IJEE 0973-7383 Volume-7 • Number-2 Jun -Dec 2015 pp. 42-52 Impact Factor 2.5 available online at www.csjournalss.com

An Improved & Energy Efficient Leach Protocol for Wireless Sensor Network

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Abstract: Wireless sensor networks (WSNs) consist of spatially distributed autonomous sensors with sensing, computation and wireless communication capabilities. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Since the operation of a sensor node depends upon limited energy of a battery, so the energy is the scarcest resource of WSN nodes, and it determines the lifetime of WSNs. The communication takes place in such a way so that the sensor nodes always remain active with available energy constraints. But energy efficiency is a critical problem for the construction of wireless sensor network. Thus a suitable protocol is needed in order to perform energy efficient routing in a network. LEACH is the simplest hierarchical protocol which possesses clustering approach and tends to reduce energy consumption in a WSN. The Matlab simulation finds an optimal and balanced clustering scheme instead of using some random method, thus using less energy and more rounds of transmission to BS. For this, it will combine few parameters such as Distance and number of nodes as basic parameter for clustering. The proposed system is supposed to increase the overall network life time of WSN.

1. Introduction:

Wireless sensor networks (WSNs) consist of spatially distributed autonomous sensors with sensing, computation and wireless communications capabilities. The WSN comprises of "nodes" ranging from few to several hundreds or even thousands and each node is connected to one (or sometimes several) other sensors. Sensor nodes are usually scattered in a sensor field which is an area where the sensor nodes are deployed. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Each sensor node bases its decisions on its mission, the information it currently has, and its knowledge of its computing, communication, and energy resources. Each of these scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external base station(s). A base-station may be a fixed node or a mobile node capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data.

2. Leach protocol:

LEACH protocol is the first hierarchical cluster based routing protocol for wireless sensor network, which allows the nodes to transmit data to the cluster heads of the cluster to which they belong. Leach selects the CH randomly and assigns these nodes by following the policy of round robin management for ensuring fair dissipation of energy between nodes. The CH is then responsible for creating and manipulating the TDMA (Time Division Multiple Access) schedule and in order to reduce the amount of information transmitted to the BS(Base Station), the CH aggregates the data from the nodes where these data is needed using the

CDMA (Code Division Multiple Access). All the other nodes are the members of cluster. LEACH is divided into two phases: A .Set-up phase B. Steady state phase

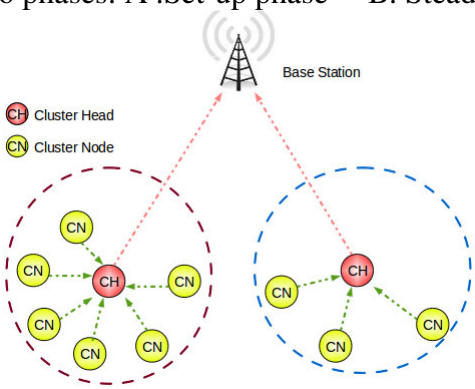

Fig.1. Architecture of LEACH Protocol

Set-up phase: The main goal of this phase is to make cluster and select the cluster head for each of the cluster by choosing the sensor node with maximum energy. As shown in fig. 1 the members nodes informs the CH, that they have become a member to that cluster by sending "join packet" contain their IDs using the CSMA. So, the CHs know or get the information about their member nodes and their IDs. On this basis of all received messages within the cluster, CH creates a TDMA schedule. Randomly pick a CSMA code, and broadcast the TDMA table to cluster members. After that steady state phase begins.

Steady Phase: It is comparatively longer in duration than the set-up deals mainly with the aggregation of data at the cluster heads and transmission of aggregated data to the Base station, shown in fig.2. All the non-CH nodes start transmitting the data, after allotment of the TDMA slots, to the CH. The nodes will keep its antenna in ON state only when the data transmission begins. In the other time, it remains OFF in order to save power. The CH will always be in the ON state. Once all the information is received from the nodes (non-CH) by the CH, it does an intelligent data aggregation on the received data and sends it to the BS.

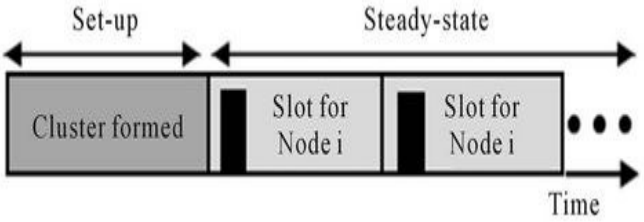

Fig.2. Timeline Showing LEACH Protocol Operation

3. An improved strategy of leach:

Though there are advantages to using LEACHs distributed cluster formation algorithm, this protocol offers no guarantee about the placement and/or number of cluster head nodes. Since the clusters are adaptive, obtaining a poor clustering set-up during a given round will not greatly affect overall performance. However, using a central control algorithm to form the clusters may

produce better clusters by dispersing the cluster head nodes throughout the network. This is the basis for LEACH-centralized (LEACH-C), a protocol that uses a centralized clustering algorithm and the same steady-state protocol as LEACH. [LEACH 2002] In contrast to LEACH, where nodes self-configure themselves into clusters, MAX_LEACH utilizes the base station for cluster formation. For better energy efficiency, LEACH-KMEANS was proposed. It increased the network lifetime and enhances the energy efficiency of the WSN as compared to previous versions of LEACH. But, in LEACH-KMEANS, the cluster heads are chosen randomly leading to unorganized unequally distributed, scattered clusters. Therefore, we propose a new protocol modified K-means protocol in which all the clusters nodes are equally distributed in all the clusters for better performance by dividing the sensor area into grids.

The changes made in the set-up phase and the steady state phase of LEACH-KMEANS are as follows: **Set-up Phase:** During setup phase, the sensor nodes are divided equally into clusters which are selected by K-means. Depending on the size of the network and no. of sensor nodes, the sensor nodes can be equally divided into n number of clusters. While selecting cluster by each node if in a cluster number of nodes exceed than the maximum permissible node then they choose another cluster.

Set-up Phase: When the node is selected as the cluster head, the cluster head broadcast the signal (Advertisement Message, ADV) to the other nodes. Each node receives ADV from different cluster heads, according to the strength of the signal, it chooses to join proper cluster, and reply to the corresponding cluster head. The cluster head receives the joining information, producing a TDMA schedule. The cluster head receives data from members of the cluster, and transmits to BS after merging into a packet. After data transmission, the network chooses the cluster head again.

4. Simulation of improved algorithm:

Simulation will be done using a well known simulator – MATLAB. It is a high-performance language for technical computing. To simulate LEACH, we have used random 200-node networks for our simulations with similar parameters used in [20]. We placed the BS at a far distance from all other nodes. For a 50m x 50m plot, our BS is located at (25,200) so that the BS is at least 50m from the closest sensor node. Table 1 depicts the most important traffic parameters used in our simulations.

Table 1: Parameter setting for Simulation

Network Architecture	
Parameter	**Value**
Network size	50x50 m
No. of nodes	200
Base Station (BS)	25, 200
Initial energy of node	0.5 J
d_0	87.7 m

Energy for transferring of each bit (ETX)	50e-9 J
Energy for receiving of each bit (ETX)	50e-9 J
Data Aggregation Energy (EDA)	5e-9 J
Packet length (number of bits in packet sent from CH to BS)	6400 Bit
ctrPacket Length (number of bits in packet sent from node to CH)	200 Bit
Power amplifier of Free space(E_{fs})	1.0e-11 J
Power amplifier of Multi Path (E_{amp})	1.3e-15 J

5. Simulation results:

In this section we present our simulation scenarios and discuss the results obtained. In order to check the performance of the proposed protocol in terms of its efficiency, there are different metrics to be used. The metrics that we selected for performance evaluation are as follows:

1. No. of rounds: It is the time required for a packet to travel from a specific source to a specific destination and back again.

2. Packet sent to BS: It calculates the total number of packets send to the base station.

3. Energy: It is remaining energy obtained by subtracting the consumed energy from total energy.

4. No. of dead nodes: It counts the number of nodes which are inactive due to depletion of energy.

The network architecture is shown below in Fig 3. The Base Station is located at the coordinates 25, 200. The base station is represented by green circle.

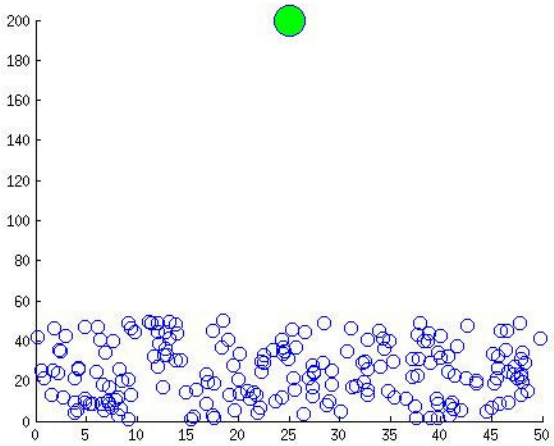

Fig 3: Node deployment

A comparison between the simulation results of our proposed protocol LEACH, MAX_LEACH and LEACH-KMEANS is performed via MATLAB software environment. The graphs generated as a result of simulation represents :

1. Number of packets sent to BS vs. Rounds
2. No. of Dead nodes vs. Rounds
3. Sum of energy of nodes vs. Rounds

The simulation results depict that our proposed protocol has better results in terms of the equi-distribution of energy and space. LEACH, MAX_LEACH and LEACH-KMEANS.

The performance of the proposed protocol is evaluated and compared with existing LEACH, MAX_LEACH and LEACH-KMEANS in terms no. of rounds, packet sent to the BS, Energy and no. of dead nodes. Some significant results are as follows:

- Number of rounds increased as compared to LEACH, MAX_LEACH and LEACH-KMEANS.
- Packets sent to the Base Station improved in comparison to LEACH and LEACH-KMEANS.
- The dwindle in energy (sum of energies of nodes) of the system improved. Energy at the end of all rounds is maximum in case of our propose protocol as compared to LEACH, MAX_LEACH and LEACH-KMEANS.
- nodes died at the end 80 out of 100 of 664 rounds in our proposed protocol. However 80 nodes died at round 418, 357 and 534 rounds of LEACH, Max_LEACH and LEACH-KMEANS respectively. It shows that nodes are available for communication for more number of rounds.

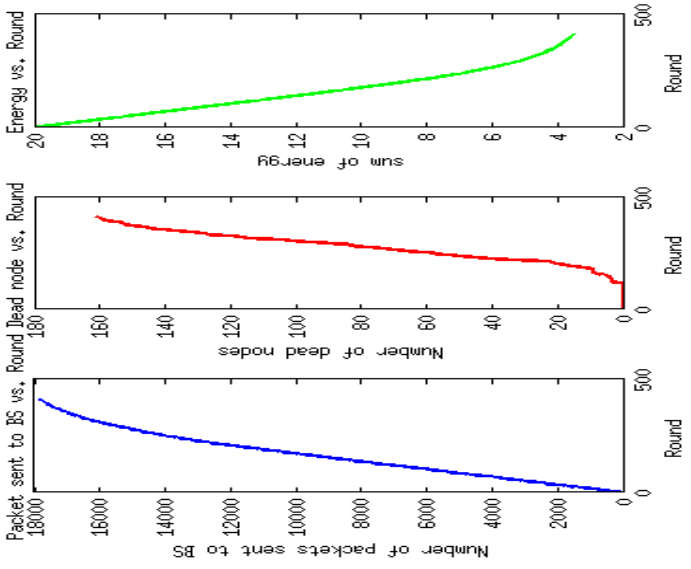

Fig 4: Experimentation Results for Random LEACH

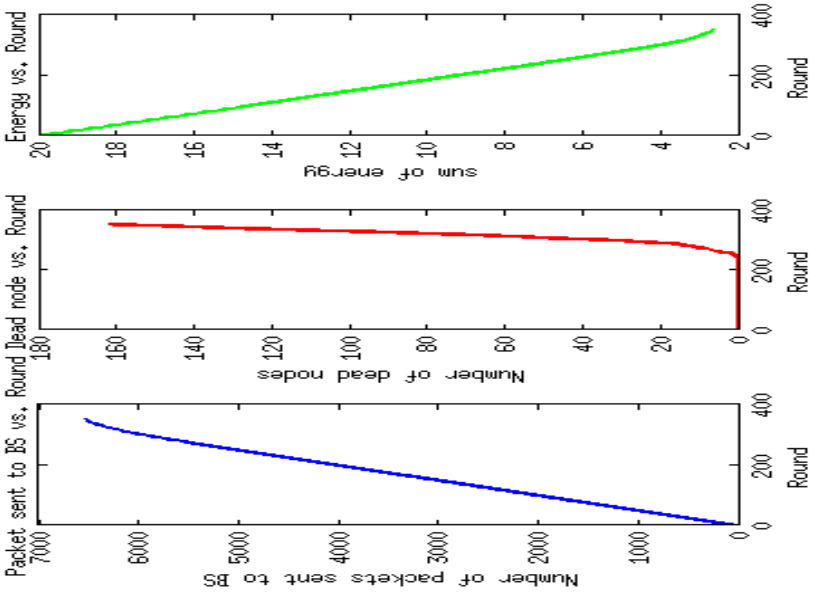

Fig 5: Experimentation Results for MAX_LEACH

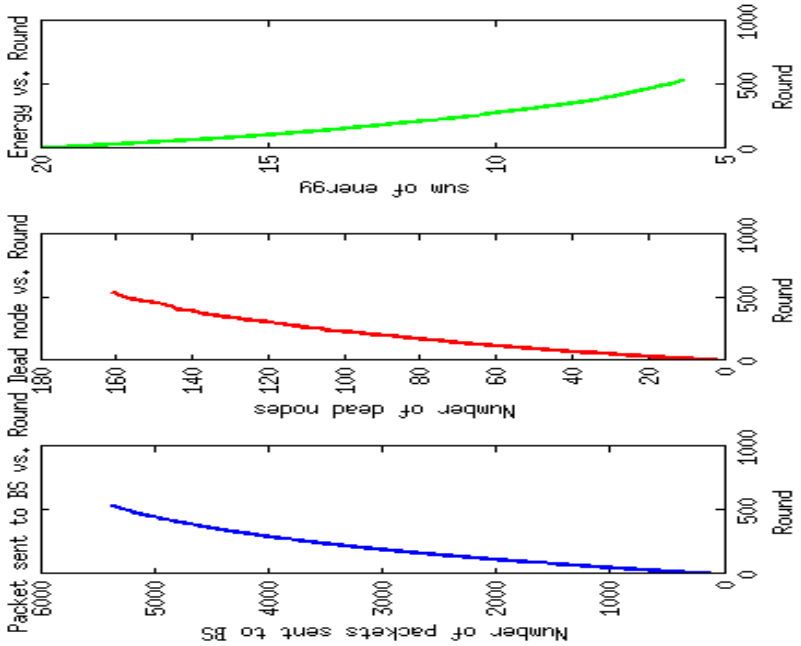

Fig 6: Experimentation Results for K-means

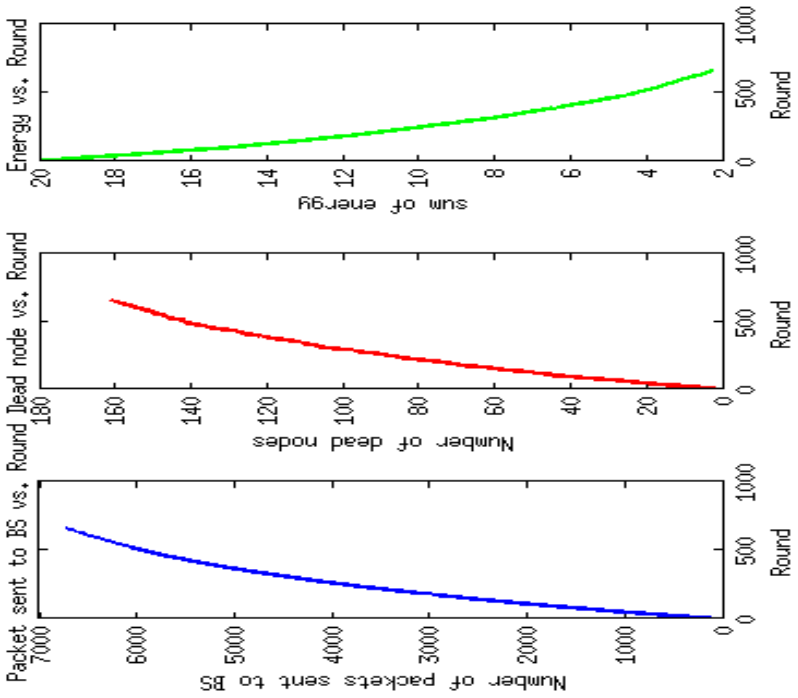

Fig 7: Experimentation Results for modified K-means

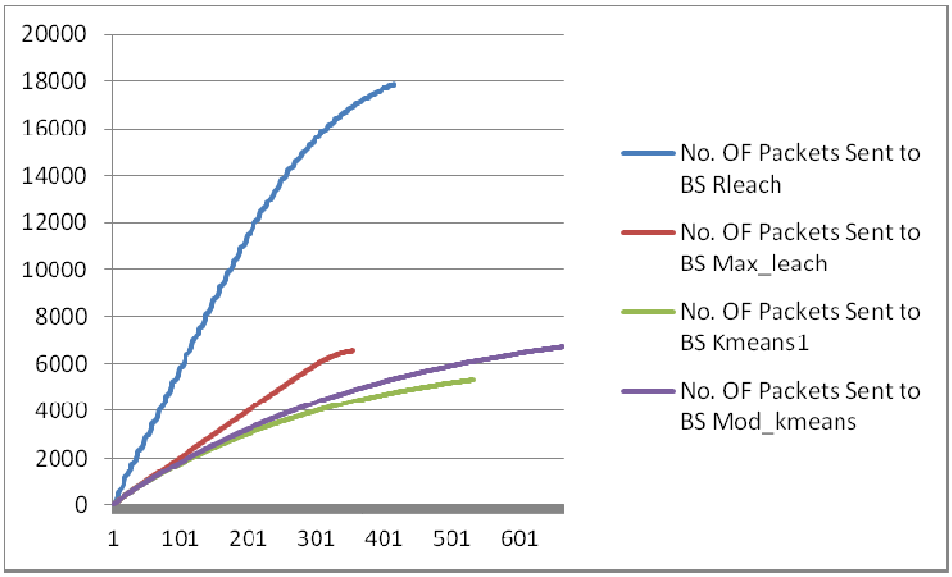

Fig 8: Comparison of four algorithms for no of packets sent to BS Vs No. of Rounds

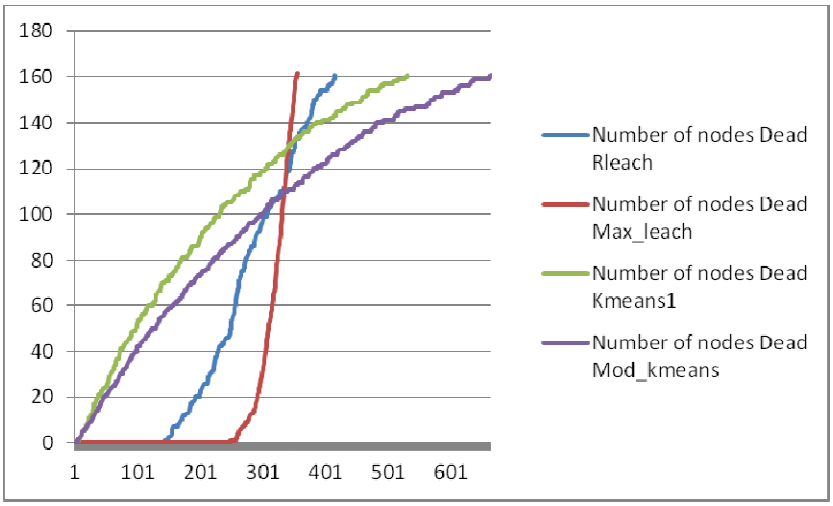

Fig 9: Comparison of four algorithms for Residual Energy Vs No. of Rounds

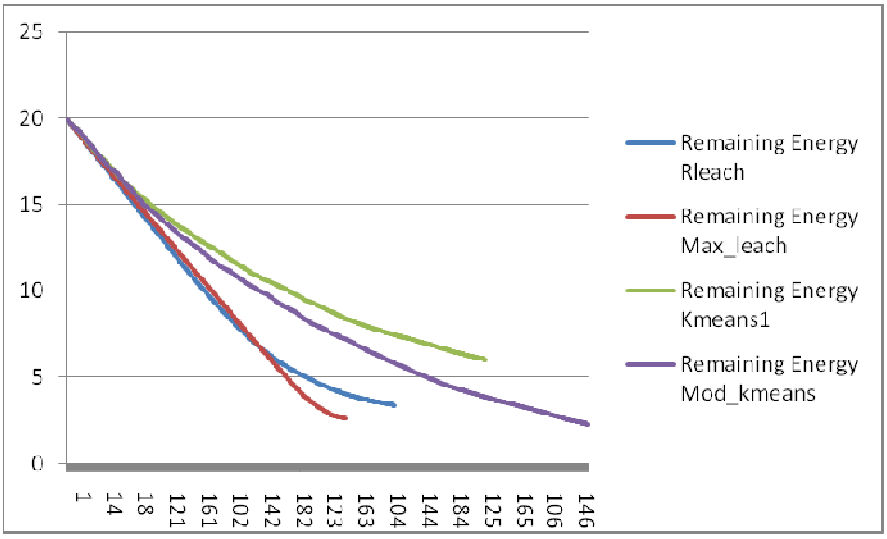

Fig 10: Comparison of four algorithms for no of dead nodes Vs No. of Rounds

Discussion:

We have measured the performance of four algorithms. Parameters for performance measurements are Residual Energy, Dead Nodes, Packets sent to BS. These parameters are shown in above figures and are plotted against number of rounds. If we consider residual energy and total number of rounds then K-means and its variants perform better than Max Energy LEACH and random LEACH. This shows that balanced k-means LEACH and Max Energy LEACH most uniformly distributed energy dissipation among nodes. For network integration or dead nodes criterion again balanced k-means based LEACH and Max Energy LEACH performs better. This can be confirmed by the graph 4 to 10 which show the comparative analysis of three simulated algorithms for three different criteria.

6. Conclusion and future scope:

We have measured performance of four algorithms in these experiments. Parameters for performance measurements are Residual Energy, Dead Nodes, Packets sent to BS. These parameters are shown in above figures and are plotted against number of rounds. If we consider residual energy and total number of rounds then MAX_LEACH and the balanced k-means algorithm perform better than random LEACH. The residual energy at the end of total number of round shows that MAX_LEACH and the balanced k-means LEACH most uniformly distributed energy dissipation among nodes and then simple k-means and random LEACH algorithms. For network integration or dead nodes criterion both algorithms perform far better than other algorithms. For number of packets sent to BS criterion the random LEACH performs better than other algorithms but this may be due to very large number of cluster formation.

One area where improvement can be made is equi-distribution of space in the nodes for better clustering in k-means because its performance depends on initial selection of centers which are not always good and its performance is not consistent. Although balancing of cluster loads have increased the energy efficiency by increasing the number of rounds but one real concern of k-means based algorithms is its early disintegration of network. This can be achieved by employing some clustering algorithm some heuristic algorithm which explores whole area for center selection instead of a limited area.

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