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Adaptive L-LEACH Protocol for Heterogeneous Wireless Sensor Network

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Abstract –**Heterogeneous Wireless Sensor Network (WSN) comprises of sensor nodes with distinctive capability, for example, diverse computing power and sensing range. Contrasted with homogeneous WSN, arrangement, and topology control are more perplexing in heterogeneous WSN. Distinctive energy efficient clustering protocols for wireless sensor networks systems and thinks about these protocols on a few focuses, in the same way as clustering method, location awareness, heterogeneity level and clustering attributes. Though, each protocol is not appropriate for heterogeneous WSNs. This paper proposes an improvement of Low Energy Adaptive Clustering Hierarchy (LEACH) clustering protocol under a few distinctive situations holding high-level heterogeneity to low-level heterogeneity.**

Keywords – ***Heterogeneous WSN, Homogenous WSN, LEACH, TDMA.***

I. INTRODUCTION

The key encounter in setting up and legitimate operation of WSN is expanding the lifetime of the system by minimizing the consumption of energy. Since from last few years a mixed bag of progressions has been made to point of confinement the energy necessity in WSN, as principally energy dispersal is more for wireless transmission and reception [1]. Principle methodologies till proposed were centering at rolling out the enhancements at MAC layer and network layer to minimize the energy dissipation. Two more real difficulties are the manner by which to place the cluster heads over the network and what number of clusters would be there in a framework. In the event that the cluster heads are accurately situated over the network and sufficient clusters are formed, it will help to reduce the dispersal of energy and would aid to expand the lifetime of the system to handle with all the aforementioned difficulties clustering have been discovered a helpful procedure [2] [3]. Clustering is dependably been alluded as a compelling technique to improve the lifetime of WSN

This paper performs an improvement in LEACH algorithm in the heterogeneous environment, so as to find a method which can fulfil the goals set, as follows:

- Minimize the energy dissipation of the network.
- Increase the network lifetime.
- Clusters must be better balanced.
- Better distribution of cluster heads in the network.

II. PROPOSED METHODOLOGY

Following are the steps for proposed methodology:
Abbreviation used in flowchart:
n = Number of nodes
m = Advanced nodes
α = Influencing factor
Th = Threshold
E(m) = Energy of Advanced nodes
E(n) = Energy of Normal nodes
Eo = Initial Energy of nodes
E_{cur} = Current Energy of nodes
P_{opt} = Optimal probability of cluster head selection
E_{ave} = Average remaining energy of all nodes in the current round
d_{ij} = Distance between nodes and cluster-head
d_j = Distance between cluster-head nodes and base station
d_{max} = Maximum distance between cluster-head and bse station
Min_dis = Minimum distance between cluster head and base station
E_{fs} = Energy for free space
E_{mp} = Energy for multipath
D_{max} = Maximum distance between all the nodes and the base station
D_{min} = Minimum distance between all the nodes and the base station
R = Random number between 0 and 1

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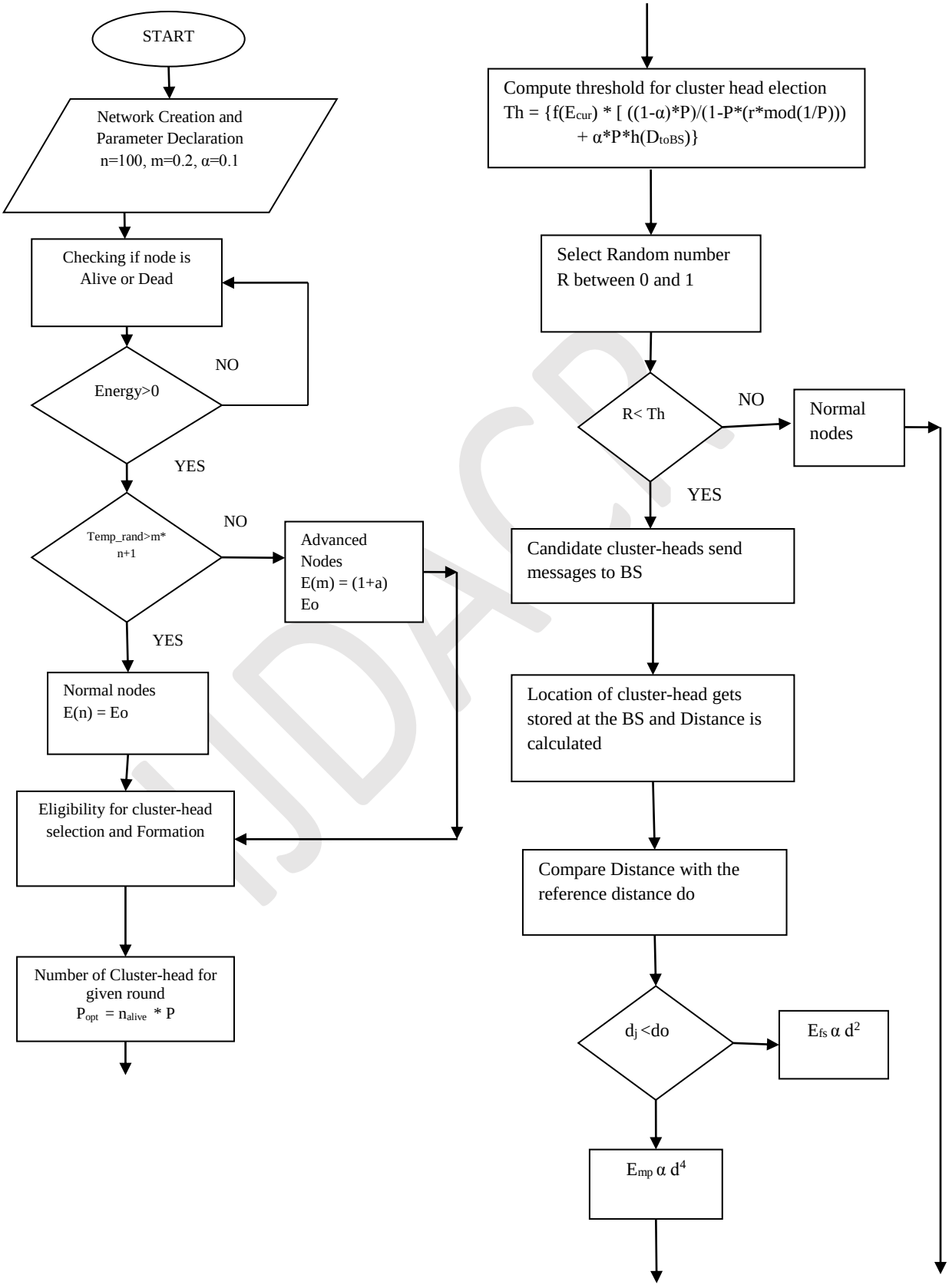
Flowchart



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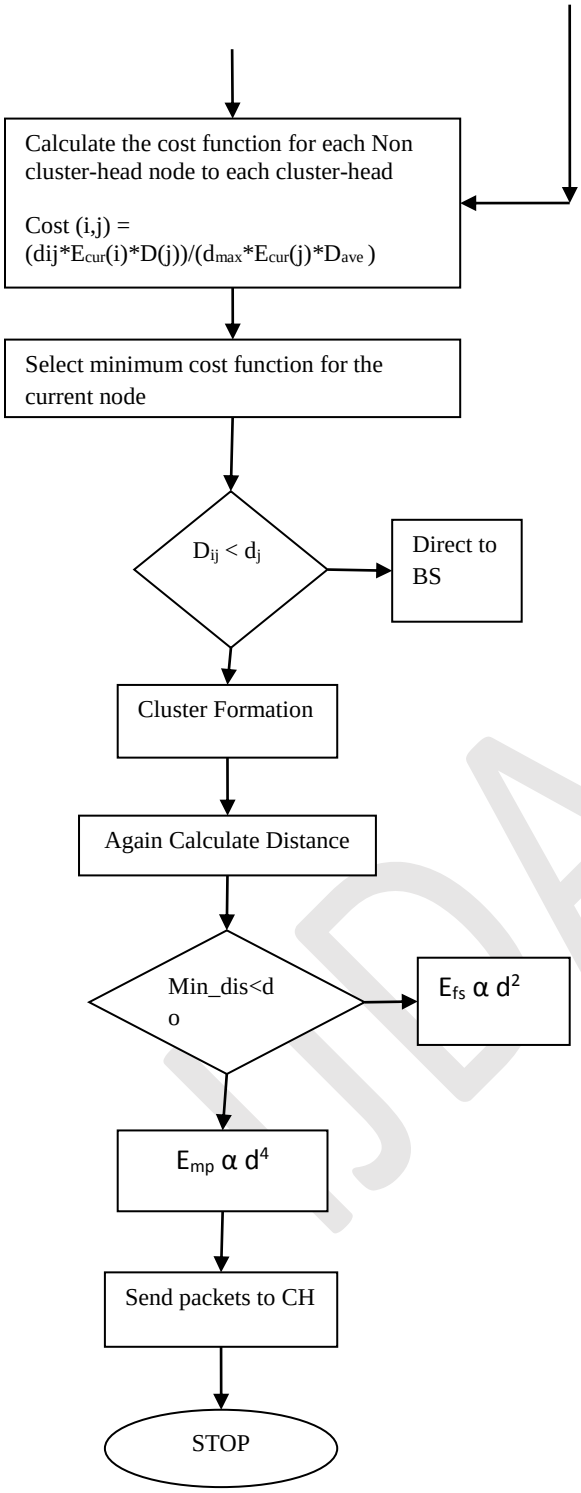

Figure 1: Flow diagram of proposed work

Adaptive L-LEACH Protocol for Heterogeneous Sensor Network

Low-energy adaptive clustering hierarchy ("LEACH") is a TDMA-based MAC protocol which is integrated with clustering and a simple routing protocol in wireless sensor networks (WSNs). The goal of LEACH is to improve the lifetime of a wireless sensor network & lower the energy consumption which required maintaining clusters. This research work proposes an improvement to Existing L-LEACH algorithm [4] using Adaptive cluster-head selection based on the number of alive nodes in a heterogeneous network configuration. The number of cluster-head elected in this scheme will be a function of the number of alive nodes and cluster-head election probability.

Number of Cluster Heads

Let n_{alive} represents the number of alive nodes with residual energy greater than the threshold energy and p be the cluster-head election probability, then the optimum number of CH elected for a given round will be:

$$P_{opt} = n_{alive} * p \quad (1)$$

Method of Cluster Head Election

The threshold formula given by **Qian Liao et al.** [4] is:

$$T(n) = \frac{p}{1-p*\left(r \bmod \frac{1}{p}\right)} * \frac{E_{cur}}{E_0} \quad (2)$$

Where E_0 and E_{cur} represent initial energy and current energy of the node respectively. The improvement in LEACH protocol takes place using the increment in the probability of high energy nodes, by which the nodes turn into the cluster-head. Although, this process causes an issue. The threshold $T(n)$ turns out to be small if the residual energy becomes very low resulting in a reduction in nodes of the network. It will result in the early death of nodes and finally the network lifetime will be less. Also, the threshold formula in equation (2) does not contain any impact of the distance between base station and nodes for cluster-head election.
Then the improvement in threshold is given as:

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$$T(n) = \begin{cases} f(E_{cur}) * \left[\dfrac{(1-\alpha)p}{1-p^*\left(r \bmod \frac{1}{p}\right)} + \alpha p^* h(D_{toBS}) \right] & n \epsilon G \\ 0 & n \notin G \end{cases} \quad (3)$$

Where, $f(E_{cur})$ is the function related to the current residual energy of the nodes. It shows the impact of node energy on the election probability. It is given by:

$$f(E_{cur}) = \frac{E_{cur}}{E_{ave}} \quad (4)$$

E_{ave} is the average residual energy of entire nodes in the current round.

$h(D_{toBS})$ is the $D(n)$'s impact on cluster-head election. It is given by:

$$h(D_{toBS}) = \frac{D_{max} - D(n)}{D_{max} - D_{min}} \quad (5)$$

Where, D_{min} and D_{max} present the maximum and minimum of the distance between all nodes and the base station respectively.

In generalized LEACH protocol, the optimal cluster-head are selected by normal nodes and the communication takes place between the base station and nodes. While the L-LEACH (improved LEACH) algorithm calculates the distance between base station and normal node. If it is found to be minimum then there is no selection takes place for cluster head which causes a direction transmission of controlling packages to the base station and data transmission occurs.

The improved LEACH also calculates the distance from a node to cluster head. The cluster-heads whose distance to the node is smaller than the distance from the node to the base station are considered as candidate cluster-heads.

At that point, the non-cluster head node selects the optimal one among the candidate cluster-heads according to the cost function. On the off chance that the cost function value is minimum, it will be selected as the optimal cluster-head. The cost function of the normal node p_i participates in the cluster with the cluster head c_j can be appeared as:

$$Cost(i,j) = \frac{d_{ij}}{d_{max}} * \frac{E_{cur}(i)}{E_{cur}(j)} * \frac{D(j)}{D_{ave}} \quad (6)$$

Where,

d_{ij} = distance from the node p_i to cluster-head c_j

d_{max}=maximum of the distances from p_i to the candidate cluster-heads.

$E_{cur}(i)$ and $E_{cur}(j)$ represent the current residual energy of node p_i and cluster-head c_j respectively.

$D(j)$ =distance from cluster-head c_j to the base station.

D_{ave}=average distance between cluster-heads and the base station.

III. Simulation Results

Simulation is carried out using MATLAB 2010a:

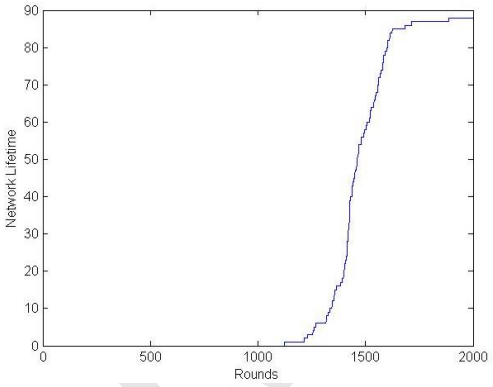

Figure 2: Network Lifetime for proposed Adaptive L-LEACH algorithm

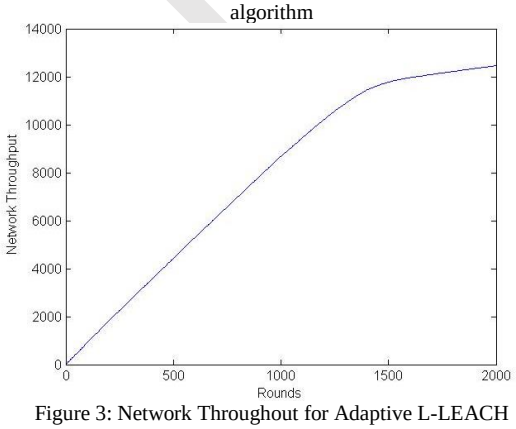

Figure 3: Network Throughout for Adaptive L-LEACH algorithm

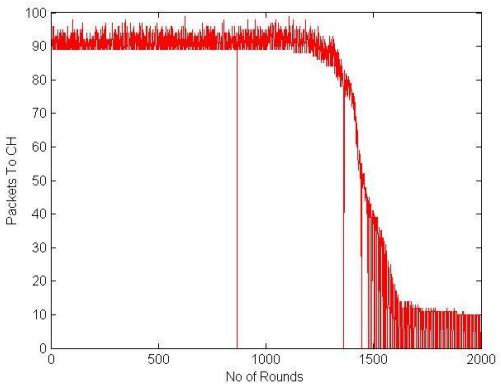

Figure 4: Packets to cluster head

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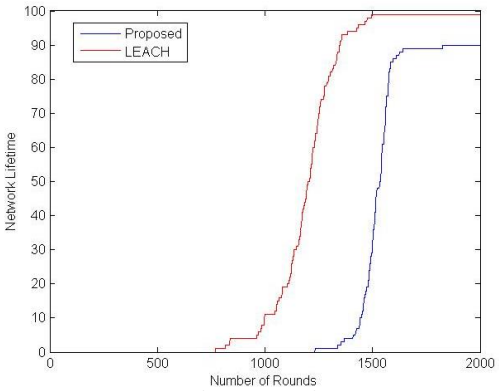

Figure 5: Comparison of Network Lifetime between LEACH and proposed Adaptive L-LEACH algorithm

The figure above shows the comparison of Lifetime for LEACH and improved LEACH clustering algorithms. It can be noticed that the improved LEACH gives better results as compared LEACH. At the end of round we are getting the minimum number of dead nodes in improved LEACH as compared LEACH.

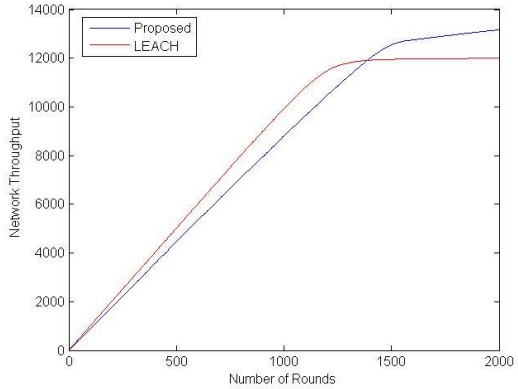

Figure 6: Comparison of Network Throughout between LEACH and proposed Adaptive L-LEACH algorithm

Figure 6 shows the comparison of throughput for LEACH and improved LEACH clustering algorithms. It can be noticed that the improved LEACH gives better throughput as compared to LEACH.

IV. CONCLUSION

We have implemented the improvement in LEACH clustering protocol for heterogeneous WSNs containing different level of heterogeneity. Simulations prove that proposed scheme performs well in the networks containing high energy difference between normal and advanced nodes. Adaptive L-LEACH has the best performance in terms of stability period and lifetime.

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