Improvement on LEACH: Seeded LEACH-KED

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***Abstract*— This paper summarizes the work used to improve low energy adaptive cluster hierarchy (LEACH) algorithm and proposes a new protocol "Seeded LEACH-KED" in order to increase the network lifetime and then compare its result with the LEACH , LEACH-C and LEACH-KED. Prolonging network lifetime is the way to provide energy efficient WSNs. This research is inspired by the fact that LEACH occupies a very important position in the area of wireless sensor networks. Most of the hierarchical routing algorithms, aiming to prolonging network lifetime, have been derived from the LEACH.**

Keywords— **LEACH, WSN, Clustering**

I. Introduction

LEACH [1] is the simplest hierarchical protocol which possesses clustering approach. It is a protocol that tends to reduce energy consumption in a WSN. However, LEACH uses single-hop routing in which each sensor node transmits information directly to the cluster-head or the sink. Therefore, it is not recommended for networks that are deployed in large regions. In this algorithm, a node becomes a cluster-head using a stochastic mechanism. This is prone to producing unbalanced energy level reserves in nodes and thus, to increasing the total energy dissipated in the network.

To avoid the problems of skewed energy distribution a centralized routing protocol, called Base-Station Controlled Dynamic Clustering Protocol (BCDCP) such as LEACH-C[2] can be used which distributes the energy dissipation evenly among all the sensor nodes to improve the network lifetime and its average energy savings are presented. The base station receives the residual energy of each node and then it computes the average energy level of all the nodes. Then it elects as candidate cluster heads a number of nodes which have a higher residual energy than this value. This protocol provides balanced energy consumption. However the selection of the node with the highest energy as a cluster head at a round may cause the other nodes to spend more energy to send data to this node. The selection of a node that allows the other nodes in the cluster to spend less energy is a better solution. All the aforementioned protocols try to minimize the energy consumption using different algorithms. These algorithms offer a good solution, since they select the node with the higher residual energy in the cluster as the cluster head for the next round. However, this does not assure the maximum prolongation of the overall network lifetime. Therefore, if the node with the highest residual energy is a node located at the side of the cluster, this can lead other nodes to spend considerable amounts of energy to reach that node, which cannot be energy efficient for the entire network. This is the reason we propose a protocol **"**Improvement of LEACH: Seeded LEACH-KED**"** that solves the following two purposes: Space equi-distribution & Energy equi-distribution. Various parameters to be considered to achieve the above said goals include: Energy conservation, Transmission of sufficient amount of packets within the network & Disintegration of network should not be fast.

II. LEACH Improvements in Literature

There exists a considerable research effort for the development of routing protocols in WSNs. The development of these protocols is based on the particular application needs and the architecture of the network. However, there are several factors that should be taken into consideration when developing routing protocols for WSNs. Energy efficiency is the most important among these factors, since it directly affects the lifetime of the network. There have been a few efforts in the literature pursuing energy efficiency in WSNs.

Heinzelman et.al [1] introduced a hierarchical protocol Low Energy Adaptive Clustering Hierarchy (LEACH) which consists of two phases: the setup phase & the steady state phase. In the setup phase of LEACH, the clusters are organized and the cluster heads are selected among all the nodes. In every round, each node determine whether it can become a cluster head by using a stochastic algorithm. Once a node becomes a cluster head, it cannot become a cluster head again for P rounds, where P is the probability of becoming cluster heads. In the steady state phase of LEACH, the data aggregated from nodes is sent to the base station. The time taken by the steady state phase is longer than the duration of the setup phase in order to minimize overhead.

LEACH is a protocol that tends to reduce energy consumption in a WSN. However, LEACH uses single-hop routing in which each sensor node transmits information directly to the cluster-head or the sink. Therefore, it is not recommended for networks that are deployed in large regions. But it has various shortcomings. In LEACH, cluster heads send aggregated data to base station in single hop manner so consumes lot of energy. Cluster heads are predefined typically taken as 5% or 10% of total deployed nodes. Probability function doesn't take residual energy of node while selecting cluster heads. It consists of rounds, while in each round, all sensor nodes take part in reconstructing new clusters and this consumes a lot of energy. Cluster size changes significantly as cluster heads are selected on random basis so the deployed nodes drain out their power unevenly which affects network connectivity, consequently lifetime of network. Clusters strength is imbalanced.

The researchers have tried to optimize LEACH algorithm in several ways. Many have tried to equally distribute energy to elongate the lifetime of WSN. Besides equi-distribution of energy, equi-spatial distribution of cluster is also important because it directly effects the energy consumption by minimizing the distance between nodes and cluster heads. Many methods are centralized controlled by base station to define clusters heads and clusters but few give decentralized control to sensor nodes in choosing their clusters. In the last two or three years many researchers have started using metaheuristic techniques such as PSO, Simulated Annealing and genetic algorithms which provide better spatial distribution of cluster heads for evenly spacing of cluster heads for better energy efficiency. But these methods have proved to be costly for their long time taking iterations. Some hybrid combination of metaheuristic methods and faster k-means method can be a better solution. One concept that has been less utilized by researchers is balanced load distribution among clusters so that every cluster almost utilizes equal energy and battery can last long. This is the area which demands more attention from the researchers.

III. PROPOSED WORK

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. In contrast to LEACH, where nodes self configure themselves into clusters, LEACH-C utilizes the base station for cluster formation.

For better energy efficiency, LEACH-KED 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-KED, the cluster heads are chosen randomly leading to unorganised unequally distributed, scattered clusters. Therefore, we propose a new protocol **"Improvement of LEACH : Seeded LEACH-KED "** in which all the clusters are equally distributed over the sensor area leading to space and energy equi-distribution for better performance by dividing the sensor area into grids.

The comparison of the above stated protocols namely, LEACH, LEACH-C, LEACH-KED[3] and our proposed protocol on the basis of the selection of Cluster Heads, organisation and arrangement of clusters and their distribution over the sensor area is summarized below:

Table 1. Comparisons of LEACH, LEACH-C, LEACH-KED and Proposed Protocol

Name of the Protocol	**Organization of clusters**	**Distribution**
LEACH	First Cluster Heads are chosen, then cluster are formed.	Random Distribution
LEACH-C	Clusters and Cluster Heads are chosen by the Base Station	Centralized Distribution
LEACH-KED	First Clusters are made, then Cluster Heads are chosen.	Random Distribution
Seeded LEACH-KED	First Cluster Heads are chosen, then cluster are formed.	Even Distribution

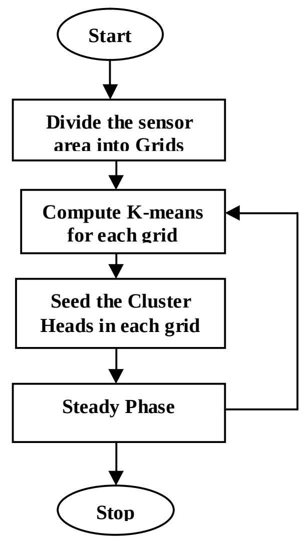

Fig. 1.Flowchart of Methodology

Network Model

Randomly distribute *N* sensor nodes evenly in a M x M rectangular sensor area and assume WSN has the following properties:

1. The network has fixed BS (Sink node) which stays away from the sensor area. The base station has enough energy supply and we would not consider BS energy consumption.
2. All the nodes in the network have limited energy and are homogeneous.
3. All the nodes in the network have the same initial energy.
4. Node transports the data collected to BS periodically.
5. All the nodes are still and uniformly distributed.
6. Node always has data to send.

Energy Model

It adopts the same energy consumption model of [1]. In the process of transmission *k* through long distance *d*, the energy consumption of the sending end is:

$$E_{TX}(k,d) = \begin{cases} k\times(E_{Elec} + Efs.d^2), & d<d_0 \\ k\times(E_{Elec} + Emp.d^4), & d\geq d_0 \end{cases}$$

The receiver energy consumption of receiving *k* data is:

$$E_{RX}(k) = k\times E_{Elec}$$

E_{elec} is the power consumption of sending and receiving, decided by the circuit itself. If the transmission distance is less than threshold d_0, the power amplifier E_{fs} of free space model is adopted. Conversely, when the transmission distance is equal or greater than the value, the power amplifier E_{mp} of multi-path attenuation model is adopted.

$$d_0 = \sqrt{\frac{E_{fs}}{E_{mp}}}$$

In [1], node energy consumption of computing is far less than energy consumption of data transmission, so we also ignore energy consumption calculation of node. [4]

Network Architecture	
Parameter	**Value**
Network size	100x100 m
No. of nodes	100
Base Station (BS)	50, 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
E_{Elec}	0.5 J
Packet length (number of bits in packet sent from CH to BS)	6400 Bit
ctrPacketLength (number of bits in packet sent from node to CH)	200 Bit
Power amplifier of Free space(Efs)	1.0e-11 J
Power amplifier of Multi Path (Emp)	1.3e-15 J

Table 2. Parameters of Network Architecture

Simulation is done using a well known simulator – MATLAB. It is a high-performance language for technical computing. It collaborate programming, computation and visualization in an interactive environment where problems and solutions are expressed in familiar mathematical notation. It is used for plotting the graphs to compare the result of our proposed protocol and the older protocols.

Set-up Phase

During setup phase, the sensor area is divided into grids. Depending on the size of the network and no. of sensor nodes, the sensor area can b divided into M x N or M x M matrix as required. After fixing the area into grids, K-means algorithm is computed for each grid to find the CH of the respective grid. In this way the CH will be seeded at the grid centres in order to organise equidistant clusters.

Steady State Phase

Seeded LEACH-KED's steady state phase is identical to that of LEACH-KED.

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
2. Packet sent to BS
3. Energy
4. No. of dead nodes

We perform simulations to analyse and evaluate the performance of the proposed protocol. Here simulation is done on MATLAB. The simulation results depict that our proposed protocol has better results in terms of the equi-distribution of energy and space. To verify the improved protocol proposed, we will compare the results with LEACH, LEACH-C and LEACH-KED.

The performance of the proposed protocol is evaluated and compared with existing LEACH, LEACH-C and LEACH-KED 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, LEACH-C and LEACH-KED.
- Packets sent to the Base Station improved in comparison to LEACH and LEACH-KED.
- 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, LEACH-C and LEACH-KED.
- 80 out of 100 nodes died at the end of 2282 rounds in our proposed protocol. However 80 nodes died at round 711 and 2170 rounds of LEACH and LEACH-KED respectively. It shows that nodes are available for communication for more number of rounds.

The results of simulation is summarised in the table below:

Name of the Protocol	Round	Packet to BS	Energy	Dead nodes	
				Node	Round
Seeded LEACH-KED	2282	11912	Start: 49.9	1st	19
			End: 9.8	50th	1148
				80th	2282
LEACH-KED	2170	11172	Start: 49.9	1st	20
			End: 6.0	50th	971
				80th	2170
LEACH-C	1312	13080	Start: 49.9	1st	1289
			End: 0.0064	37th	1312
LEACH	711	11446	Start: 49.9	1st	105
			End: 4.7	50th	290
				80th	711

Table 3. Comparative results of Proposed protocol, LEACH-KED, LEACH-C & LEACH

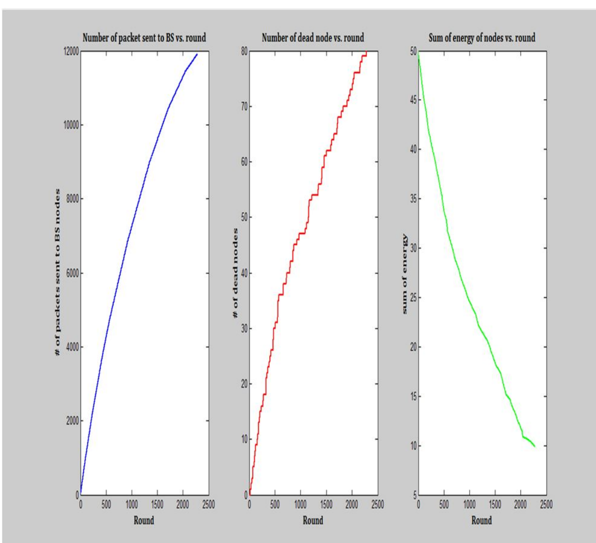

Fig. 2. Graphical representation of result of simulation of Seeded LEACH-KED

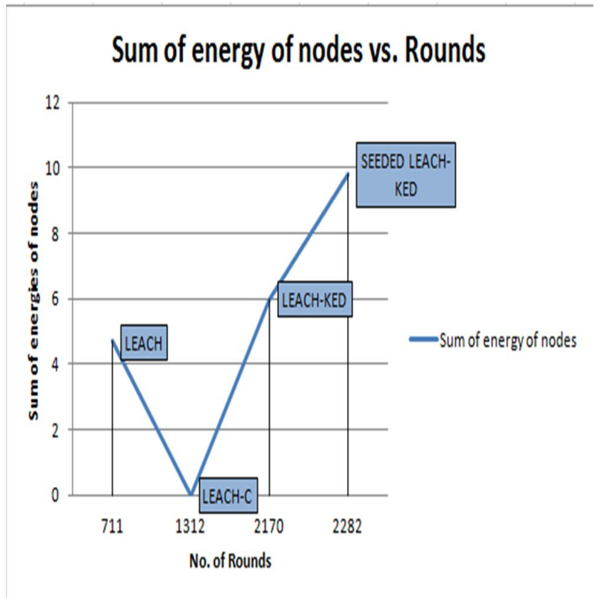

Fig. 3. Graph showing comparison on the basis of Sum of energy of nodes vs. Rounds

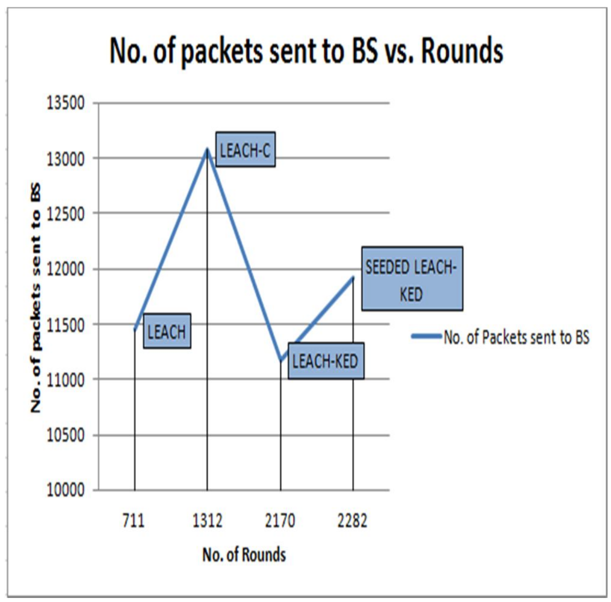

Fig. 4. Graph showing comparison on the basis of No. Of packets sent to BS vs. Rounds

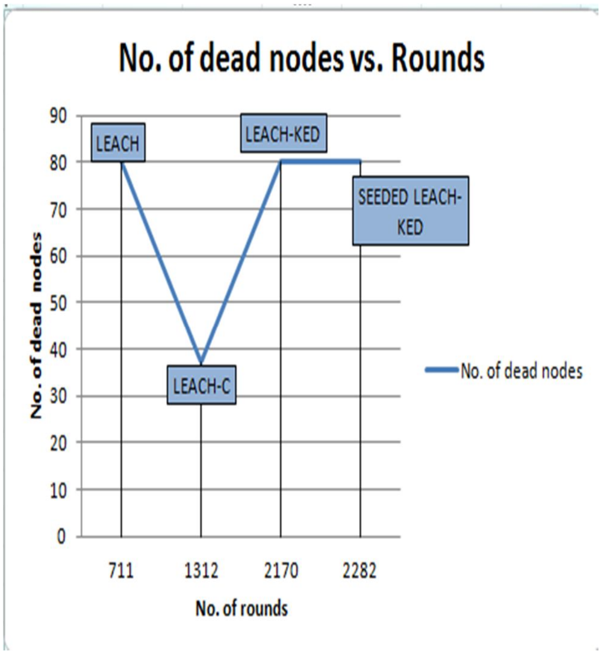

Fig. 5. Graph showing comparison on the basis of No. Of dead nodes vs. Rounds

IV. CONCLUSION

In this paper we have proposed a new protocol Seeded LEACH-KED, an improvement of LEACH. From the graphs, it can be observed that our proposed protocol outperforms the LEACH, LEACH-C and LEACH-KED protocols on different parameters. The simulation results show that there is 9.24% improvement over the LEACH-KED protocol.

Therefore, the proposed clustering approach is more energy efficient and hence effective in prolonging the network life time compared to LEACH-KED.

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