

# A Novel Energy Efficient Multi Level Leach Protocol with Multi Grouping at Various Levels

Greeshma Arya, D. S. Chauhan

**Abstract:** Traditionally, Wireless sensor networks (WSN) are powered by battery. Power diminish aggressively in various operations like data communication, aggregation and data compression so due to these constraints Multi hop routing becomes very promising solutions for high end applications of WSN such as defence area surveillance, monitoring of sensitive environmental conditions, also in precision agriculture, pervasive computing etc. In this paper we proposed that classic Multi Level Leach (ML-Leach) protocol can be further refined to achieve optimum utilization of energy by performing re-grouping at various levels in network considering uniform distribution of node.

**Keywords:** Cluster Head, Homogeneous, Multi- Grouping, Reliable data transfer

## I. INTRODUCTION

Conventional wireless sensor networks are generally works for different ranges from hundreds to thousands of kilometres as shown in Figure 1. The energy restrictions make the multi hopping popular among researchers. As data collected by numerous sensor nodes increases the redundant data based on common data forwarding and aggregation methods. So due to these constraints the surfeit of protocols recommends the multi hoping protocols in place of single hop protocols for long distance communication, shown in Figure 2. There is also considerable research in the area of dynamic and self configured energy efficient protocols designed for multi level wireless sensor networks. Though, the energy optimization is application specific in many cases, still we can summarize three ways to reach optimal levels for energy variables subjected to trade off among spectral efficiency and high speed.

- ❖ Reducing the amount of data processed using distinct data compression methods,
- ❖ Utilizing promising features of multi hop techniques. as they eliminates energy overheads burden created during of efficient and reliable long distance communications.
- ❖ Keeping number of operations limited to decrease total number of duty cycles.

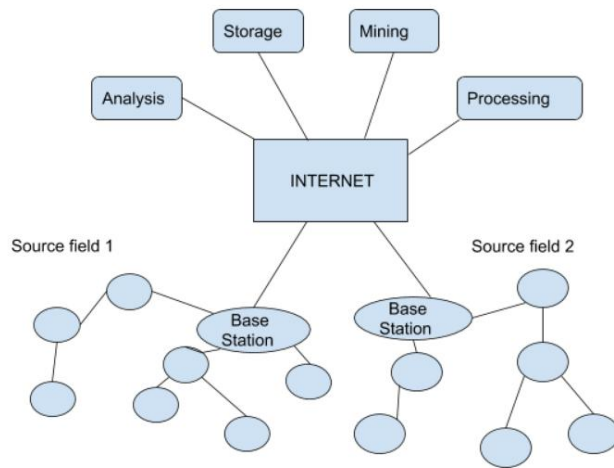


Figure 1: Wireless sensor broad purview network

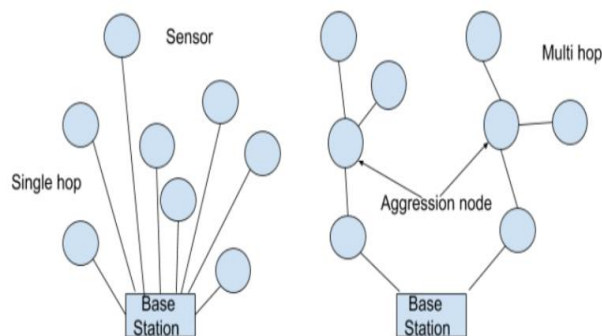


Figure2: Direct Communication (Single hop) versus Multi-hop Communication

## II. ML – LEACH PROTOCOL

Cluster based hierarchical protocol in uniformly distributed network. Protocols based on the real concept of hierarchy outperform other routing protocols. Energy is always a big constraint in designing efficient and faster routing protocols as it reduces the lifetime of network. Multi levels are introduced in cluster-based routing protocol for continuous data streaming based large network areas. The classic LEACH protocol concept is changed by partitioning clusters into levels as described in TL-LEACH [3]. Further we have profiled few nodes as cluster heads, and head-set after running selection algorithm. The nodes given the job of head-set will be accountable for control and management of the network.

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Correspondence Author:

Greeshma Arya, Department of ECE, UTU, Dehradun, India.

Email: [arya.greeshma@gmail.com](mailto:arya.greeshma@gmail.com)

Prof. D. S. Chauhan, Department of Electrical Engineering, IT BHU,

Varanasi, India. Email: [pdschauhan@gmail.com](mailto:pdschauhan@gmail.com)

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Any head-set node will collect bit streams from the adjoining member nodes and the after apply techniques for data compression and aggregation it will propagate aggregated data to the next node of next level and so on the process keeps going until the event is happening and current data is available for collection by various nodes. Now as strategic step towards saving energy sensor nodes that are collecting data and nodes that are used for network management and control can be dynamically managed to reduce the energy dissipation in handling redundant data. These strategic moves enhance network lifetime. However this increase in network lifetime comes with a compromise in of spectral efficiency of data delivered.

TL-LEACH [3] protocol is base of our proposed model and it also follows the two phase operation model as used in classic LEACH. The clusters head are elected in first phase also know as set up phase. Cluster heads communicate with base station rather than each node is allowed to communicating with base station. Due to this technique power dissipation is reduced and network sustain for more time period.

This protocol performs well for large area network where every node is far away from sink and regular monitoring of event is required, so collecting data from many distant nodes make it a costly issue in terms of power management of network.

The election of head for a cluster is done by using following equation. The participating node gives any random value which lie in a range from 0 to 1. If randomly chooses value is less than the defined  $T(n)$  value, then this node will elected as head of this cluster and other nodes will join as member nodes. The definition of threshold  $T(n)$ :

$$T(n) = \begin{cases} P & \text{if } n \in G \\ \frac{1-P*(r \bmod 1/p)}{0} & \text{otherwise} \end{cases}$$

Where  $P$  = Percentage of cluster-heads,  
 $r$  = Current round,

$G$ =Set of nodes that are

not elected in last  $1/P$  rounds.

Next phase is steady state phase in this phase data propagation and aggregation occurs.

According to radio model used to show relationship between energy dissipation and data communication can be seen in following equations. If distance between transmitting and receiving device is  $d$  then using radio model we can conclude that for small distance communications the energy consumed is proportional to  $d^2$  and for long distance propagation it is proportional to  $d^4$ . Using this model, the energy consumed to transmit an  $l$ -bit message for a longer distance,  $d$ , is given by:

$$E_T = l * E_e + E_l d^4$$

Similarly, the energy consumed to transmit an  $l$ -bit message for a shorter distance is given by:

$$E_T = l * E_e + E_s d^2$$

Moreover, the energy consumed to receive the  $l$ -bit message is given by:

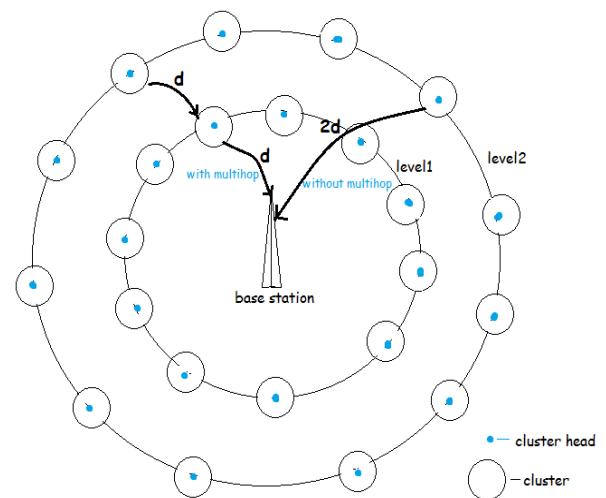
$$E_R = l * E_e$$

## III. THE PROPOSED MODEL FOR MULTI GROUPING IN ML-LEACH:

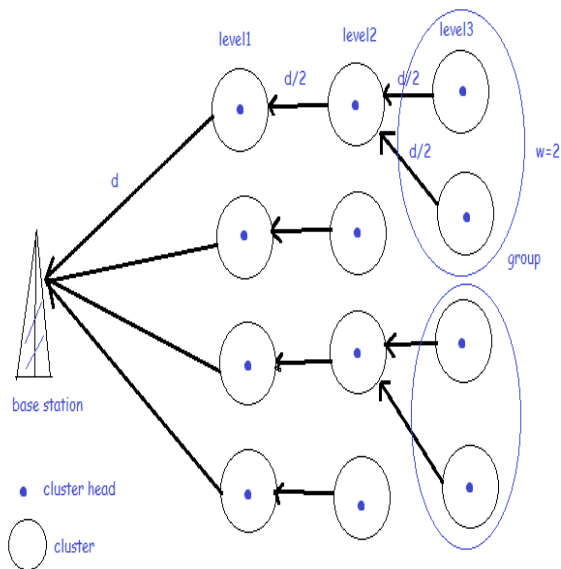
To enhance the reduction in power dissipation in long distance communication, we have introduced grouping of cluster within their levels in network. The data will be forwarded to the same CH in the upper level (super level) of network. Here we have implemented this model for 3-level LEACH. Following is the network model for multi grouping within 3-level LEACH, and parameters used in perform the test are given in table 1.

**Table 1: Simulation Parameters for various variables**

Definition of variable	Variable	Assign Value
Energy used in short distance communications	$E_s$	10 pJ /bit /m <sup>2</sup>
Energy used in long distance communications	$E_l$	0.0013 pJ /bit /m <sup>4</sup>
Energy used by transmitter or receiver circuits	$E_e$	50 nJ /bit
Energy used in data collection at sink	$E_{DA}$	5 nJ /bit
Bits in a message	$l$	4000
Total Nodes in the network	$n$	1000
Total number of clusters	$k$	5 to 60
Number of headsets	$m$	1,3
Network Diameter	$M$	100m to 550m
Levels in the network	$L$	2,3



**Figure: 3 Level LEACH Wireless Sensor Network Model**



**Figure 4: Multi Group within ML-Leach for three levels in uniform network**

Considering network uniform and divided into two levels as shown in figure 3 we can assume  $n$ =total number of nodes,  $k$ =total number of clusters,  $m$ =number of head set members,  $\frac{n}{k} - m$ = Number of nonCH nodes in a cluster. As the network is considered uniform and divided into two levels hence the number of clusters in each level will be  $\frac{k}{2}$ . For the proposed model let the nodes in Level 1 be the clusters near to the base station while Level 3 become clusters farthest  $n$  and, Level 2 be the intermediate level between level1 and level 3. Assuming  $d_1 = d/2$  = distance between the levels, where  $d$  is defined as distance between the level1 and BS. Considering the network circular area and uniform distribution therefore,

$d^2 = \left(\frac{M^2}{\pi k}\right)$  And  $\frac{k}{3}$  be the no. of cluster in each of the three levels.

Considering that  $w$  is the number of clusters in level 3 which will forward data to super Cluster Head and  $y$  be the number of cluster in level2 which will forward their own data

$$y = \frac{k}{3w}$$

As seen from the model diagram, we have 5 different types of cluster in the network, like at level 3 we have clusters forwarding their data to their immediate upper level cluster heads, at level 2. We have also assumed two types of clusters, the one who only forward their data to upper level cluster head i.e. level 1 and other type who in addition to transmitting its own data also transmits data coming from its previous level cluster heads. Similarly like level 2 we have two types of cluster at level 1; only difference is that instead of transmitting data to upper level it transmits data to base station.

Energy equation for Level 3: Election phase equation for both the CH and Non CH is same as for LEACH protocol, therefore using energy and distance relationship given as,

$$E_{3CH-ELEC} = l(E_e + E_s d_1^2) + \left(\frac{n}{k} - 1\right) l E_e$$

$$= \frac{n}{k} l E_e + l E_s d_1^2 \quad (1)$$

$$E_{3nonCH-ELEC} = (k + 1) l E_e + l E_s d^2 \quad (2)$$

Data transfer phase : CH uses energy in receiving and transmitting messages to level 2 cluster

$$E_{3CH/Frame} = (l E_e + l E_s d_1^4) + \left(\frac{n}{k} - m\right) l E_e + \left(\frac{n}{k} - m + 1\right) l E_{dA}$$

Energy consumed by nonCH in transmitting messages to CH

$$E_{3nonCH/Frame} = l E_e + l E_s d_1^2$$

$$f_1 = \frac{1}{\frac{n}{k} - m + 1} \times \frac{1}{k}$$

$$f_2 = \frac{\frac{n}{k} - m}{\frac{n}{k} - m + 1} \times \frac{1}{k}$$

Here  $f_1$  and  $f_2$  are the fraction of frames transmitted by CH and nonCH nodes respectively.

$$E_{3CH\_data\_frame} = f_1 N_f E_{3CH/Frame}$$

$$E_{3nonCH\_data\_frame} = f_2 N_f E_{3nonCH/Frame}$$

where  $N_f$  is the total number frames in the network given. Calculating total energy at level 3

$$E_{3CH/iter/cluster} = E_{3CHElec} + E_{3CH\_data\_frame}$$

$$E_{3nonCH/iter/cluster} = E_{3nonCHElec} + E_{3nonCH\_data\_frame}$$

Hence start energy of the one cluster at level 3 is given by,

$$E_{3start} = \frac{1}{m} [E_{3CH/iter/cluster} + E_{3nonCH/iter/cluster}]$$

And total energy consumed by one cluster at level 3

$$E_{3C} = E_{CH/frame} + \left(\frac{n}{k} - m\right) E_{nonCH/frame}$$

Total energy of clusters at level3

$$E_{3level} = \frac{k}{3} E_{3C} \quad (3)$$

Similarly we can calculate Energy equation for Level 2:

So total energy of clusters at level2 is given by this

$$E_{level21} = \left(\frac{k}{3} - y\right) E_{21c} \quad (4)$$

Clusters who will transmit their own data as well as data incoming from level 3 to level 1 cluster and  $y$  are the total number of such cluster at level 2

$$E_{22CHElec} = \frac{n}{k} l E_e + l E_s d_1^2$$

$$E_{22nonCHElec} = (k + 1) l E_e + l E_s d_1^2$$

Hence start energy of the one cluster of this type at level 2 is given by,

$$E_{22start} = \frac{1}{m} [E_{22CH/iter/cluster} + E_{22nonCH/iter/cluster}]$$

$$E_{22C} = E_{22CH/frame} + \left(\frac{n}{k} - m\right) E_{22nonCH/frame} \quad (5)$$

Total energy of clusters of this type at level2

$$E_{level22} = y \times E_{22C} \quad (6)$$

Energy equation for level 1: Clusters that will transmit their own data only to base station and  $\frac{k}{3} - y$  are the total number of such cluster at level 1

$$E_{11CHElec} = \frac{n}{k} l E_e + l E_s d_1^2 \quad (7)$$

$$E_{11nonCHElec} = (k + 1) l E_e + l E_s d_1^2 \quad (8)$$

Data transfer phase:CH uses energy in receiving and transmitting messages to level 1 cluster

$$E_{11CH/frame} = 2(l E_e + l E_s d_1^4) + \left(\frac{n}{k} - m + 1\right) l E_e + \left(\frac{n}{k} - m + 1\right) l E_{dA}$$

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Total energy of clusters of this type at level 1

$$E_{level11} = \left(\frac{k}{3} - y\right) \times E_{11c} \quad (9)$$

Hence start energy of the one cluster of this type at level 1 is given by,

$$E_{12\text{ start}} = \frac{1}{m} [E_{12\text{ CH/iter/cluster}} + E_{12\text{ nonCH/iter/cluster}}]$$

$$E_{12c} = E_{12\text{ CH/frame}} + \left(\frac{n}{k} - m\right)E_{12\text{ nonCH/frame}}$$

Total energy of clusters of this type at level1

$$E_{level12} = y \times E_{12c} \quad (10)$$

Therefore, complete energy of the network can be written as considering all levels,

$$E_{level} = E_{level3} + E_{level21} + E_{level22} + E_{level11} + E_{level12}$$

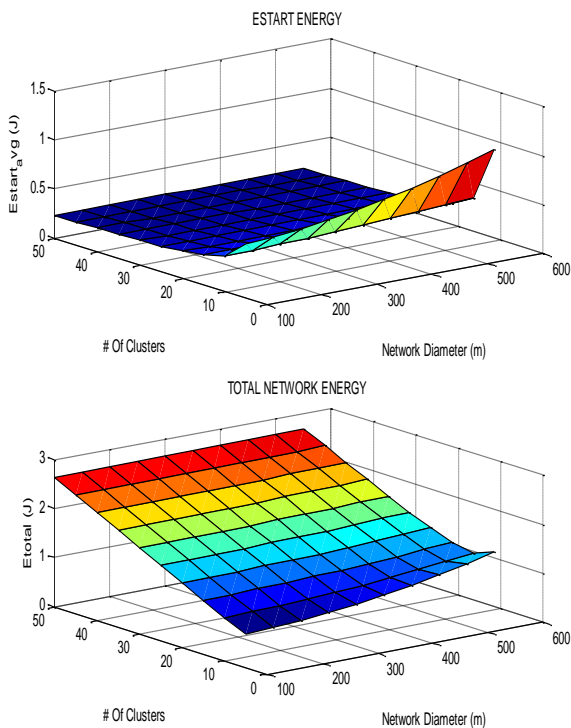
(11)

Average start energy required by the network is given by,

$$E_{start\text{ avg}} = (E_{3\text{ start}} + E_{21\text{ start}} + E_{22\text{ start}} + E_{11\text{ start}} + E_{12\text{ start}}) / 5 \quad (11)$$

## IV. RESULT

This reduction in energy consumption is achieved by implementing multi group within ML-Leach and it can further be decreased by increasing the value of w.

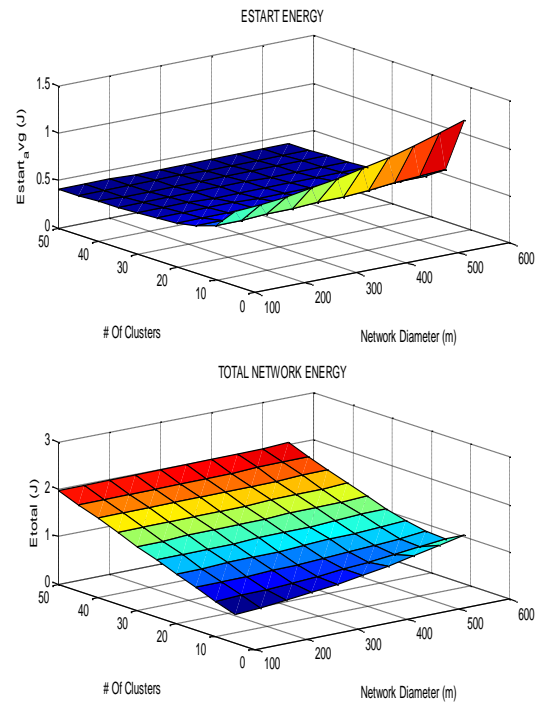


**Figure 5: Multi level with super data forwarding for value, w=1**

Figure 5 and 6 show the comparison between multi level with super data forwarding for w=1 and w=2 respectively. Parameters used are same as discussed above. Figure 4 shows proposed protocol for 3 levels and m=3. Results clearly shows for changing w from w=1 to w=2, total network energy reduces about 24.5 %.

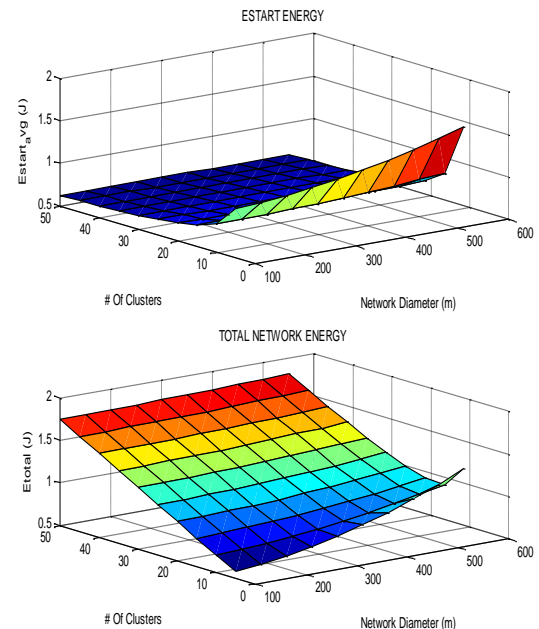
Additionally, figure 5 and 6 also depicts that start energy per node increases about 27.7% as we go from w=1 to w=2. This increased start energy per node is justified because super cluster heads perform transmission for number of

packets. Here the redundant data during data aggregation is discarded that optimized per node energy. This is a trade off between network energy and node performance.



**Figure 6: Multi level with super data forwarding for value, w=2**

Here Figure 7 depicts that 22.5 % total energy of network is reduced and 26.08 % start energy per node is increased which is justified for same reasons as discussed above. Results are provided for w=1, 2, 3.



**Figure 7: Multi level with Super Data Forwarding for w=3.**

Figure 8 shows the number of optimum clusters for proposed protocol when used for 2 levels and different head set sizes ranging from 0 to 60. It shows optimum number of clusters for proposed protocol.

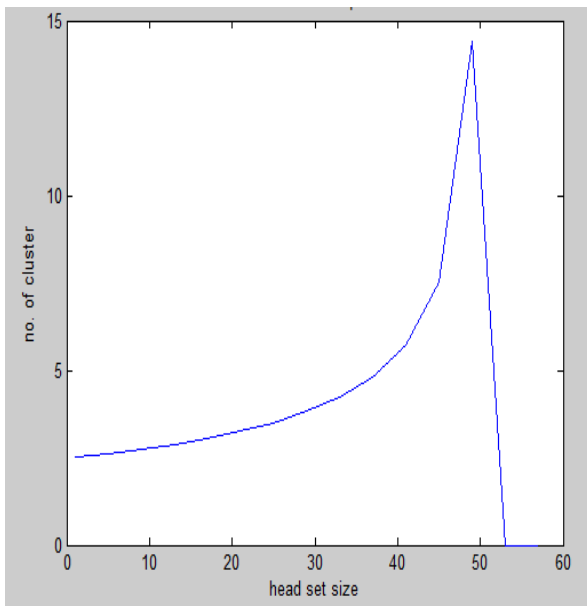


Figure 8: Optimum no. of clusters in 2 levels protocol

## V. CONCLUSION

After viewing results we can conclude that this partitioning and re grouping in network layer is a promising solution for developing energy efficient routing protocols for large hierarchical networks which comprise widespread nodes and requires continuous monitoring of event considering reliable data transfer and aggregation. .

## APPLICATIONS

A list of high end applications of wireless sensor networks follows.

- ❖ Home appliances automations
- ❖ Automated delivery of services
- ❖ Vehicle tracking system globally
- ❖ Smart city modelling
- ❖ Tracking and monitoring any industrial area.
- ❖ Surveillance in defence and isolated areas
- ❖ Drug administration
- ❖ Forest fire detection
- ❖ Weather/ Seismic / Tsunami forecasting
- ❖ Nuclear/ Radioactive plant surveillance
- ❖ Chemical industries for supervision

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## AUTHORS PROFILE



**Ms Greeshma Arya**, received her B Tech in Electronics and Instrumentation Engineering from Lucknow University, and M Tech in Digital Communication from AKTU, Lucknow. She has more than 10 years of teaching experience. Her area of research are electronic circuits and wireless communication. She has authored 8 research papers in refereed international Journals and another two are accepted for publication in scopus journals. Presently she is working as assistant professor in ECE department with IGDTUW, Delhi.



**Prof. D S Chauhan**, born on 18<sup>th</sup> September, 1949 at Dholpur (Rajasthan), was Vice-Chancellor, U.P. Technical University (2000-06), Lovely Professional University (2006-07), Jaypee University of Information Technology (2007-09), Uttarakhand Technical University (2009-13), Chairman, BOAT(NR), Kanpur had his post doctoral work at Goddard Space Flight Centre, Greenbelt Maryland, USA and B.Tech. (1972) IIT.B.H.U., M.Tech (1978) N.I.T., Tiruchirapalli, and Ph.D (1986) IIT, Delhi. He has served at Banaras Hindu University since 1979 till April, 2013 began as Assistant Professor then Associate Professor and the Professor. He has served Director, KNIT (State Govt. Engg. College), Sultanpur (1999-2000). He was Member of AICTE (2001-04) and member, University Grants Commission (2006-09). Lead delegation NAFSA 2009 Indian team to USA. He has produced 41 Ph.D. and 2 D.Sc. and published 267 research papers in International and National Journals and Conferences.