** is working as Assistant Professor

efficient clustering protocol should be designed for them. Heterogeneous WSNs are very much useful in real deployments because they are more close to real life situations.

We can divide heterogeneous WSN system mainly in three parts.

1) Computational heterogeneity
2) Link heterogeneity
3) Energy heterogeneity

Computational heterogeneity

In this type of system, some of the nodes have more energy than the other normal nodes. The heterogeneous nodes can provide some benefits such as complex data processing and long term storage with the use powerful computational resources. We are going to use this approach in SEA LEACH Phase 2.

Link heterogeneity

Here, some of the heterogeneous nodes have higher bandwidth and longer distance network transceiver than the normal nodes. It can provide more reliable data transmission.

Energy heterogeneity

This system has some of the heterogeneous nodes that are line powered or their batteries are replaceable.
For our protocol, Computational heterogeneity is the best suitable. Because in SEA LEACH, we are trying to increase the lifetime of the network. By distributing powerful calculations to advance nodes, we can increase the network lifetime. Link heterogeneity is dealing with the quality and reliability of packets whereas; Energy heterogeneity can be implemented in practical situations. We are not considering Link and Energy heterogeneity from the algorithm point of view.

Heterogeneous SEP Protocol

SEA LEACH Phase 2 is dependent on SEP (A Stable Election Protocol for clustered Heterogeneous WSNs) protocol. SEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. SEP tries to maximize the stability of the network. Stability can be increased by increasing the time of last node death. Clearly, larger the stable and unstable regions are, better is the reliability of the clustering process.

On the other hand, there is a trade-off between reliability and the lifetime of the system. Until the death of the last node, we still can have some feedback about the sensor field even though this feedback may not reliable. The unreliability of the feedback stems from the fact that there is no guarantee that there is at least one cluster head per round during the last rounds of the operation. In our model, the absence of a cluster head prevents reporting about the cluster to the sink at all. The throughput quantity captures the amount of such data reporting to the sink.

In a heterogeneous WSN, LEACH doesn't work well as it is very sensitive to the heterogeneity.

SEA LEACH Phase 2

In this section we present SEA Phase 2 protocol. Here we assume that after couple of rounds of homogeneous system, system will be no longer homogeneous. This is possible because of data transmission is not always same from all the nodes. Nodes which are nearer to the base station, they have to pass more data compared to the nodes which are far away.This is the reason we assume that, the nodes at a far end from the base station have more energy and are considered as advance nodes. Nodes which are near to the base station are normal nodes with lesser energy than advanced node.

Our protocol is extension of SEP. It follows the hybrid approach i.e. direct transmission as well as transmission via cluster head. Depending on Energy of nodes, we can divide all the nodes in advanced nodes with more energy than normal nodes. For SEA Phase2 setup, we will put advance nodes in the corner for direct transmission and normal nodes in-between through cluster head transmission.

Proposed Algorithm

Architecture

At the end of SEA Phase 1, we assume that the nodes are placed randomly and with different amount of energies in all. So we can divide the nodes based on their energies: zone 0, Head zone 1, and Head zone 2.
We assume that the advance nodes are having fraction of more energy than the normal nodes. Total m numbers of nodes out of n are having α time more energy than normal nodes. We refer these nodes as advance nodes and *(1-m) ×n* are normal nodes.

Nodes in zone 0 have less energy and they are deployed near to the base station. These nodes will directly transmit the data to the sink. Nodes in Zone 1,2 have α times more energy than nodes in zone 0. Where o is Normal node, + is special energy activated node and x is BS

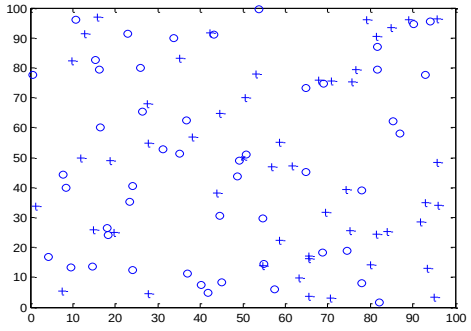

Fig: Setup for the Advanced and normal node for SEA phase 2

Operation

SEA phase 2 uses two modes of data transmission techniques.

- Direct communication
- Transmission through cluster head

Direct Communication

Normal nodes will sense environment and gathers data of interest. After that they will send it data to base station through direct communication.

Transmission via Cluster head

Clustering Nodes in Head zone 1 and Head zone 2 transmit data to the base station through clustering algorithm. Cluster head is selected among nodes in Head zone 1 and 2. Cluster heads collect data from member nodes, aggregate them and transmit them to the base station. Cluster head selection is very important because it collects data from member nodes and transmits to sink. Figure shows only advanced node is creatingclusters. Assume an n is the number of advance nodes and optimal number of clusters K_{opt}. According to SEP, optimal probability of cluster head is

$$\mathbf{P_{opt}=}\frac{\mathbf{Popt}}{\boldsymbol{n}}$$

Every node has to decide if it wants to be the cluster head in current round. A random number is generated between 0 and 1. As per SEP, if the generated number is less than or equal to threshold, that node will selected as cluster head.

Threshold is given by

$$\mathbf{T(n)} = \frac{\mathbf{Popt}}{\mathbf{1-Popt}\left(\mathbf{r}*\mathbf{mod}\frac{\mathbf{1}}{\mathbf{Popt}}\right)} \quad \mathbf{if\ n\ €\ G}$$

$$\mathbf{=0}$$

Otherwise

Where G is the set of all the nodes which have not been selected as cluster heads in the last $1/P_{out}$rounds. Equation below gives the probability for advance nodes to become cluster head.

$$\mathbf{P_{opt}} = \frac{\mathbf{Popt}}{\mathbf{1}+(\propto.\boldsymbol{m})} * (\mathbf{1}+\propto)$$

Also the threshold for advance nodes is given as,

$$\mathbf{T(adv)} = \frac{\boldsymbol{Padv}}{\mathbf{1-}\boldsymbol{Padv}\left(\boldsymbol{r}*\boldsymbol{mod}\frac{\mathbf{1}}{\boldsymbol{Padv}}\right)} \qquad \mathbf{if\ adv\ €\ G'}$$

$$\mathbf{=0} \qquad \mathbf{otherwise}$$

Where G' is the set of all the advance nodes that have not been selected as cluster head in the last $1/P_{out}$ rounds.

Same as LEACH, Once the CH is selected then the CH will broadcast an advertisement message to all the other nodes. Other nodes will receive the message and decide whether to join with this CH or any other. This phase is known as cluster formation phase.

On the basis of the received signal's strength, nodes respond to cluster head and become member of cluster head. Cluster head then assign a TDMA schedule for the nodes during which nodes can send data to cluster head. After the clusters formation, every node data and sends it to the cluster head in the time slot allocated by the cluster head to the node. Cluster head then aggregates the received data from the nodes and sends it to the base station. This phase is called as transmission phase.

Because of the energies of normal nodes are less than those of advance nodes, normal nodes are not able to form a cluster. Also in receiving the data from all other nodes, the cluster head will consume more energy. If normal nodes are allowed to become cluster head then they will die soon making the stability period short.

Simulation Results and Analysis

We have simulated our wireless sensor network in a sensing field of 100m x 100m.The plot of the result as shown one by one and they are finally tabulated to describe the performance of our purposed SEA LEACH and compared with the normal LEACH algorithm .Consider two cases:

1. m=0.1, a=1.5
2. m=0.1,a=1.0
3. **Case-a:** As described in previous section this case m=0.1 and a=1.5 we have generated plots for number of alive nodes of difference round shown in figure 1a. Where y axis represented the number of alive nodes and x axis represented the number of rounds. There are two lines green and blue color where green color normal LEACH and blue color SEA LEACH. We can observed that in the LEACH alive nodes start decreasing from round r1=994 and it gets completely zero at round r2=1796 while in SEA LEACH r1=1541 and r2=2271.

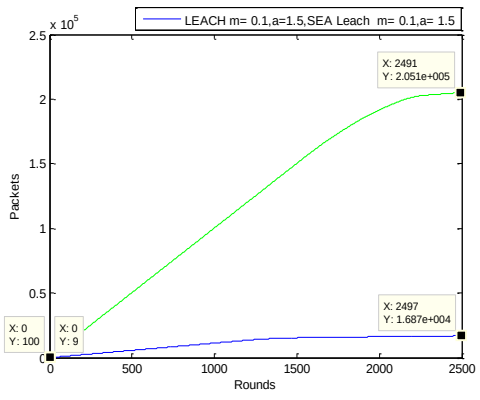

Fig.1 a: Number of Packets Sent at different rounds

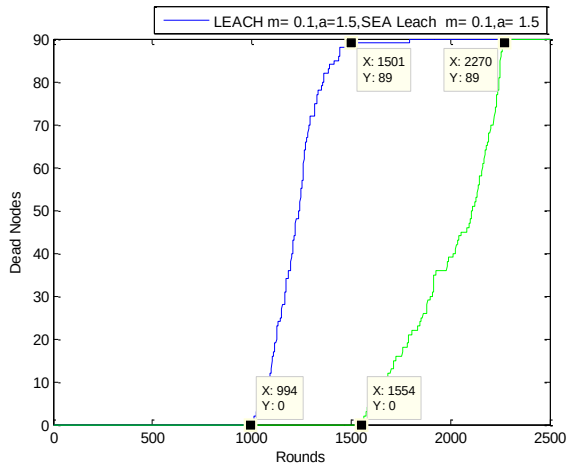

Fig.1b: No. of dead nodes at different rounds

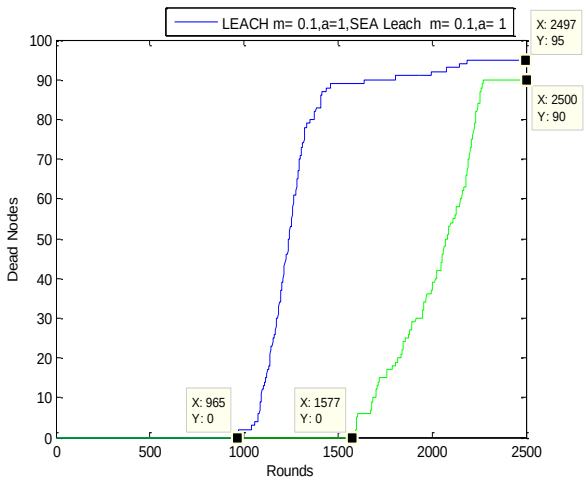

Fig.2b:No. of dead nodes at different rounds

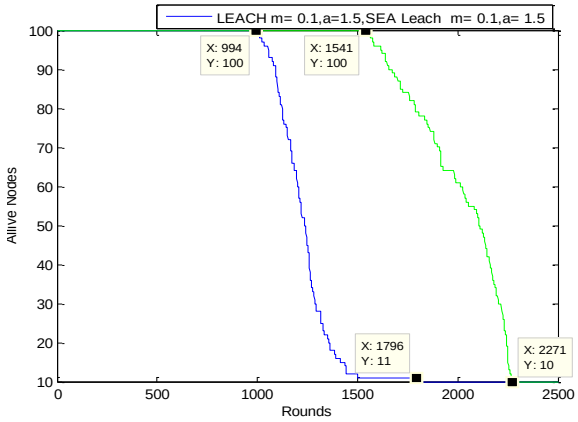

Fig.1c: No. of alive nodes at different rounds.

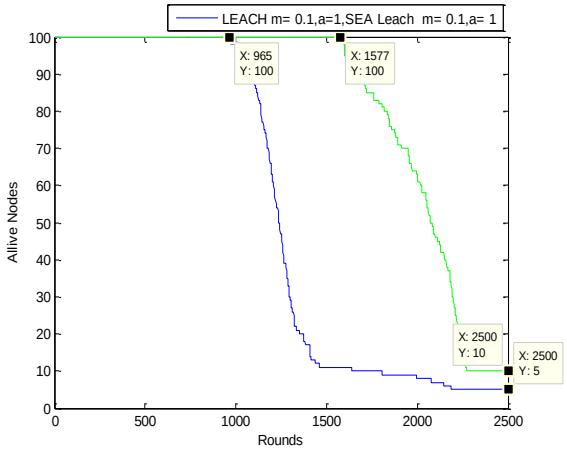

Fig.2c: No. of alive nodes at different rounds.

Case-b: As described in previous section this case m=0.1 and a=1.0 we have generated plots for number of alive nodes of difference round shown in figure 1a. Where y axis represented the number of alive nodes and x axis represented the number of rounds.There are two lines green and blue colour where green colour normal LEACH and blue colour SEA LEACH.We can observed that in the LEACH alive nodes start decreasing from round 965 and while in SEA LEACH it start decreasing from 1577 round.

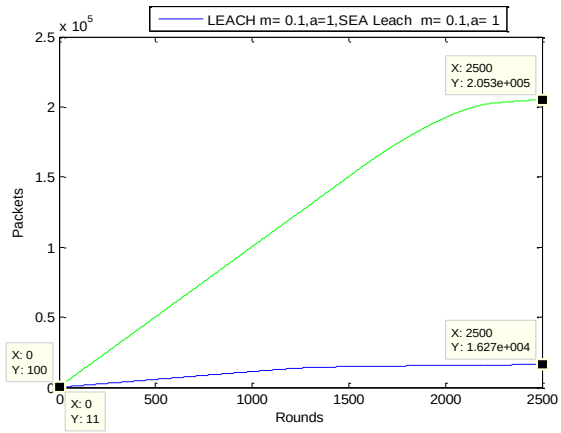

Fig.2a: Number of Packets Sent at different rounds

Conclusions

In our work we have briefly describe how cluster based routing protocol LEACH can be utilized in better way for homogeneous and heterogeneous environment. Our simulation shows SEA LEACH gives better throughput of the system compare to LEACH. We can get better efficiency by including new CH replacement scheme and different transmission energy.Results are generated for different number of special energy activated nodes out of total nodes for different probabilities of election of SEA nodes as the cluster heads. It has been observed that in any combinations of m and a the SEA LEACH sends higher number of packets as compared to normal LEACH. For minimum value of m=0.1 and a=0.5 the SEA leach shows higher life time than the LEACH. Hence it can be concluded that even if we consider only 10 %cent nodes as SEA nodes with energy 50% higher than other nodes we can significantly enhance the network life time and data transmission rate. Moreover, stability of SEA LEACH can be improvised by using two different transmission techniques direct transmission and CH to sink transmission in heterogeneous. In future, SEA

LEACH can be improvised by adding more techniques for hierarchal transmissions between CH to Sink. Again it will be interesting to apply advanced node concept with Energy heterogeneity.

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