ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

EECLA: CLUSTERING AND LOCALIZATION TECHNIQUES TO IMPROVE ENERGY EFFICIENT ROUTING IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Wireless sensor network is an efficient technology in coming future. The main problem of the WSN is consuming energy hence poor energy efficient routing. As per our survey we found that to perform poor routing is localization problems with respective to the clustering of the cells in the network. Hence we proposed a clustering and localization techniques for improving an efficient energy routing methods. We hope proposed methods given better solutions than the existed techniques for more energy consumption and inefficient localization problems. This research aims to optimize the energy consumption of wide scale wireless sensor networks. This paper performs the survey on results, comparison and analysis of the different existed works from, we feel confident to prove our work is better by work on load balancing of each cell in the network, measurement of node, cells overall availability and it is related to energy with respective to the distance and data transfer, deal with the nodes in between two clusters and finally make all nodes die almost at the same time by using an adaptive system for solving these problems. We got confidant that this work improves the energy conservation with 94% regards to the original LEACH Algorithm, clustering and localization techniques. Finally the results are shown and compared to the existed LEACH, clustering and localization approaches.

Keywords: *Wireless sensor networks, clustering, localization, LEACH, EECLA, CLAEER.*

1. INTRODUCTION

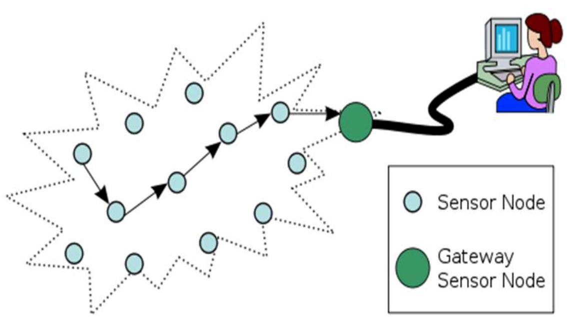
As the technology spreads widely in terms of computers and communication era; the communication through networks for exchange of data, data transfer, maintenance and management of data played good role. The wired networks performed well in this regard still few issues are there from the user suffered a lot like compatibility, rate of speed, efficiency, mobility, routing, Data base centric, deployment, coverage, base stations and finally quality of services. Hence the solution for these problems can be fixed most by using wireless sensor networks.

WSN service better than wired nets still WSN suffers from energy efficient routing and localization problems which causes poor

performance in all respects. Many techniques proposed like LEACH and its consequents, which solved it some extent with respective to few based criteria's. Any how we tried it for little, got better solutions in our research. Any how we are not giving details of that at this context since this paper focuses of the survey on different existed works, studies which proved solutions for the mentioned problems. During this survey we got abundant knowledge which may be useful to proceed further our work. In this survey we have under gone many algorithms and other researcher works which helped us to give better solution through our research work.

2. WSN

A wireless sensor network (**WSN**) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions. A **WSN** system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes (see Figure 1).



Source: From Google images

The WSN contains nodes which are used for hopping data from one to each other is called "NODE" with a set of protocols. The connection and cooperation of large number of nodes makes a rigid network with high capabilities and specifications [1]. This networks type is currently deployed to be used in wide range of applications with a suitable cost with respect to its prospective [2]. The wireless sensor networks major rule is to measure specific field and logging its measurements to a host, and this is the most application that known and directly used.

From the other hand, cancellation of large hardware installations and cabling, reduces significantly the cost of maintenance, neither emergency maintenance nor proactive maintenance. Over that, the outdoor installations, especially cables, almost are subjected to be stableman. This topology of wireless sensors reduces the probability of stalling the equipment and hardware, because of no use of cables [3]. The wireless sensor nodes also, don't require communicating directly with the nearest control tower which is high power or even don't require directly communicating to the base station. But it communicates with the nodes local peers only. Thus, this connection will be a pear-to-pear connection making a mesh network. The mesh architecture implies a flexible networking of hopping branches. And the system is very adaptive for node failure substitution and compensation [4]. WSN establishes "Routing Topology" or "Network Topology". The mount of sensors can be extended from tenth or hundreds to thousands in some cases [5]. The main objective of this paper is to perform and compare to get the best solution for the mentioned problems in the paper by conducting an intensive survey.

3. LITERATURE SURVEY

Many researches were submitted in the past few years concerning the wireless sensor networks issues, and specially, communication and control protocols. Those researches include energy management and power consumption, optimal clustering, communications structure and topology, etc. Here down, major researches, those with core related to this proposed thesis.

Table.1 Different deploment techniques

Technique	Algorithm	Deployment Method
Sensor node Deployment	Howard *et al.* [16]	Deployment of a mobile nodes in an unknown environment.
	Heo *et al.* [17]	Deployment of mobile sensor nodes in the region of interest.
	Dhillon *et al.* *1*[28]	Probabilistic optimization of number of sensors.
	Zou *et al.* [19]	Virtual force algorithm as a sensor deployment strategy.
	Wang *et al.* [10]	Deployment problem using the Voronoi diagram approach .
	Lin *et al.* [11]	Near-optimal deployment to achieve complete coverage.
	Liu *et al.* [12]	Power-aware sensor node deployment.
	Poe *et al.* [13]	Considering coverage, energy consumption, and delay.
	Park *et al.* [14]	Nodes deployment using Fuzzy C-means algorithm.
Base Station Deployment	Pan *et al.* [3, 4]	Minimum Enclosing Circle with lower and upper bound.
	Bogdanov *et al.* [18]	Minimizing power consumption of sensor nodes.
	Efrat et al. [9]	Approximation schemes for locating a base station.
	Wong *et al.* [10]	Binary integer programming for base station placement.
	Akkaya *et al.* [5]	Dynamic positioning of base station to increase network lifetime.
	Basheer *et al.* [11]	Receiver placement using reducing localization error.
	Paul *et al.* [6]	Using geometrical approach for maximum lifetime.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table.2. Different localization Techniques

Technique	Algorithm	Localization Method
Anchor Based Localization	Priyantha *et al.* [4]	Localization using time diff of arrival (TDoA).
	Doherty *et al.* [5]	Semi program based localization.
	Savvides *et al.* [6]	Localization using collaborative Multilateration.
	APS [7]	Localization using angle of arrival.
	APIT[8]	Approximate PIT Test using neighbor information.
	Meertens *et al.* [9]	Localization using inter node distance.
	Peng *et al.* [10]	Localization using angle of arrival.
	Cheng *et al.* [11]	Localization using MDS and proximity distance mapping.
	Huang *et al.* [12]	Localization using Monte Carlo method.
	Basheer *et al.* [13]	Localization using stochastic tunneling.
Anchor Free Localization	Bulusu *et al.* [7]	GPS-less low cost outdoor localization.
	ABC [9]	Assumption Based Coordinates (Solved geometrically).
	SPA [8]	Localization using distances be- tween the nodes.
	AFL [10]	Anchor Free Localization using hop count.
	Moses *et al.*[11]	Localization using time-of-arrival and direction-of-arrival.
	Moore *et al.* [14]	Localization using robust quadrilaterals.
	KPS [15]	Knowledge-based Positioning System.
	Basheer *et al.* [16]	Localization using receive error factor and diversity.
	MSPA [7]	Matrix transform-based Self Positioning Algorithm.
	Wang *et al.* [8]	Cluster based localization using residual energy and node degree.
	Basheer *et al.* [9]	Localization using cross correlation of shadow fading noise and copulas.

The evaluation metrics includes a key variables that should be monitored and recode its validity. Those variables describe the capabilities of the wireless sensor networks and include Cost, Power ,dissipation, Coverage, The ease to use and deploy, Life time, Security, Accuracy, Effective sampling rate, Response time.

Table.3. Different clustering algorithms

Algorithm	Clustering Rule
LEACH [1]	Random probabilistic clustering.
LEACH-C [2]	Centralized clustering algorithm to produce better clusters.
LEACH-F [2]	Clustering with fi ed number of clusters.
TEEN [12]	Total number of transmissions are reduced by allowing the nodes to transmit only when the sensed value less than a threshold value.
APTEEN [13]	New TDMA schedule is introduced to avoid collisions of close-by nodes which fall in the same cluster. As these nodes sense similar data and try to send their data simultaneously.
PEGASIS [14, 17]	Each node communicates only with a close neighbor and takes turns in transmitting to the base station, thus reducing the amount of energy spent per round.
HEED [15, 16]	Cluster heads are selected periodically according to a hybrid of the node residual energy and node proximity to its neighbors or node degree.
EECS [16]	Clustering based on residual energy through local radio communication while achieving better cluster head distribution.
Hansen et al. [13]	Clustering for large sensor networks using a minimum separation distance.
TB-LEACH[10]	Nodes which have the shortest time intervals from randomly selected time interval by nodes will win the competition and become cluster heads to ensure that the partition of cluster is balanced and uniform.
EEHC [11]	Cluster head selection based on weighted election probabilities according to the residual energy in each node. Heterogeneous topology is assumed.
EECED [12]	Nodes with more residual energy have more chances to be selected as cluster head.
IB-LEACH [11]	Clustering using characteristic parameters of heterogeneity.
MMCR [12]	Multi-interface multi-channel routing for enhancing capacity of wireless sensor network.

4. RELATED WORK

Many researches were submitted in the past few years concerning the wireless sensor networks issues, and specially, communication and control protocols. Those researches include energy management and power

consumption, optimal clustering, communications structure and topology, etc. Here down, major researches, those with core related to this proposed thesis. Many researches were submitted in the past few years concerning the wireless sensor networks issues, and specially, communication and control protocols. Those researches include
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As new fabrication and integration technologies reduce the cost and size of micro-sensors and wireless interfaces, it becomes feasible to deploy densely distributed wireless networks of sensors and actuators. These systems promise to revolutionize biological, earth, and environmental monitoring applications, providing data at granularities unrealizable by other means. In addition to the challenges of miniaturization, new system architectures and new network algorithms must be developed to transform the vast quantity of raw sensor data into a manageable stream of high-level data. To address this, we propose a tiered system architecture in which data collected at numerous, inexpensive sensor nodes is filtered by local processing on its way through to larger, more capable and more expensive nodes. We briefly describe Habitat monitoring as our motivating application and introduce initial system building blocks designed to support this application. The remainder of the paper presents details of our experimental platform.

PROBLEM DEFINITION AND MOTIVATION

The wireless sensor depends on its battery to run along its life time, thus, the life time depends on the consumption of the power. This is related to many variables, including the distance between the sensor and the head of cluster, the transfer packet size, the energy slope of that sensor which is related to its physical measuring structure, and other effects. From that, the problem of energy optimization in wireless sensor networks is important case for the modern researchers, and taken into place for all manufacturers and developers of such systems. Whereas, the main issue of this problem - from computer systems and information technology side is the clustering of the wireless sensors network.

By developing a good new adaptive clustering algorithm EECLA (Energy Efficient Clustering and Localization Algorithms) of the network, it can be save energy by 93% or more in large scale wireless sensors network related to the original LEACH Protocol.

This paper focuses on adaptive energy conservation and optimization in the wireless sensors networks. Hence, the wireless sensor depends on its battery, the energy and power consumption is so critical in such applications. The power flow of the wireless network should be balanced in order to get symmetrical power dispatch in the overall transfer period. This research focuses on making the energy losses in all sensors approximately equals. This is done by balancing the transfer and introducing new clustering technique.

When clustering and dividing the sensors of the wireless network into clusters, some sensors can be added to more than one cluster without damage the cells and with correct clustering processer. Thus, this research developed a new methodology and technique of wireless sensor networks clustering. This clustering is fuzzy-clustering based. And comprise variable clusters every transfer process. Where, the clusters and also, the head of cluster, are being changed every transfer process. And this thesis also, introduces a new concept in distributing sensor (nodes) on the cells (clusters), depending on the potential of the cluster. The potential of the cluster is an introduced and adapted variable that included implicitly all physical variables those affect the energy dispatch and transfer of the network. Finally, this research in determined concept, concentrate on deploying wireless sensor networks clustering procedure that ensures all nodes to be dead in a time limit approached to zero. The result of the introduce protocol will be compared to LEACH, LEACH-M, and LEACH-L methodologies.

5. s

LEACH is acronym regards "Low Energy Adaptive Clustering Hierarchy". The hierarchal clustering was introduced by Heinzelman. It clusters all nodes of the network into clusters (cells) where each cell has center called "head of cluster". In such protocol, each node transmit its information to the head of cluster, and it collects the data from all cluster's nodes, then, it compress and format the data before sending it to the base mobile station [2]. The cluster's head consumes more power than other sensors, because of the load on it. The load is subjected to collecting data from all nodes, formatting data, sending and receiving data from base station. This needs to make the CH to have max power or energy than other sensor nodes. The LEACH, uses random selection of the head of cluster, so, it may not be the maximum energy node. The LEACH protocol rotates the node that is selected as head of cluster when its energy becomes low after a threshold value [16].

Proposed System

We proposed an algorithm called EECLA (Energy Efficient Clustering and Localization Algorithm).Starting by network data collection, it includes the calculation, determining the energy of each sensor and the initial nodes clustering (distributing on the cells) over the measurement space and initialization. The initialization is plotting the location of each sensor in measurement space and applying (FCM) traditional clustering algorithm to get the starting location of the head of each cluster. That done after receiving the number of clusters that is needed to be used for cells from the base station.

The next is to start the EECLA clustering procedure, which is continue overall running period of the network. During this mode, the network is re-clustered every transfer time and re-localizes a new head of cluster and new distribution of nodes (sensors) in the cells (clusters). When the nodes start to die, the base station should stop collecting data from the network and generates the decision and command to replace the sensors.

Clustering

Nodes classification in clusters (cells) is the core of the LEACH protocol and its extensions (i.e. LEACH-M, LEACH-L). In general, grouping a set of points (nodes) into cells or clusters is interested methodology in modern applications and researches, especially, in networking and scalability of the networks. The grouping a bulk of nodes into clusters is highly dependent on the deployment specifications, system's architecture, scheme of bootstrapping, cluster characteristics, etc. The center of the cluster is commonly known as Head of Cluster "CH". The head of cluster is

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

one of the cluster's nodes. The number of nodes in one cluster is almost differs from it in the other clusters. Where the head of cluster can form in some systems a second tier of the network and thus, another hieratical level can be formed, or it may be just the data to another point [8].

The clustering in theory has many advantages in addition to the network scalability support. Also, it minimized the routing table's size that stored at individual nodes, and allows to safe the bandwidth of the communication because it limits the cluster interactions scope to the head of clusters, the redundancy avoiding would result and change among nodes is being enabled.

The Proposed Clustering Algorithm

The EECLA is an adaptive developed structural algorithm that locates the head of cluster by cluster centroid localization of data set that consists of geometric distribution of sensor-nodes in x-y plan or even capable to be used in 3-D space of sensing. EECLA is based on the original Fuzzy C-mean algorithm of clustering data in 2-D plan, and improving it that by the use of "Potential" concept of the networks nodes and clusters. When calculating the overall sensor-nodes potential to the centroid that is being obtained from FCM, the nodes will be distributed into clusters easily

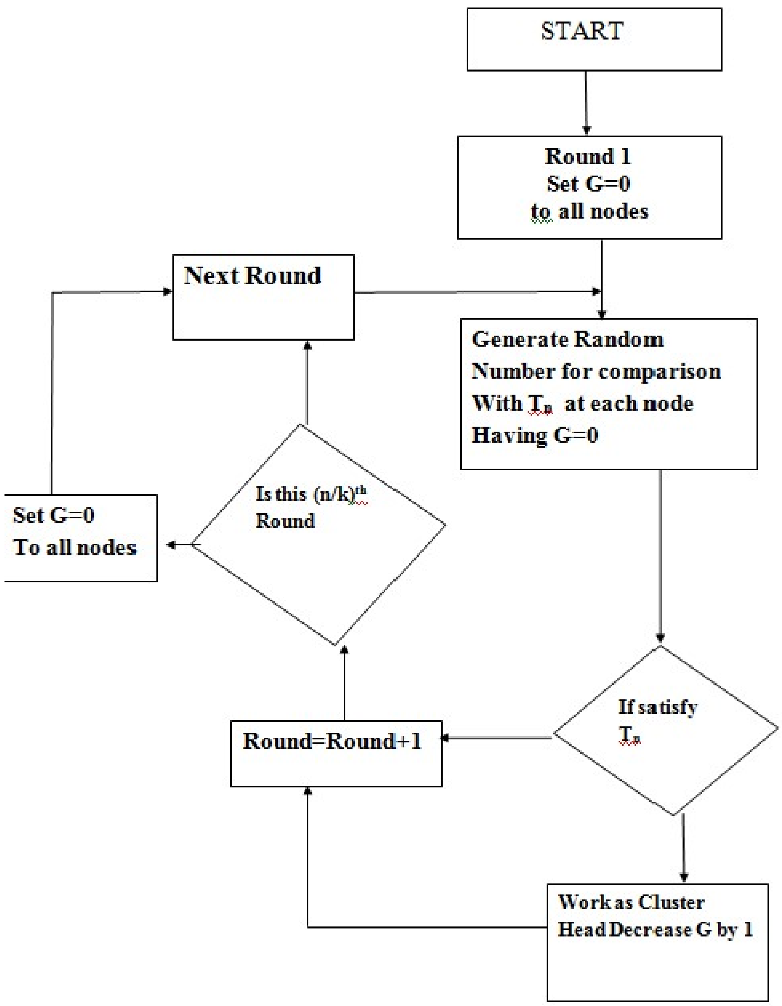


Fig.1. EECLA Algorithm Model

by the mean of its potential not Euclidean distance.

In the contributed EECLA algorithm, once the potential of each node is calculated, the head of cluster (CH) will be localized via the traditional FCM algorithm. The clustering process will follow the last centroid (head of cluster) determination phase. This will be determined and localized using the current suggested modification (addition) to the fuzzy approach of clustering. The developed procedure in this thesis will generate clusters that are equivalent in potential. Equation 3.2 expresses the contributed potential mathematical form.

$$P = \frac{1}{Eq} + \frac{1}{Er} - d \; X \; Tq - k$$

Where: P is the Potential.

Eq: is the Euclidian distance.
Er: is the total remaining energy in the sensors battery.
D is the transmission data cost function.
Tq is the energy slop of transmission data.
K is the battery self-leakage.

This above equation calculates the potential of the node, and it represents a non-linear relation between the Euclidean distance, and the sensor's current working energy (which is the maximum initial energy minus the running cost energy), in addition to the energy cost (assumption) of each data bit; the energy consumption is known as (energy slope). When the potential is taken into consideration, the specification of internal battery surely has leakage. Its leakage is represented by the Equation below equation.

$$d(p,q) = d(q,p) = \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}$$

The above equation illustrates how to calculate the Eq.Dist between target point "q" and destination pint "p". Here the distance is "d". The destination point may be the head of cluster or normal node [9] The proposed methodology of the thesis consists of three phases. The bulk network of sensors should be divided into clusters and that process is so called "Clustering". The thesis assumed to use the fuzzy logic approach of clustering by what is called C-mean. The phase one distribute the sensor points into separate clusters, each cluster has its own head. That clustering is potential-based as illustrated in this chapter above. The below equation is being used to calculate the contributed potential.

$$Pc = \min(Pco \sum(Pco - 1) + (Pco + 1))$$

This research is a novel clustering algorithm for improving the conservation of energy in WSN's.
Hence, the asymmetry of clusters (cells), the nodes will consume asymmetrical power, due to the asymmetrical structure, design, and pocket data transfer. While, it can be managed to balance the cluster's load by introducing a specific variable or concept that can express the overall load of the cluster and also node. Whereas this variable or concept should be mathematically and physically meaningful for all conditions and variables that affect the sensors battery and cluster communication transfer. This variable or concept is so called in this thesis "POTENTIAL".

This thesis, introduces the "POTENTIAL" concept of the wireless sensors network. The potential of the node represents the availability of that node (sensor) to transfer data and for how long a time. The POTENTIAL of the cell is the availability of the cluster of sensors to measure and send data for a how long time. In thesis, the symmetry of all clusters (Cells) enables all clusters to work in the same time long. Thus, all clusters will start to die at the same time. This ensures that, no cluster work and other die.

Also, the symmetry inside the cluster, make to whole network nodes work in the progress together for a time long, and the all nodes will start in death in the same moment. This ensures a time interval for nodes death to be approaches zero. The symmetry of the clusters and nodes can be achieved in different methodologies. This paper use three methodologies and techniques to perform this approach. The first one is to re-cluster all networks continuously after each transfer process. Although, this will increase up the computational power, but this rise is always negligible with comparison of optimization. The second technique is to make the head of clusters to be variable, and all heads of clusters are being changed continuously over the time after each data transfer process seemingly.

While, the third technique is to deal with specific sensor nodes, whose represents sensors located in between two – or more – clusters. Those sensors can be added in clustering process to any

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

one of the clusters those the nodes located near to it without any big change in cell load. The "in between" nodes is a good concept to handle. The calibration of cluster balance can be done by controlling those nodes in order to fine tune the POTENTIAL of the clusters. The small change of cluster's potential can be tuned using those nodes interestingly. Fuzzy logic clustering is an intelligent method to distribute the nodes over the cells or clusters, but its result is always generated Not-Equal sizes clusters and also, Not-Equal Potentials.

This thesis introduced and implemented a new modification on the fuzzy C-mean clustering algorithm. This modification uses the POTENTIAL to distribute the nodes over the cells (clusters). The fuzzy C-mean clustering is used to determine the initial nodes those can be represented as "head of clusters" and the modification of the algorithm is to retest each node and add it to the appropriate cluster by POTENTIAL.

The fact that, if we got symmetrical clusters by POTENTIAL over the time of data transfer, then all nodes and clusters will start to die and die in the same time, leads to implement the variable clustering algorithm. This clustering includes re-locating the head of cluster after each transfer of data process, and then re-clustering all data.

6. RESULTS

Performance Evaluation

This Thesis developed MATLAB program to experiment and simulate EECLA algorithm and getting the results. In such, two assumed areas are used for testing the protocol. The wireless sensor networks are distributed in the two scope areas individually and both are tested, and the parameters measured individually. The "round" concept represents a complete transmission process over running of the wireless sensors network.

The first scope is 300 by 300 m, where the second is 500 by 500 m. Initial conditions and test conditions are illustrated in the below tables.

The test will consider almost on the energy optimization measurements with respect to a LEACH, LEACH-M, and LEACH-L protocols. The result will be compared and given in the table 3.

Table 4. Simulation Parameters

Parameter	**Test conditions 1**	**Test conditions 2**
Network validity scope"m"	300 by 300	500 by 500
No# of wireless sensors	900	2500
Energy at Starting	0.5J	0.5J
E (J)energy parameter	1	1
Transmission packet length "bits"	4000	4000
$E_{(DA)}$ (Energy required for data aggregation)	5×10^{-9}	5×10^{-9}
P(cluster-head section probability used during cluster creation)	0.1	0.1
M(Multipath-Fading)	0.1	0.1
D (distance between transmitter and receiver)	70m	70m
Transmission-Distance(m)	30	30

Table 4 illustrated the assumed parameters that have been implemented in simulation for testing purpose. Those parameters are selected in order to make the comparison between the EECLA protocol and the other LEACH protocols more meaningful. Thus, the new modifications, improvements, and optimization – especially in energy – are clearer in the Figures.

Journal of Theoretical and Applied Information Technology
15th January 2018. Vol.96. No 1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

The trends and Figures illustrated the energy scope and performance. The energy consumption will be shown in Figures to show how the energy is being consumed. The dead node trends show the node activity until it died. The overall nodes death displays the performance of the network optimization.
The testing of EECLA is done in two topological scenes; the first is over 500 by 500 meters, while the other comprises 300 by 300 meters.

Experimental Result

From the Figures bellow, it's easily and clearly to see that, the contributed Energy Efficient Clustering Algorithm "EECLA" comprises the minimized power consumption via time unit. So, the backup power of the sensors will be saved for longer time.

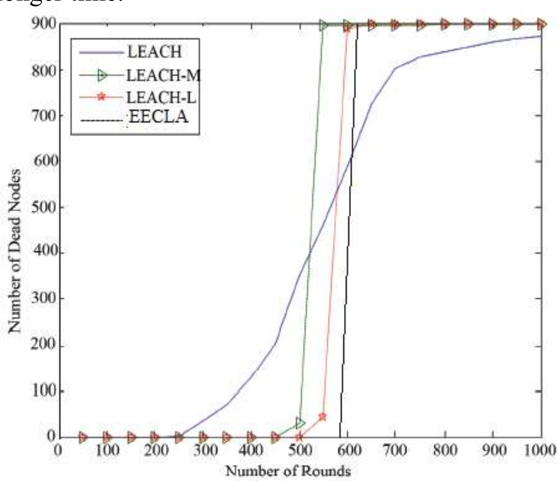
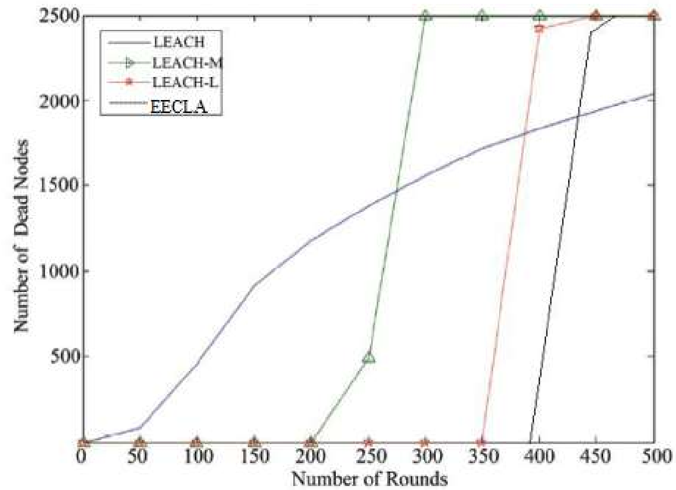


Figure 2. Nodes Death over 300 x 300 round in different protocols.

The cycle across the total running time of the network of 300X300 m results are displayed in Figure 4. From the Figure, it's clear that, the nodes using the EECLA algorithm are running for more number of cycles than the others and the death of the nodes is very balanced in the contributed EECLA algorithm. While in comparison to other LEACH schemes, there is a larger interval. Again, that cause to save more



power and energy by prolong the nodes running time.

Figure 3. Dead Nodes over a round of 500 x 500 in different protocols

Whereas Figure 3 displays the nodes death scheme for an area of 500 by 500m. It can be shown that EECLA algorithm has two benefits: The system is running for more number of rounds than using other LEACH protocols and the time death interval between the first and last node is the shorter than others. So EECLA system can minimize the death nodes interval, reduce the power consumption, save more energy and prolong the lifetime of the nodes.

7. ENEGRY CONSUMPTION MODEL

Before discussing the energy consumption model, understanding of cluster is important. Clustering (see Fig.1) is a process of grouping nodes using an algorithm to perform certain tasks efficiently as per the requirements. Clustering can also be used to divide the topology into sub-regions based on certain criteria e.g. whole area should be covered, minimum energy consumption, maximum lifetime.

$$E_{TX}(N_i, d_i) = \begin{cases} N_i.E_{elec} + N_i.\epsilon_{fs}.d_i^2 & if \quad d_i < d_0 \\ N_i.E_{elec} + N_i.\epsilon_{mp}.d_i^4 & if \quad d_i \geq d_0 \end{cases}.$$

Table.5.Energy optimization of different clustering algorithms

Algorithm	Energy Optimization Percent
EECLA	96%
EECA	93%
LEACH-M	80%
LEACH-L	65%

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

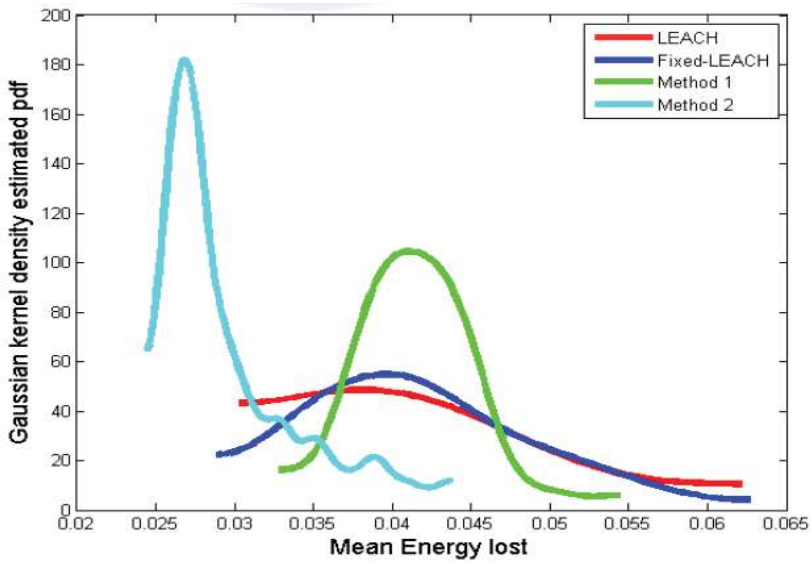


Fig.4 PDF of mean energy lost in one epoch

$$E_{TX}(N_j, d_j) = \begin{cases} N_j.E_{elec}+N_j.\epsilon_{fs}.d_j^2 & if \;\; d_j<d_0 \\ N_j.E_{elec}+N_j.\epsilon_{mp}.d_j^4 & if \;\; d_j\geq d_0 \end{cases}.$$

8. CONCLUSION

This paper was given new methodology to implement EECLA algorithm for wireless sensors adaptive clustering and localization techniques to provide energy efficient routing. Any many past works were given the same about the problem. The optimization of wireless network energy researches either concerns on hardware modification and optimization or either software management. The past researches on clustering of wireless sensor networks

got a result of saving an interesting amount of energy and sensor's life. This research added a value of saving more energy and power, and building adaptive algorithm.

This algorithm as shown in chapter four, was been tested on different scopes of wireless sensors networks in different conditions. From that point the following conclusions have been got The energy of wireless sensor networks is important issue and needs more hardware and software solutions to get good optimization methods. Energy optimization can significantly be done by a suitable clustering algorithm.

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