Energy Efficient Routing Protocol In Wireless Sensor Network- Advance LEACH-EE

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***Abstract* - This paper proposes an energy efficient routing protocol in WSN. LEACH is a primary hierarchical protocol. LECH and its variant having its different constraint that reserves energy for extend network life time. Here we have proposed a protocol that more efficient than LEACH and that takes into account the node that become cluster head in first round that will also taken as the candidate of cluster head selection process using the weighting factor that assign by using residual energy of node. NS-2 simulations show that our proposed scheme outperforms existing algorithms in terms of the node lifetime and the network life time.**

***Keywords* - Wireless sensor network, weight factor, LEACH-EE, residual Energy, cluster, residual energy, average energy**

I. INTRODUCTION

LEACH divides the network into several clusters of nodes. Through a cluster head (CH) selection procedure, each node in the network has an equal chance of becoming a CH overall. Each CH gathers and processes data from its members, then forwards the aggregate data to the base station (BS). In this way, LEACH attempts to balance the energy consumption among all the nodes. However, if the BS is far away from the sensor field, the energy expense for the CH to send data to the BS increases according to the 4-th power of its distance to the BS [1]. As such, even though all the nodes have an equal chance of becoming a CH, the ones far away from the BS will run out of energy before the closer ones. Therefore, in order to further balance the energy consumption, the probability of a node becoming a CH should be computed based on its distance to the BS.

Several distance-based CH selection algorithms have been proposed. In [2], a CH election algorithm is proposed using the minimum and maximum of the distance to the BS. In [3], the authors investigate inner-CH multi- hop routing using Dijkstra's algorithm. In [4], the relative distance to the BS is considered with a weighting factor. In [5], far zone heads are adopted for multi-hop routing; but the interference between the cluster and its far zone needs to be addressed. All the aforementioned approaches are heuristic based on the intuition that the far away nodes should communicate relatively less than the closer ones.

Rather than using a heuristic approach, we propose a distributed LEACH-based CH selection algorithm in which nodes are self-selected to become CHs with different probabilities based on their distances to the BS, in such a way that the energy consumption among the nodes are balanced. This is in contrast with the original LEACH protocol where all the nodes are self-selected to become CHs with a constant pre- designed probability, and thus is suboptimal Flat routing protocols like sensor protocol for information via negotiation (SPIN), directed dif- fusion, and rumor routing are not efficient in energy conserva- tion as compared to the hierarchical clustering routing protocols like low energy adaptive clustering hierarchy (LEACH), leach-centralized (LEACH-C), routing protocol of wireless sensor networks based on dynamic setting cluster, enhanced energy-efficient adaptive clustering (EEEAC), and base station con- trolled dynamic clustering protocol (BCDCP) [2], [3]. On the other hand, location based routings might consist of flat rout- ing or hierarchical routing and in this category of routing too, hierarchical clustering routing protocols obtain greater energy conservation as compared to the flat counterparts [2]. In hier- archical clustering routing protocols, clusters are created and a cluster head (CH) is assigned to each cluster. These CHs have the responsibilities of collecting, aggregating the data from their respective clusters, and transmitting these data to the BS (we use CH and CH node interchangeably in this work). The aggrega- tion of data at CHs greatly reduces the energy consumption in the network by minimizing the total data messages to be trans- mitted to the BS. Also, the CHs act as local sinks for the data, so that data are transmitted over a shorter transmission distance [2].

II. LEACH PROTOCOL

This section describes the LEACH Protocol.
The main objectives of LEACH are:

- Extension of the network lifetime
- Reduced energy consumption by each network sensor node
- Use of data aggregation to reduce the number of communication messages

To achieve these objectives, LEACH adopts a hierarchical approach to organize the network into a set of clusters. Each cluster is managed by a selected cluster head. The cluster head assumes the responsibility to carry out multiple tasks. The first task consists of periodic collection of data from the members of the cluster. Upon gathering the data, the cluster head aggregates it in an effort to remove redundancy among correlated values. The second main task of a cluster head is to transmit the aggregated data directly to the base station. The transmission of the aggregated data is achieved over a single hop. The third main task of the cluster head is to create a TDMA-based schedule whereby each node of the cluster is assigned a time slot that it can use for transmission. The cluster head advertises the schedule to its cluster members through broadcasting. To reduce the likelihood of collisions among sensors within and outside the cluster, LEACH nodes use a code-division multiple access–based scheme for communication.

The basic operations of LEACH are organized in two distinct phases, setup phase and steady state phase. These phases are illustrated in Figure 4.2. The duration of the setup is assumed to be relatively shorter than the steady-state phase to minimize the protocol overhead.

a. The first setup phase

- For organizing the network into clusters
- Advertisements of the cluster heads
- Transmission schedule creation

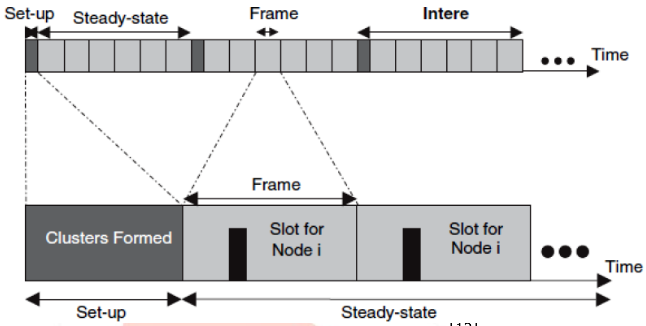

Fig 1 LEACH phases [12]

b. The second steady state phase

- The data aggregation
- Compression
- Transmission to the sink

At the beginning of the setup phase, a round of cluster-head selection starts. The cluster-head selection process ensures that this role rotates among sensor nodes, thereby distributing energy consumption evenly across all network nodes. To determine if it is its turn to become a cluster head, a node, n, generates a random number, v, between 0 and 1 and compares it to the cluster-head selection threshold, T(n). The node becomes a cluster head if its generated value, v, is less than T(n).The cluster-head selection threshold is designed to ensure with high probability that a predetermined fraction of nodes, P, is elected cluster heads at each round. Further, the threshold ensures that nodes which served in the last 1/P rounds are not selected in the current round. To meet these requirements, the threshold T(n) of a competing node n can be expressed as follows[11]

$$T(n) = \begin{cases} \dfrac{p}{1 - p \times \mathrm{mod}(r, \frac{1}{p})} & \text{if } \forall n \in G \\ 0 & \text{if } n \notin G \end{cases}$$

The variable G represents the set of nodes that have not been selected to become cluster heads in the last 1/P rounds and r denotes the current round. The predefined parameter, P, represents the cluster-head probability. It is clear that if a node has served as a cluster head in the last 1=P rounds, it will not be elected in this round. At the completion of the cluster-head selection process, every node that was selected to become a cluster head advertises its new role to the rest of the network. Upon receiving the cluster-head advertisements, each remaining node selects a cluster to join. The selection criteria may be based on the received signal strength, among other factors. The nodes then inform their selected cluster head of their desire to become a member of the cluster. Upon cluster formation, each cluster head creates and distributes the TDMA schedule, which specifies the time slots allocated for each member of the cluster. Each cluster head also selects a CDMA code, which is then distributed to all members of its cluster. The code is selected carefully so as to reduce inter cluster interference. The completion of the setup phase signals the beginning of the steady-state phase. During this phase, nodes collect information and use their allocated slots to transmit to the cluster head the data collected. This data collection is performed periodically.

The main drawbacks in Leach are as follows

The time duration of the setup phase is non-deterministic and the collisions will cause the time duration too long and hence the sensing services are interrupted. Due to that Leach may be unstable during the setup phase that depends on the density of sensors.

Flowchart

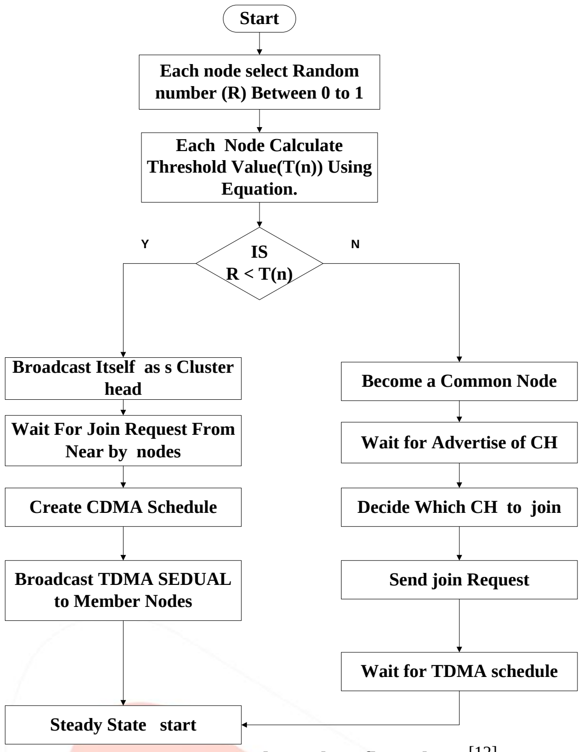

Fig 2 LEACH Algorithm flowchart [12]

III. LEACH-EE

Introduction

As we have seen that LEACH is very good routing protocols that randomize the cluster head such a way that it equally distribute the energy consumption in a network. One of the limitations of original LEACH is that it does not consider the energy of a node in selection of cluster head. Second, node that has been cluster head is not able to become cluster head again until all nodes becomes cluster head once though it may have more energy than others. Our propose algorithm LEACH-Exclusion elimination (LEACH-EE) assigns weight factor propositional to remaining energy of a node. Simulation results shows that it increase the network lifetime of a network compared to normal LEACH.

LEACH-Exclusion Elimination [12]

In LEACH-EE, we make the following three assumptions to facilitate the design of the clustering mechanism:
Assumption 1: All sensor nodes are homogeneous in physical characteristics such as initial energy, antenna gain, etc.
Assumption 2: All sensor nodes are location-aware.
Assumption 3: The base station and all nodes are stationary. The LEACH-EE uses the "round" idea which is used in LEACH original; each round includes the formation of cluster phase and data transition phase.
Assumption 4: Cluster head directly communicate with sink node.

Improved threshold

LEACH original uses the distributed algorithm for the formation of cluster head, each node make decision by itself. Once the node becomes cluster head, it cannot take part as candidate cluster head till all nodes become cluster head once.

In LEACH-EE, once the node become cluster head, the probability of being cluster head is reduced. Node that becomes cluster head once is assigned weight factor L depending on remaining energy of particular node. Initially in first round all nodes are having weight factor value set to 1. After that, once the node becomes cluster head, every 10% reduction in energy, the weight factor value will reduce by 0.1.

Table 1 Weight factor table [12]

Remaining Energy Band	Weight factor
2.0≤ E<1.8	1.0
1.8≤ E<1.6	0.9
1.6≤ E<1.4	0.8
1.4≤ E<1.2	0.7
1.2≤ E<1.0	0.6
1.0≤ E<0.8	0.5
0.8≤ E<0.6	0.4
0.6≤ E<0.4	0.3
0.4≤ E<0.2	0.2
0.2≤ E<0.0	0.1

For example, assuming initial energy of node 2 joule, when nodes energy is between 1.6 and 1.8, level value will be 0.9.So the new threshold is given by

$$t(n) = \begin{cases} \dfrac{p}{1 - p \times r \times \operatorname{mod}\left(\dfrac{1}{p}\right)} & where\ \forall n \notin G \\ \dfrac{p \times l}{1 - p \times r \times \operatorname{mod}\left(\dfrac{1}{p}\right)} & otherwise \end{cases} \quad (4)$$

Where p is the predetermined percentage of cluster heads (e.g., p = 0.05), r is the current round, and G is the set of nodes that have not been cluster heads in the last 1/p rounds, L is thee weigh factor as shown in table 4-1. Every node wanting to be the cluster-head chooses a value, between 0 and 1. If this random number is less than the threshold value, T (n), then the node becomes the cluster-head for the current round. Steady state phase is same as normal LEACH protocol. Radio model is also same as normal LEACH.

IV. ADVANCE LEACH-EE

Introduction

The algorithm LEACH Exclusion elimination (LEACH-EE) assigns weight factor propositional to remaining energy of a node. Simulation results shows that it increase the network lifetime of a network compared to normal LEACH. But this protocol has one drawback that it has fixed weighting factor according to its energy. Our Proposed protocol assigns the adaptive weighting factor to make node to become cluster head in particular round. For that I have consider average network energy to assign weighting factor. Simulation results shows that it increase the network lifetime of a network compared to normal LEACH-EE.

a. Advance LEACH-EE

Advance LEACH have all the assumption that are taken in to LEACH And LEACH-EE and also it has same working property like them but it have adaptive threshold in each round. Adaptive weight assigns By

Average energy given by =

$$\mathbf{E_{avg} = \frac{Total\ energy}{Total\ alive\ node}}$$

Adaptive weight assign according to average energy.

$$\mathbf{Energy\ gap = \frac{Total\ average\ energy}{10}}$$

This means that more than half initial energy it will have same feature like LEACH. But after half initial energy then it will have different weighting factor. These weighting factor assign by equation:

$$\mathbf{comparison = E_{avg} - energy\ gap * Daynamic\ \ range}$$

Dynamic range is the multiplication factor that put weight factor in to dynamic range.

Algorithm of advance LEACH EE:

- Node given initial energy
- Calculate average network energy
- Normal LEACH EE runs until average initial energy reaches 50% of initial energy.
- At 50% of initial energy algorithm takes adaptive band for weight factor allocation.
- For adaptive band more weighting factor is given to the node that has more energy than average energy.
- For adaptive band there are fewer bands than LEACH EE. So node having greater energy get high weighting factor.
- For adaptive LEACH EE allocation of band is given by using energy gap.

Algorithm

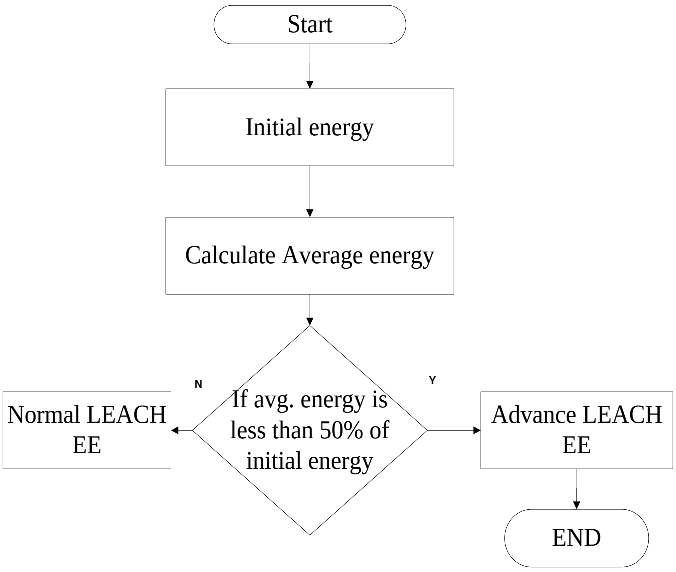

Fig 2 Adaptive LEACH EE algorithm

For example, if in middle case there is 1.6 joule average energy and if we take node energy also 1.2 joule then adaption is taken by table shown below.

Table 2 comparison example

Average	Gap	Dynamic range	Weight factor	Comparison
1.6	0.16	1	0.9	1.44
1.6	0.16	2	0.8	1.28
1.6	0.16	3	0.7	1.12

From the algorithm if node energy less than the comparison that weight factor is assign to that node here node energy is 1.2 joule and comparison at dynamic range 3 is 1.12 is less than node energy. Weight factor 0.7 is assign to the node for CH selection process.

V. Experiment Results

Simulation result done to compare LEACH EE and advance LEACH EE. Result shows that advance LEACH EE is having 18% to 20% better response than normal LEACH EE.

Simulation parameter

Table 3 simulation parameters

Parameters	Value
Channel Type	Wireless
Propagation Type	Two Ray Ground
MAC protocol	Mac-802.11
Queue Type	Drop tail
Antenna	Omni Antenna
Number of nodes	100
Queue length	50
Routing Protocol	LEACH
Network Area	200mx200m
Base Station	(250,250)
Node energy	2 joule

Result generated after simulation

Simulation result done to compare LEACH EE and advance LEACH EE. Result shows that advance LEACH EE is having 18% to 20% better response than normal LEACH EE.

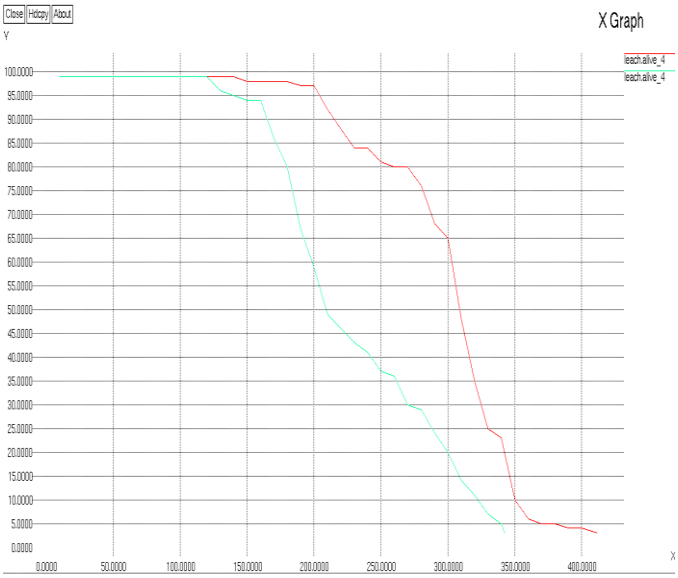

Fig 3 Comparision of Alive node of Advance LEACH and LEACH EE at p=0.04(Node Vs. time)

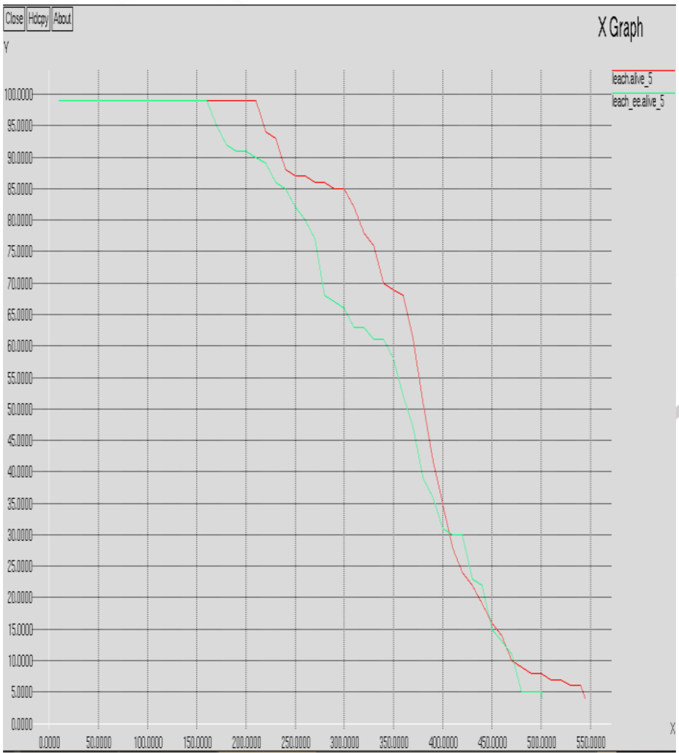

Fig 4 Comparision of Alive node of Advance LEACH and LEACH EE at p=0.05(Node Vs. time)

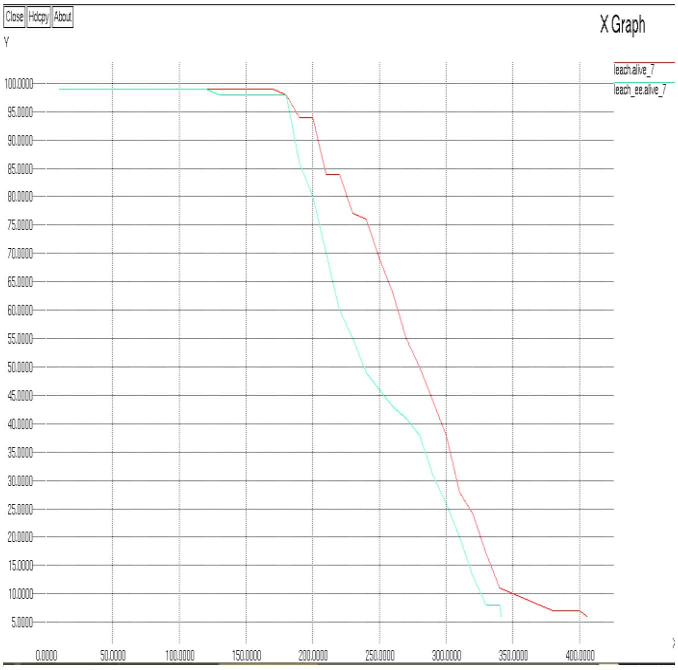

Fig 5 Comparision of Alive node of Advance LEACH and LEACH EE at p=0.07(Node Vs. time)

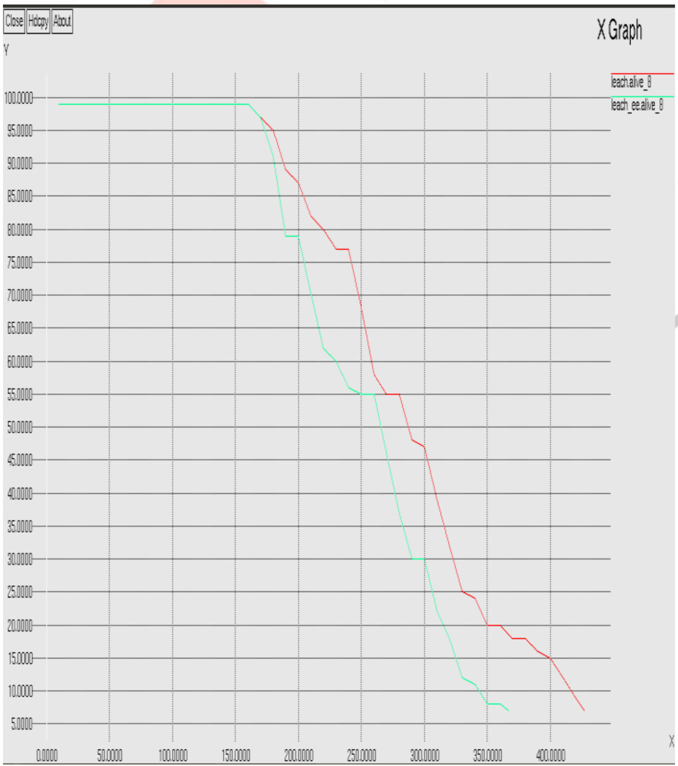

Fig 6 Comparision of Alive node of Advance LEACH and LEACH EE at p=0.08(Node Vs. time)

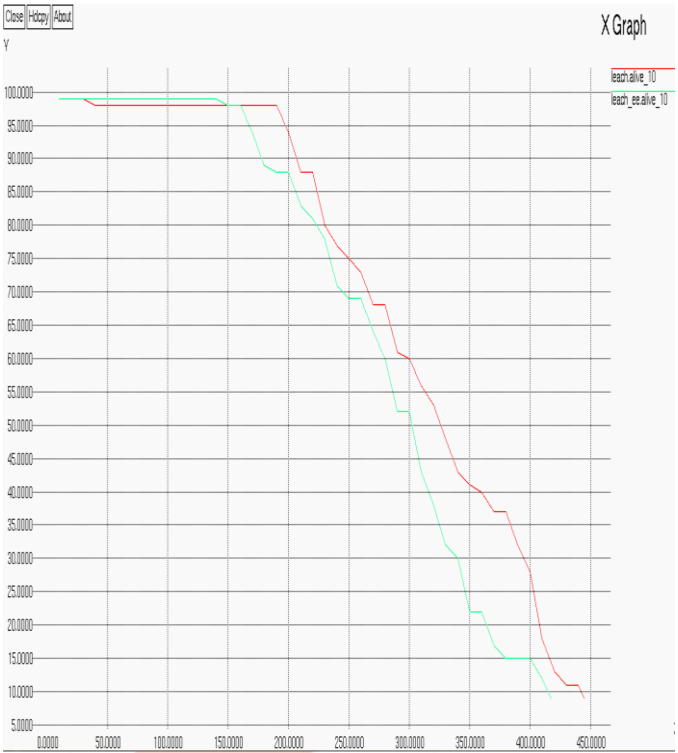

Fig 7 Comparision of Alive node of Advance LEACH and LEACH EE at p=0.10(Node Vs. time)

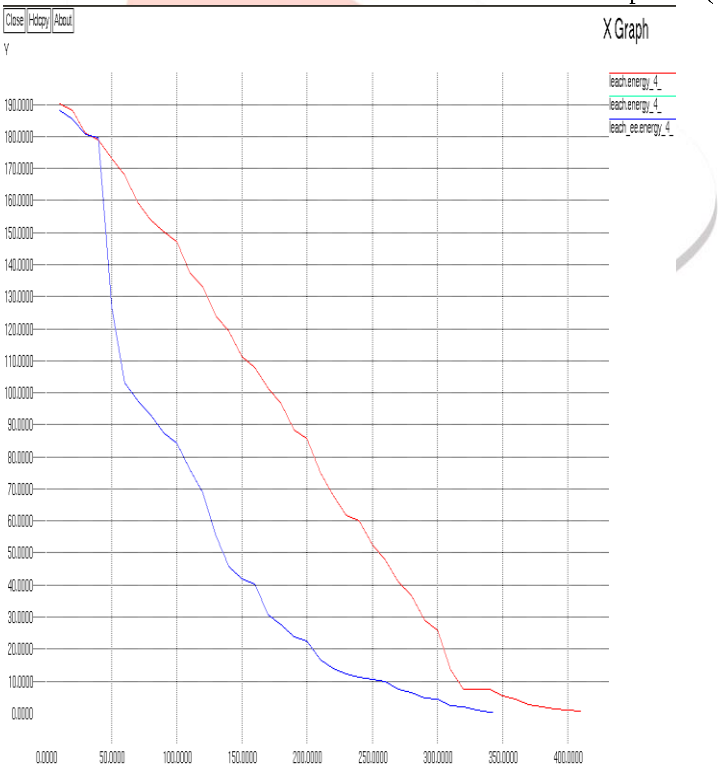

Fig 8 Comparison of network life time of LEACH EE and Advance LEACH EE at p=0.04

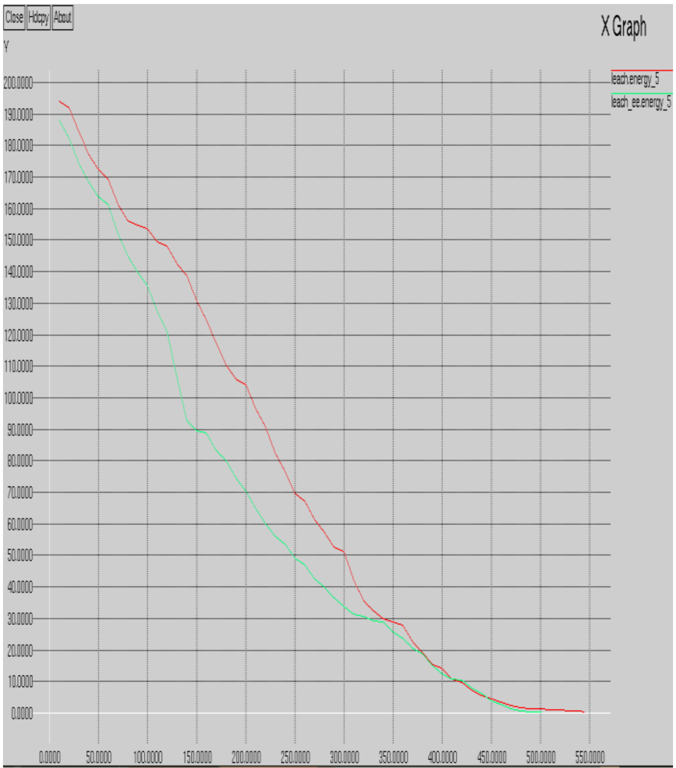

Fig 9 Comparison of network life time of LEACH EE and Advance LEACH EE at p=0.05.

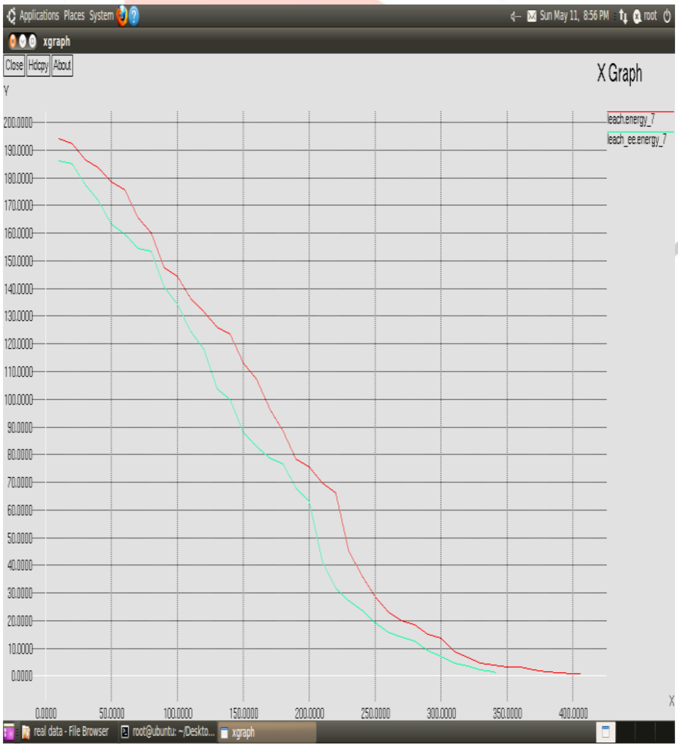

Fig 10 Comparison of network life time of LEACH EE and Advance LEACH EE at p=0.07.

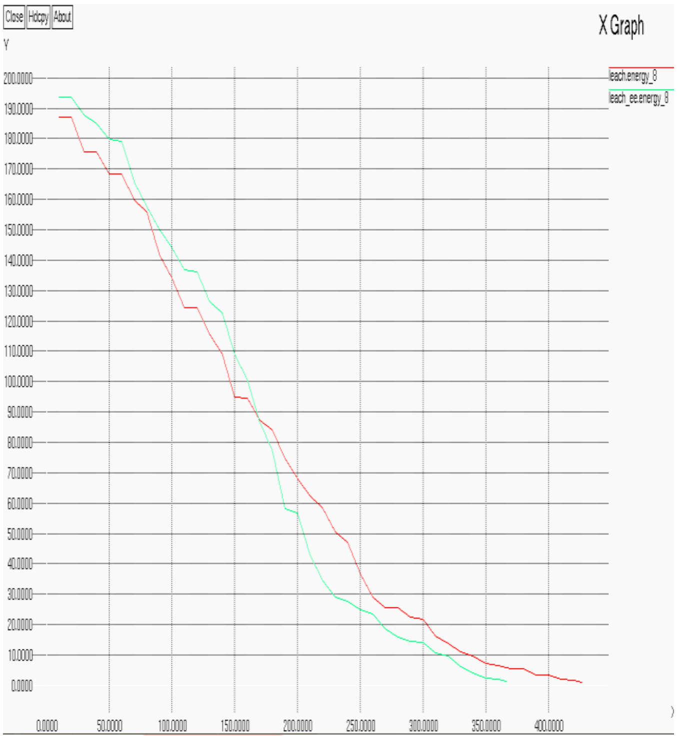

Fig 11 Comparison of network life time of LEACH EE and Advance LEACH EE at p=0.08.

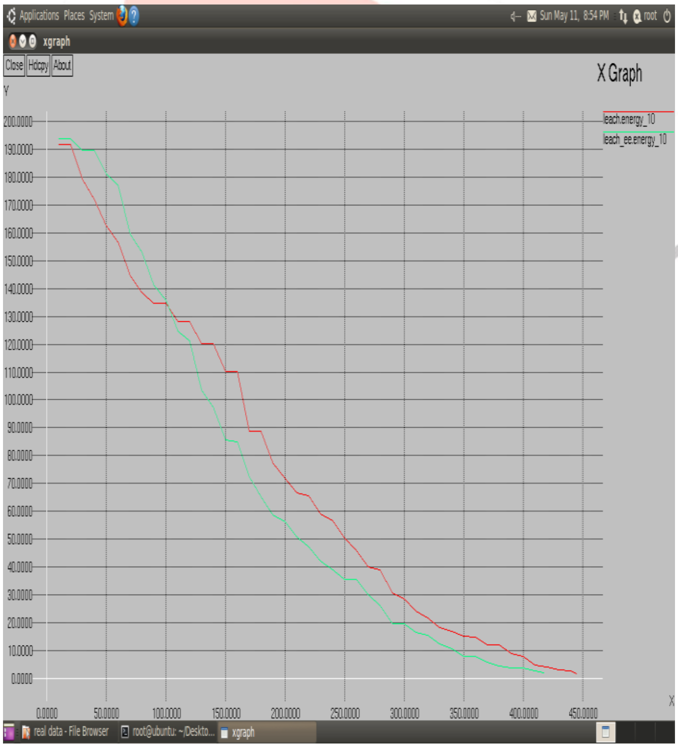

Fig 12 Comparison of network life time of LEACH EE and Advance LEACH EE at p=0.10.

Table 4 Result analysis of LEACH EE and Advance LEACH EE

Percentage probability of become CH	Network life in case of LEACH EE (sec)	Network life in case of advance LEACH-EE (sec)	Improvement in network life (%)
P=0.04	342.5	411.2	20.05
P=0.05	501.1	544.5	8.66
P=0.07	417.5	444.8	8.53
P=0.08	366.7	426.7	16.36
P=0.10	341.3	405.6	18.81

Varying percentage of become cluster head (P) in network, network life time also get affected. Also it is preferable to select appropriate P for specific network.

VI. CONCLUSION

LEACH protocol is purely random basis clustering protocol, and LEACH-EE considers nodes candidate residual energy at each round in to CH selection. LEACH-EE gives better performance as increase in percentage of CH node in round. Using average network energy and made Advance LEACH-EE has better performance than LEACH EE because it uses dynamic weight factor allocation.

REFERENCES

[1] Gautam, Navin; Pyun, Jae-Young, "Distance aware intelligent clustering protocol for wireless sensor networks," *Journal of Communications and Networks*, , vol.12, no.2, pp.122,129, April 2010

[2] Pantazis, N.A.; Nikolidakis, S.A.; Vergados, D.D., "Energy-Efficient Routing Protocols in Wireless Sensor Networks: A Survey," *Communications Surveys & Tutorials, IEEE* , vol.15, no.2, pp.551,591, Second Quarter 2013.

[3] Ming Yu; Leung, K.K.; Malvankar, Aniket, "A dynamic clustering and energy efficient routing technique for sensor networks," *Wireless Communications, IEEE Transactions on* , vol.6, no.8, pp.3069,3079, August 2007

[4] Jau-Yang Chang* and Pei-Hao Ju "An efficient cluster-based power saving scheme for wireless sensor networks" EURASIP Journal on Wireless Communications and Networking 2012, http://jwcn.eurasipjournals.com/content/2012/1/172

[5] Kang, S.H.; Thinh Nguyen, "Distance Based Thresholds for Cluster Head Selection in Wireless Sensor Networks," *Communications Letters, IEEE*, vol.16, no.9, pp.1396,1399, September 2012

[6] Sungoh Kwon; Shroff, N.B., "Energy-Efficient Unified Routing Algorithm for Multi-Hop Wireless Networks," *Wireless Communications, IEEE Transactions on* , vol.11, no.11, pp.3890,3899, November 2012

[7] W.B. Heinzelman, A.P. Chandrakasan and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks," IEEE Transactions on Wireless Communications, vol.1, no.4 , Oct 2002, pp. 660- 670.

[8] Qian Hong-yan; Chen Bing; Qin Xiao-lin, "A novel energy-efficient clustering protocol based on specific location," *Wireless Communications & Signal Processing, 2009. WCSP 2009. International Conference on* , vol., no., pp.1,5, 13-15 Nov. 2009

[9] Network Simulator -2 http://www.isi.edu/nsnam/ns/doc/index.html

[10] Ekram Hossain and Teerawat Issariyakul, Introduction to Network Simulator NS2.: Springer Science+Business Media, 2009.

[11] Heinzelman, W.B.; Chandrakasan, A.P.; Balakrishnan, H., "An application-specific protocol architecture for wireless microsensor networks," *Wireless Communications, IEEE Transactions on* , vol.1, no.4, pp.660,670, Oct 2002

[12] Munjani Jayesh H., M.Tech Thesis, "Routing Protocol for Wireless Sensor Network", Gujarat Technological University, May 2012