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Energy Efficient Routing Protocol in Wireless Sensor Network

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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 Aeon LEACH Phase-1 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 Aeon LEACH Phase-2 by applying different ways of communication (between CH to sink) for advanced and normal nodes. By showing simulation, we prove that Aeon LEACH is more energy efficient and has longer lifetime of network than LEACH in homogeneous and heterogeneous environments.

Keywords*— *Distributed system, Data aggregation, Dynamic cluster head rotation, Heterogeneous system, Homogeneous system, Threshold value concept.

1. Introduction:

Wireless Sensor Networks (WSNs) represent a new paradigm in wireless technology drawing significant research attention from diverse fields of engineering. WSN technology is listed in "Top 10 Emerging Technologies" that will change the world. WSNs consist of many sensor nodes. These nodes sense the changes in the physical parameters similar to – pressure, temperature, etc. The data sensed by these nodes are then transmitted to the Base Station (BS) for estimation. WSNs are used for the variety of purposes like military surveillances, habitat monitoring, forest fire detections, and landslide detections (Fig 1).

The main task of many researchers in this field is to develop smart surroundings with the help of WSNs containing thousands of planned or ad-hoc deployed sensors, each capable of detecting ambient conditions like temperature, sound, movements, light, or the presence of particular objects. It is very important to make these sensing nodes as cheap and energy efficient as possible and trust them to obtain high quality results. Hence, to have battery operated sensor nodes is a good option. But despite of their small sizes, these batteries must be capable of giving a longer life to these sensing nodes. The network protocol used must be very efficient to optimize the lifetime of the nodes.

We also need to focus on algorithms and physical circuitries that can make maximum out of limited power source. Some of the promising routing algorithms can be categorized into three types as direct transmission algorithms, hop to hop transmission algorithms and cluster based algorithms. In cluster based protocols, most of the energy consumption depends on cluster head selection, cluster formation and the algorithm developed for routing the information.

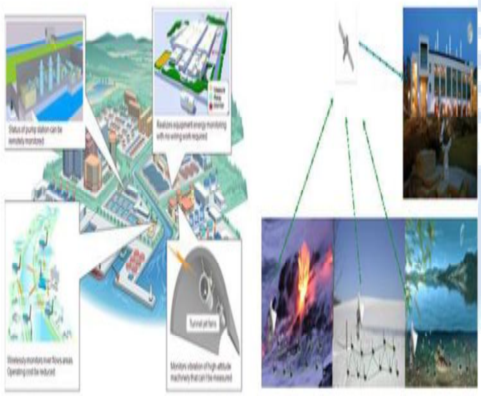

Fig. 1. Application of Wireless Sensor Network

1.1 LEACH Protocol:

LEACH is Low-Energy Adaptive Clustering Hierarchy, a clustering-based protocol that minimizes energy dissipation in sensor networks.

The key features of LEACH are:

- Localized control and coordination for cluster set-up and its operation
- Randomized rotation of the cluster "base stations" or "cluster-heads" and the corresponding clusters
- Compression done locally to reduce global communication

LEACH protocol has advantage over previous WSN routing protocols. It requires small transmit distances for most of the nodes, which uses only a few nodes to transmit far distances to the base station. LEACH outperforms classical clustering algorithms by using adaptive clusters and rotating cluster-heads, thus allowing the distributed energy requirements of the system among all the sensors.

In addition, LEACH is able to perform local computation in each cluster to reduce the amount of data that has to be transmitted to the base station. This reduces the energy dissipation, as computation is much cheaper than communication.

LEACH is following periodic process. In 1st Advertise Phase, election of cluster head and nodes covered in that cluster is defined. The 2nd Setup Phase consists of the planning of cluster schedule with base station. In the 3rd steady state, nodes send data to the respective base stations.

LEACH is completely distributed and non-centralized control system. It can reduce communication costs by up to 8x because LEACH keeps the first node alive for up to 8x longer and the last node by up to 3x longer.

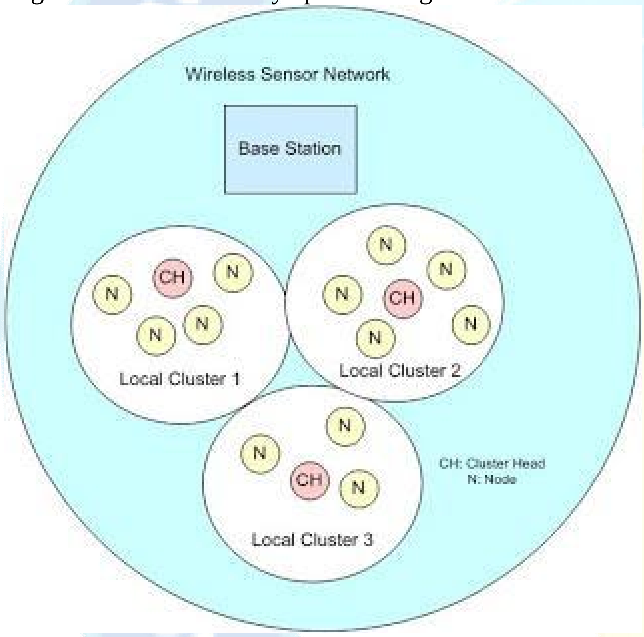

Fig. 2. LEACH Protocol

2. Related Work:

Georgios Smaragdakis et.al. (2004) [2] they study the impact of heterogeneity of nodes, in terms of their energy, in wireless sensor networks that are hierarchically clustered. In these networks some of the nodes become cluster heads, aggregate the data of their cluster members and transmit it to the sink. We assume that a percentage of the population of sensor nodes is equipped with additional energy resources—this is a source of heterogeneity which may result from the initial setting or as the operation of the network evolves. We also assume that the sensors are randomly (uniformly) distributed and are not mobile, the coordinates of the sink and the dimensions of the sensor field are known. We show that the behavior of such sensor networks becomes very unstable once the first node dies, especially in the presence of node heterogeneity. Classical clustering protocols assume that all the nodes are equipped with the same amount of energy and as a result, they can not take full advantage of the presence of node heterogeneity. We propose SEP, a heterogeneous-aware protocol to prolong the time interval before the death of the first node (we refer to as stability period), which is crucial for many applications where the feedback from the sensor network must be reliable. SEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. We show by simulation that SEP always prolongs the stability period compared to (and that the average throughput is greater than) the one obtained using current clustering protocols. We conclude by studying the sensitivity of our SEP protocol to heterogeneity parameters capturing energy imbalance in the network. We found that SEP yields longer stability region for higher values of extra energy brought by more powerful nodes.

They proposed SEP (Stable Election Protocol) so every sensor node in a heterogeneous two-level hierarchical network independently elects itself as a cluster head based on its initial energy relative to that of other nodes. Unlike [5], we do not require any global knowledge of energy at every election round. Unlike [4, 8], SEP is dynamic in that we do not assume any prior distribution of the different levels of energy in the sensor nodes. Furthermore, our analysis of SEP is not only asymptotic, i.e. the analysis applies equally well to small-sized networks. We are currently extending SEP to deal with clustered sensor networks with more than two levels of hierarchy and more than two types of nodes. They are also implementing SEP in Berkeley/ Crossbow motes and examining deployment issues including dynamic updates of weighted election probabilities based on current heterogeneity conditions. SEP code and results are publicly available at http://csr.bu.edu/sep.

The first work that questioned the behavior of clustering protocols in the presence of heterogeneity in clustered wireless sensor networks was [5]. In this work Heinzelman analyzed a method to elect cluster heads according to the energy left in each node. The drawback of this method is that this decision was made per round and assumed that the total energy left in the network was known. The complexity and the assumption of global knowledge of the energy left for the whole network makes this method difficult to implement. Even a centralized approach of this method would be very complicated and very slow, as the feedback should be reliably delivered to each sensor in every round.

In [4], Duarte-Melo and Liu examined the performance and energy consumption of wireless sensor networks, in a field where there are two types of sensors. They consider nodes that are fewer but more powerful that belong to an overlay. All the other nodes have to report to these overlay nodes, and the overlay nodes aggregate the data and send it to the sink. The drawback of this method is that there is no dynamic election of the cluster heads among the two type of nodes, and as a result nodes that are far away from the powerful nodes will die first. The authors estimate the

optimal percentage of powerful nodes in the field, but this result is very
difficult to use when heterogeneity is a result of operation of the sensor network and not a choice of optimal setting.

In [8], Mhatre and Rosenberg presented a cost based comparative study of homogeneous and heterogeneous clustered wireless sensor networks. They proposed a method to estimate the optimal distribution among different types of sensors, but again this result is hard to use if the heterogeneity is due to the operation of the network. They also studied the case of multi-hop routing within each cluster (called M-LEACH). Again the drawback of the method is that only powerful nodes can become cluster heads (even though not all of the powerful nodes are used in each round), and that M-LEACH is valid under many assumptions and only when the population of the nodes is very large.

3. Methodology:

Architecture:

At the end of Aeon 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.

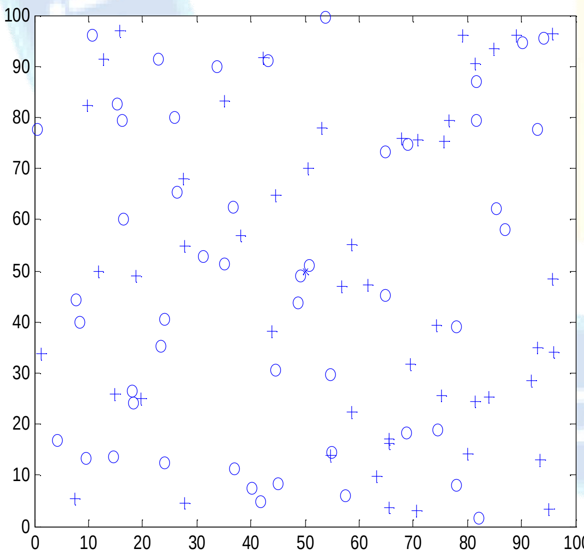

Fig. 3. Setup for the Advanced and normal node for Aeon phase 2

Operation:

Aeon 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 creating clusters. 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

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

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

$$T(n) = \frac{Popt}{1 - Popt(r * mod\frac{1}{Popt})} \qquad if\ n \in G$$

$$= 0 \qquad Otherwise$$

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.

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

Also the threshold for advance nodes is given as,

$$T(adv) = \frac{Padv}{1 - Padv(r * mod\frac{1}{Padv})} \qquad if\ adv \in G'$$

$$= 0 \qquad otherwise$$

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.

Flow Chart for Phase 2:

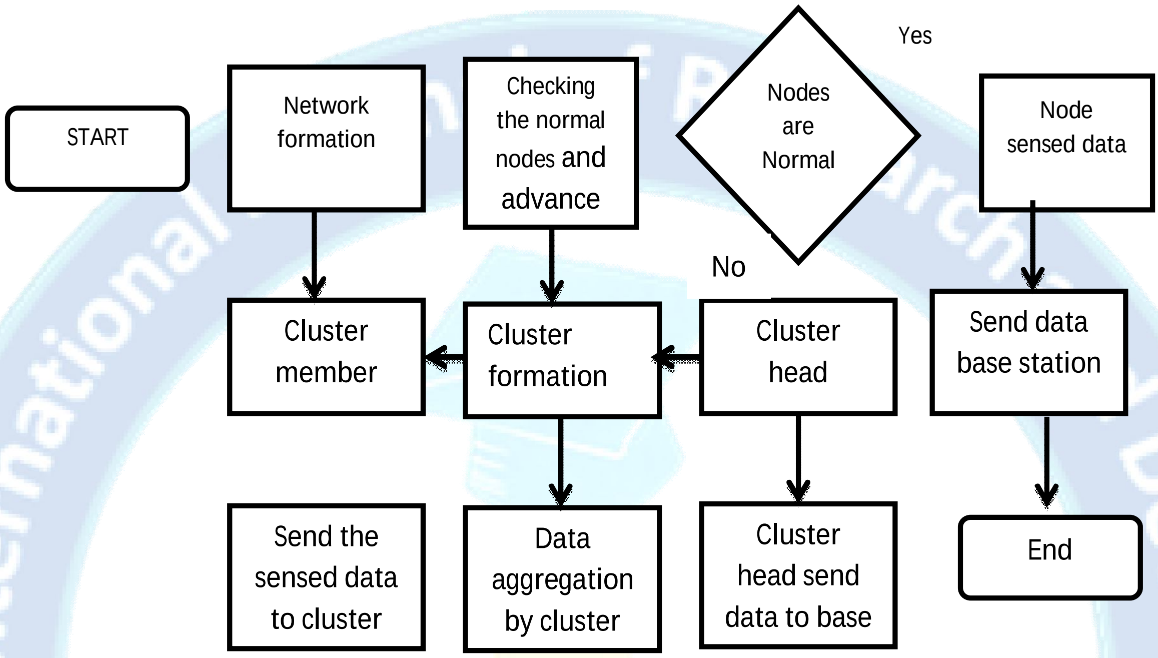

Fig 4. Flow chart of SEA Phase 2

Figure 4 briefly explain the operations of Aeon phase 2 for normal and advanced nodes. 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.

4. Result and Discussion:

In this paper we are developed an energy efficient wireless sensor network model having modified version of LEACH protocol having special energy activated sensor nodes called as SEA LEACH. In this we have considered an area having randomly distributed wireless sensor network having equivalent initial energy some of the node having additional energy known as special node. We have taken m as the special node e.i m=0.1 then it mean that 10% node are special mode out of all the nodes the energy of these node is Es=E(1+a).There Es is energy special node. If a=0.5 then Es=(1.5*E) that is energy of special node is 1.5 times of the normal node. For various combination of m and a we have run our algorithm to generate the different number of dead nodes at different rounds.All the result are divided in to 9 difference case-

(a) m= 0.1,a=0.5

The plot of the result as shown one by one and they are finally tabulated to described the performance of our purposed SEA LEACH and compared with the normal LEACH algorithm

Case-a: As described in previous section this case m=0.1 and a=0.5 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 colour where green colour normal LEACH and blue colour SEA LEACH. We can observed that in the LEACH alive nodes start decreasing from round 970 while in the SEA LEACH alive nodes start decreasing from round 1509.

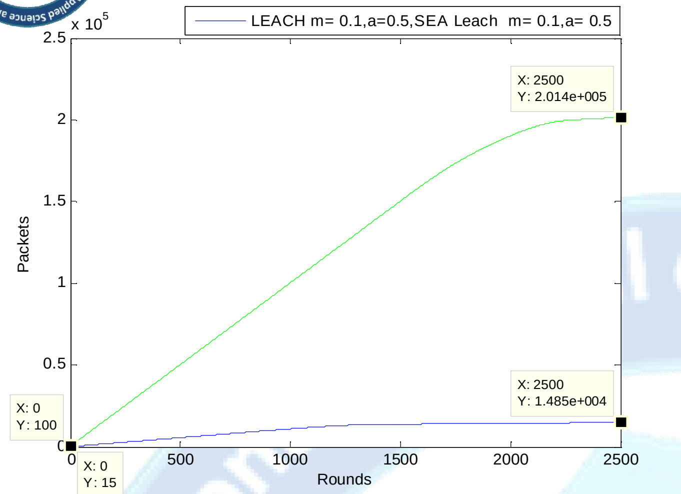

Fig 5 (a). Number of Packets Sent at different rounds.

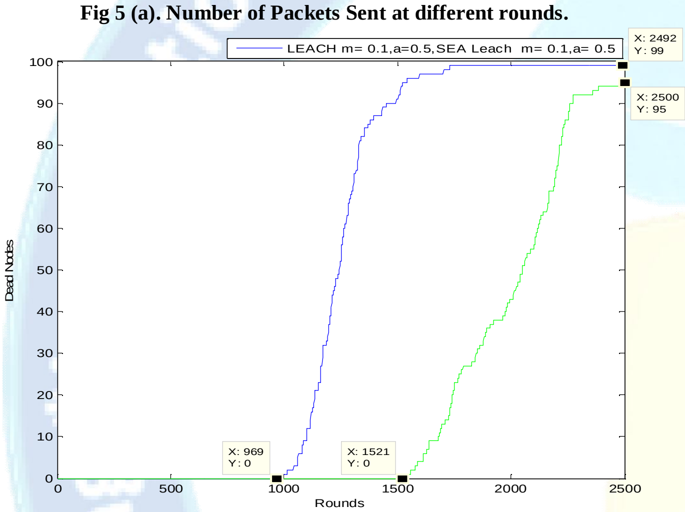

Fig 5 (b). No. of dead nodes at different rounds.

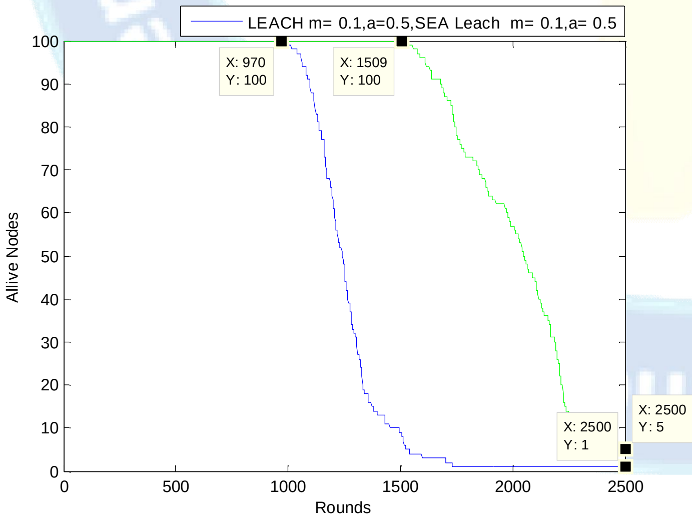

Fig. 5(c). No. of alive nodes at different rounds.

5. Conclusion:

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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