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Energy Management in Wireless Sensor Networks using M-SEP and LEACH

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Abstract –**Thanks to the great steps taken in recent years in technological development, and in particular microelectronics and wireless communication techniques, small, networked and inexpensive communicating sensors are increasingly being used in industrial applications and applications, observation of the environment. However, the use of wireless sensor networks in such applications has to face several limitations imposed by sensors such as processing capacity, small memory size and energy. Or the limits imposed by the network itself, such as the narrow bandwidth, the network dynamics due to the topological variation of the network and the appropriate communication protocols adapted to this type of network. In this paper, we test Modified-Stable Election Protocol (M-SEP) and Low-Energy Adaptive Clustering Hierarchy (LEACH) under a few distinctive situations holding high level heterogeneity to low level heterogeneity. The performance comparison metrics are; network lifetime, network throughput and number of alive nodes.**

Keywords – **GPS, LEACH, M-SEP, SEP, WSN.**

I. INTRODUCTION

Now-a-days the whole life of any person becomes mobile. It also proves a remarkable power of mobility in global development. In past only money was the important thing in life of every person without which nobody left the home. But at present, most of us don't take wallet to us while sleeping and even don't check it after few minutes. Apart from this, the popularity of laptops, GPS devices and intelligent computing devices is increasing day-by-day [1]. Hence wireless network become a crucial part in our daily life. Recent technologies all together form a new version of wireless network named as Wireless Sensor Networks (WSNs) which were developed about 5 to 10 years ago. It helps us to manage our lives with lower preparation and maintenance cost, contributing modern root ages of easily accessible information [2].

Wireless sensor network also termed as distributed sensor nodes network in which each node are independent of each other and can perform transferring of data packets individually. A wireless sensor network is an accumulation of small randomly dispersed devices [3]. Moreover in WSN, each node communicates with their neighbour node for transferring data from source node to sink node. The size of sensor nodes may change from small grain size to large box according to the requirement of application [4]. Networking topologies may also vary. In WSN assumption, a user may retrieve the information by sending query to the system and then getting the results accordingly [5].

The architecture of WSN consist two main components which are Sensor node and Sink node. Sensor node is the node where actual event is occurred and sink node is the one which have high energy or power to control all the actions in the routing [6].

These nodes are selected on the basis of their working ability. All the information is send to the sink node which broadcast it to the internet [7].

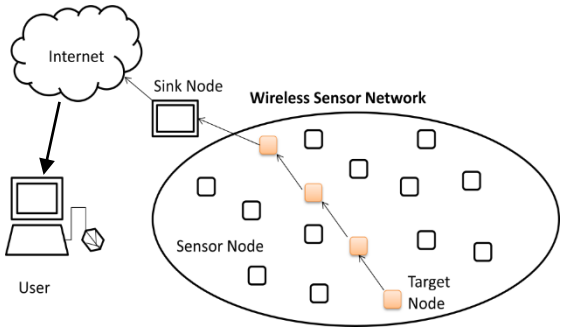

Figure 1: Architecture of wireless Sensor network [8]

The design of routing algorithm purely dependant on the application which are required in WSN. As we know that in Wireless network the redundancy problem of data exists, hence any address centric protocol cannot be used for the routing purpose. The working pattern of WSN is different from other networks, hence WSN demand different routing

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protocol for data routing. This purpose is fulfilled by data centric protocol which retrieves data from querying message [9].

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This paper performs an investigational comparison among Stable Election Protocol Modified-Stable Election Protocol (M-SEP) and Low-Energy Adaptive Clustering Hierarchy (LEACH) based cluster head election.

II. Proposed Method

A. Low-Energy Adaptive Clustering Hierarchy (LEACH)

During the configuration phase, randomly generated cluster head, the random number is selected in a range between 0 and 1 in each sensor node, if the selected number is smaller than some threshold $T(n)$, then the node is selected as the head of the cluster. Formulas of $T(n)$ as follows [10]:

$$T(n) - \int_0 \frac{p}{1-p\left[r \bmod \left(\frac{1}{p}\right)\right]} \text{ with } n \in G \qquad (1)$$

Where, p is the percentage of the number of cluster headers and the total number of nodes in the network, r is the number of the current round, G is the set of cluster nodes except the cluster head of the last rounds $\frac{1}{p}$. Then, the header node of the cluster transmits the message that it is becoming a cluster head in the entire network, each node decides to join that cluster according to the intensity of the received information and responds to the corresponding cluster header. Then, in the next phase, each node uses the TDMA method to transmit data to the cluster header node, the cluster head sends the fusion data to the receiving node. Among the clusters, each cluster competes with the communication channel with the CDMA protocol. After a period of stable phase, the network enters the next round of the cycle again, continuous cycle.

B. Stable Election Protocol (SEP)

Stable Election protocol (SEP) [11] takes in consideration the heterogeneity of sensor nodes, means each node has a different energy level as compared to other nodes. The cluster-head selection process in SEP involves the initial energies of participating nodes. This clusterhead selection mechanism will extend the time interval before the first node gets dead. This period is known as stability period and it is very important in many conditions where response from every sensor node is desired. In SEP network region is composed of a number of normal nodes (n) whose energy is E_0 and a fraction of advance nodes (m) with energy (α) times greater than normal nodes. Where α is energy factor. SEP maintains balance between energy consumption of normal and advance nodes to extend the stable region. In other words advance nodes are elected as clusterhead more often than normal nodes in order to maintain balanced energy consumption.

Let E_0 be the initial energy of normal node then energy of advance node will be:

$$E_0 * (1 + \alpha) \qquad (2)$$

The total energy of the new heterogeneous network will be:

$$n * (1 - m) * E_0 + n * m * E_0 * (1 + \alpha) = n * E_0 * (1 + \alpha * m) \qquad (3)$$

Hence total energy of WSN will be $1 + \alpha * m$ times more than as compared to homogenous environment. This will increase the number of epochs in proportion to energy which is first improvement over conventional protocols like LEACH. To extend the stability period new epoch must be $1/popt * (1 + \alpha * m)$, since the networks has $\alpha * m$ times greater energy and $\alpha * m$ more normal nodes.

Hence the Stable Region can be increased by $1 + \alpha * m$ through SEP if:

1. Each normal node will be elected as clusterhead only once $\frac{1}{popt} * (1 + \alpha * m)$ rounds per epoch;
2. Each advanced node will be elected as a cluster head exactly $(1 + \alpha)$ times every $\frac{1}{popt} * (1 + \alpha * m)$ rounds per epoch; and
3. The average number of clusterhead will be $n * popt$ per round per epoch.

C. Modified-Stable Election Protocol (M-SEP)

Modified-SEP [12] is an improvement over stable election protocol where different levels of heterogeneity have been considered for enhancing overall system performance.

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M-SEP utilizes the concept of normal as well as advance nodes like SEP and sleep-awake schedule to enhance system performance. Nodes with different initial energies will result in higher coverage area while maintaining same deployment cost. The network model considered for M-SEP contains several levels of heterogeneity with some nodes with initial energy as in conventional LEACH protocol, some advance nodes with higher energy index with respect to normal nodes and also some super advance nodes whose energy level is even greater than those of advance nodes.

When network is simulated with these levels of heterogeneity, it is observed that performance is much better in term of network lifetime, throughput etc. The process of clusterhead selection is same in M-SEP as in SEP; the difference lies in the existence of heterogeneity levels.

In M-SEP as level of heterogeneity changes normal nodes, advance nodes and also the super advance nodes could be part of clusterhead selection process.

Levels of Heterogeneity

Consider a network model with n number of normal nodes and m is fraction of normal nodes to be advance nodes. Let the probability function for normal and advance nodes are p_{nrm}, p_{adv} and α is the energy difference between normal and advance nodes.

Then the probability of election of normal and advance nodes as clusterhead will be given as:

$$p_{nrm} = p/(1 + \alpha * m) \quad (4)$$

And for advance nodes:

$$p_{adv} = p * (1 + \alpha)/(1 + \alpha * m) \quad (5)$$

Considering three levels of heterogeneity and allowing super advance nodes with β time more energy than advance nodes to be a part of network. Then the election probabilities for normal, advance, super advance nodes can be computed as:

$$p_{nrm} = \frac{p}{1+(m*(\alpha+m_0*\beta))} \quad (6)$$

$$p_{adv} = \frac{p(1+\alpha)}{1+(m(\alpha+m_0*\beta))} \quad (7)$$

$$p_{sup} = \frac{p(1+\beta)}{1+(m(\alpha+m_0*\beta))} \quad (8)$$

Here p being the clusterhead selection probability.

III. Simulation And Results

The performance of proposed algorithms has been studied by means of MATLAB simulation.

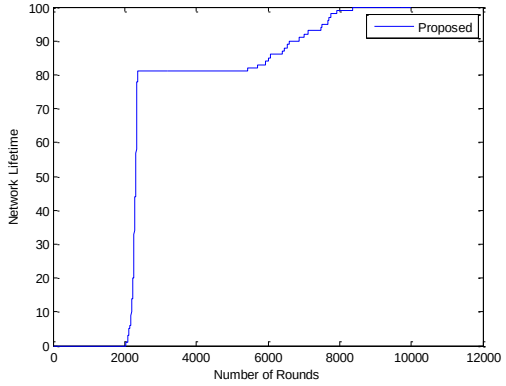

Figure 2: Graph between network lifetime and no. of rounds for M-SEP approach

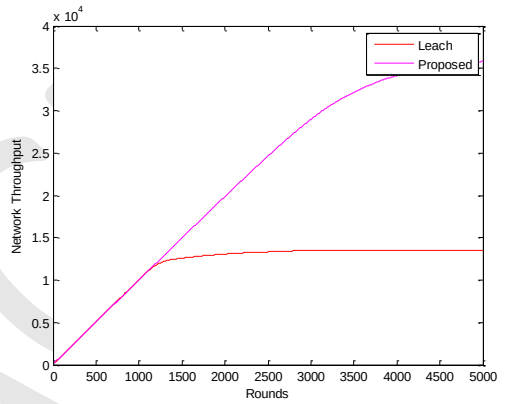

Figure 3: Throughput comparison between LEACH and proposed M-SEP

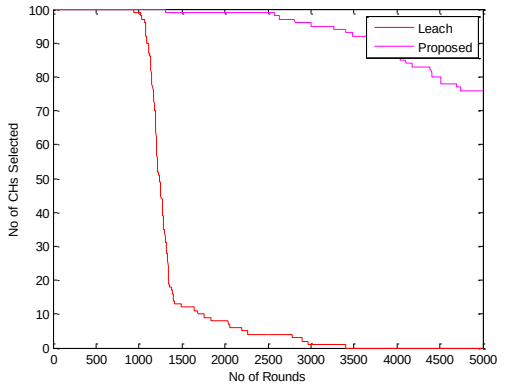

Figure 4: Comparison of selected clusterhead between LEACH and proposed M-SEP

IV. Conclusion

Under the conclusion of this work, several points were taken under consideration. For better understanding of our work that is evaluation of routing protocols for Wireless sensor network we have framed our work in two scenarios which consist of a simple WSN protocols, for now we have taken M-SEP protocol in consideration and

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performed a comparative study by implementing various topologies.

We have examined Modified Stable Election Protocol (M-SEP) and LEACH algorithm based cluster-head election for heterogeneous WSNs containing different level of heterogeneity. Simulations prove that M-SEP based cluster-head election performs well in all scenarios. It has best performance in terms of Network Throughput and Lifetime.

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