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A Review of Improvement on LEACH Protocol in Wireless Sensor Network

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Abstract – Wireless sensor network is a network that is composed of number of non rechargeable or non replaceable sensor nodes due to its limited battery power. In WSN routing techniques energy consumption is one of the most important issue to be considered. Hierarchical routing protocols are the best known protocols to minimize the energy consumption. LEACH protocol is one the cluster based hierarchical routing protocol. LEACH increases the network lifetime by consuming small percentage of total energy dissipated in network. This paper reviews on the LEACH protocol and its descendents.

***Keywords*—**LEACH, Clusterhead, Cluster Selection, energy consumption, lifetime

I. INTRODUCTION

A wireless sensor network (WSN) consists of low cost, tiny device called sensors to monitor physical or environmental conditions (i.e. temperature, sound, vibration, pressure, humidity etc) and to transfer their data through the network to main location.

There are several numbers of sensor nodes which are connected to one another and that consists of radio transceiver with an internal antenna. WSNs have broad applications such as military surveillance and tracking, environment monitoring and forecasting, healthcare etc. Since Wireless Sensor Nodes cannot be recharged, the energy consumption and energy balancing issue has become more important [15].

Different types of routing algorithm have been proposed to reduce the energy consumption and prolong the network lifetime [1]. Clustering algorithm is an energy-efficient technology for

WSNs. Clustering is a technique used in hierarchical routing to aggregate the number of nodes into a group; these groups are known as cluster. Clustering helps to improve routing at the network layer by reducing the size of the routing tables and it also decreases transmission overhead. The main elements of clustering are cluster head, cluster member and sink.

Within each cluster one node is selected as the clusterhead (CH) and rest of all the nodes are treated as cluster members. Clusterhead (CH) collects the data from the cluster members within the cluster and transmits it directly or multihop to the base station (sink). CH utilizes more energy than other sensor nodes. Thus, the workload of the CH is distributed among the other non clusterhead nodes and its role is rotated among all the nodes to balance the energy consumption.

Developing an energy-efficient routing protocol is one of the major issues in WSN. LEACH [2] is the first hierarchical routing protocol to reduce energy consumption. J.Gnanambigai *et al.* [3] surveyed the different hierarchical routing protocols derived from LEACH.

II. LEACH Protocol

LEACH [2] is called Low Energy Adaptive Clustering Hierarchy is the first dynamic energy efficient cluster head protocol proposed for WSN. Here the clusters are formed by using a distributed algorithm, where there is no central control for decision making. All the nodes get a chance to become CH to balance the energy spent per round by each sensor node. Initially, a node decides to be a CH with a probability "*p*" and broadcasts its decision. After CH election, each CH broadcasts an advertisement message to the other nodes and each one of the other (non-CH) nodes determines a cluster to which it belongs to, by choosing the CH that can be reached using the least communication energy. The role of being a CH is rotated periodically among the nodes of the cluster to balance the load. The rotation is performed by getting each node to choose a random number "T" between 0 and 1. A node becomes a CH for the current rotation round if the number is less than the following threshold:

$$T(i) = \begin{cases} \dfrac{p}{1-p*\left(r \bmod \left(\frac{1}{p}\right)\right)} & \text{if } t \in G \\ 0 & \text{otherwise} \end{cases}$$

Where

p is the desired percentage of CH nodes in the sensor population

r is the current round number

G is the set of nodes that have not been CHs in the last $1/p$ rounds.

In LEACH the whole process is divided in two phases- setup phase and steady state phase. In setup phase the cluster creation and CH selection is done and in steady state phase the nodes other than CH sends their data to their CH throughout their allotted time slot using TDMA.

A. Advantages

i. Most of the communication is confined inside the clusters thus, provides scalability.

ii. Single-hop routing from node to cluster head, thus saving energy.

iii. Distributiveness, where it distributes the role of CH to the other nodes.

iv. Increases network lifetime by reducing the energy dissipation in three ways. Firstly, distributing the task of CH which consumes more energy than normal nodes to the other nodes. Secondly, data aggregation by the CHs. Finally, TDMA, assigned by the CH to its members, puts most of the sensor nodes in sleep mode, especially in event-based applications. Thus, increases the network lifetime but reduces 7-fold the energy dissipation than direct communication [4].

v. It does not require location information of the nodes in cluster formation. So, it is powerful and simple.

vi. Finally, it is dynamic clustering and well-suited for applications where regular monitoring is required and periodic data collection occurs to a centralized location.

B. Disadvantages

i. It depends on cluster head and faces robustness issues like clusterhead failure.

ii. Additional overheads due to cluster head changes and calculations leading to energy inefficiency for dynamic clustering in large networks.

iii. Direct communication between CH and sink needs high transmission power.

Hence, it does not work well in large- scale networks that need single-hop communication with sink.

iv. CHs could be located at the edges of the cluster due to non uniform distribution of CH.

v. Random CH selection does not take into account energy consumption.

vi. LEACH is not applicable to large region network as it uses single hop routing where each node can transmit directly to CH and the sink.

III. Enhancement on LEACH

A. E-LEACH(Enhanced-LEACH or Energy Low Energy Adaptive Clustering Hierarchy)

E-LEACH is the enhancement of LEACH. This protocol has following some objectives:

- Cluster-head failure handling.
- To handle non-uniform and dynamic residual energy of the nodes.

The total number of cluster heads is a key factor which affects the overall performance of hierarchical routing protocols. If the number of CHs is less, then each CH has to cover larger region, hence it will consume more energy [2]. By considering the residual energy of sensor nodes as the main key factor, it decides whether that node should turn into the cluster head or not in the next-round. The large number of cluster-heads leads to increase the energy consumption of the whole network and reduces the network lifetime. Therefore, it is necessary to choose optimal number of cluster heads for minimum energy consumption. E-LEACH uses the minimum spanning tree among cluster heads and chooses that cluster head which has largest residual energy at the root node [4].

B. TL-LEACH(Two-Level LEACH)

A next version of LEACH called Two-level Leach was evolve to reduce the energy consumption in sending information from cluster head to the base station which is located too far and will die faster. In this protocol Cluster Head (CH) collects data from other cluster members as original LEACH, but instead of sending data to the Base

Station directly, it uses one of the Cluster Heads (CHs) that lies between the Cluster Head (CH) and the Base Station (BS) as a relay station. Thus, the total energy consumption is reduced by reducing the number of nodes needed to transmit to the base station [4].

C. M-LEACH (Multi-Hop LEACH)

MLEACH modifies original LEACH by allowing multihop communication used by sensor nodes within the cluster if the distance between the clusterhead nodes and the base station is larger [3]. In this protocol, the CH sends the data to the Bs using the other CHs as relay stations in order to increase the energy efficiency.

D. LEACH–C (Centralized LEACH)

The drawback to LEACH is that the number of CH nodes is ambiguous to count [2].LEACH-C has been proposed to solve this problem. It is similar to LEACH except cluster formation. Here, centralized clustering algorithm is involved. The steady state remains same but in setup phase each node broadcast its current location and energy level to base station. The base station then runs a centralized cluster formation algorithm to select the clusters for that round. It has problems such as pre-selection cluster-head, equal opportunities for cluster-head selection mechanism, and the unbalancing energy loads. . However, since this protocol requires location information for all sensors in the network (normally provided by GPS), it is not robust [5].

E. V-LEACH (Vice-Cluster Head LEACH)

The main disadvantage of LEACH that when the cluster head dies due to insufficient energy to transmit cluster members data, it loses all of its data. Another disadvantage of LEACH protocol is the random selection of cluster heads. There are chances that the cluster heads selected are unbalanced. They may remain in one part of the network and making some part of the network unreachable [2]. To overcome this problem V-LEACH has introduced the concept of alternate Cluster Head called Vice Cluster Head.
V-LEACH includes:
1. It is the responsibility of cluster head to transmit the data to the base station which it receives from the cluster members.
2. A vice-CH defined as that node which will become a CH of the cluster when the existing CH dies due to insufficient energy.
3. Cluster nodes used in gathering data from the environment and send the gathered data to the CH.

The problem with V-LEACH is when Vice-CH dies, the network start dissipating the energy very quickly and finally the network dies completely. But it improves the overall network life and total communication over the network [4].

F. Cell LEACH

In this protocol the network is divided into different sections called cells to eliminate the problem of redundancy in LEACH. Each cell contains one of the sensors as a cell head and the seven nearby cells forms a cluster with the cluster head. Each cellhead and the clusterhead change randomly. Each cell should send its data to the cell-head in allocated time based on TDM (Time Division Multiplexing) only. While transferring data, all the cell nodes remain off except the nodes which have the time slot. Then cell head will either delete redundant data or aggregate the data. After removing redundant information and aggregating data in cell-head, this information will be send to cluster-heads and the same functions will be performed in cluster-head as well. Cell-head and cluster-head selection will be done by the same technique. Primarily, after the network arrangement, a cell-head and a cluster-head are determined randomly, since all the sensors have the same energy. In next times, as an example, each old cell-head selects a new cell-head dynamically and replace it with new one [6].

G. LEACH-F (Fixed No. of Clusters Low Energy Adaptive Clustering Hierarchy)

In LEACH-F, the clusters are formed only once and are fixed for each round. LEACH-F uses the same centralized cluster formation algorithm as LEACH-C. In LEACH-F, new nodes cannot be added to the network and nodes cannot adjust their behaviour when any node dies in the network. It also does not handle the node mobility. The cluster head position is rotated among the nodes within the cluster same as LEACH protocol [2]. The advantage of this protocol in comparison to LEACH is that, there is no network setup overhead at the beginning of each round and the cluster formed is maintained stable throughout the network lifetime to avoid re-clustering [7].

H. LEACH-L (Energy Balanced Low Energy Adaptive Clustering Hierarchy)

Leach-L is an advanced multi-hop routing protocol and is based only on the distance. It is suited for large area region for wireless sensor network. CH located close to base station, can communicate directly to the BS, but when located far the from the base station, can communicate by the multi-hop way and the shortest transmission distance is limited. Sensors can use different frequencies to communicate with the base station. In each round clusters are updated where each round has two phases: set-up phase and steady state phase. In each round, new cluster head is elected, the load distribution and load balancing is done among the nodes. [3], [7]

I. LEACH-B (Balanced Low Energy Adaptive Clustering Hierarchy)

LEACH-B is known as Balanced-LEACH which uses the decentralized algorithms of cluster formation in which each sensor nodes know only about its own position and the destination node position and has no information about the location of any other sensor nodes.
Leach-B includes the following techniques:
1. An Algorithm for Cluster head selection
2. Cluster formation
3. And transmission of data with multiple access
By analysing the energy dissipated in the path between final receiver and itself, each of the sensor nodes selects its cluster head. Efficiency of Leach-B is better than Leach [2].

J. A-LEACH (Angled Low Energy Adaptive Clustering Hierarchy)

A-LEACH protocol reduces the amount of traffic generated at the base station. The first phase that is cluster formation and clusterhead selection is same as LEACH in this protocol. This protocol assumes that some of the nodes in the network may not belong to any of the cluster in the network. These nodes transfer their data directly to the sink which causes a huge amount of traffic at the sink node; this affects the load balancing at the sink and also the energy efficiency factor. A-LEACH protocol calculates the angles among the nodes in such a way that, the nodes transferring the data to their respective cluster heads should lie at an angle less than or equal to 45° to the cluster head. This process would reduce the overall traffic in the network and hence increases the energy utilization. The angles of the nodes to their respective cluster heads and the sink node is calculated by the dot product of the position of the nodes, cluster heads and the sink node [9, 11, 14, and 15].

K. LEACH-A (Advanced Low Energy Adaptive Clustering Hierarchy)

In original Leach protocol, Cluster Head is transmits data directly to BS which increases energy consumption. In Advanced-LEACH, the data is processed by a technique called mobile agent. This is a heterogeneous energy protocol developed for the purpose of energy saving, reliable data transfer, decreasing the probability of node's failure and for increasing the time interval before the death of the first node. It uses synchronized clock, through which each sensor would know about the starting of each round [3], [7].
Following are the advantages of Leach-A protocol over LEACH:
1. The fusion of data reduces the amount of information transmitted to the BS.
2. More energy can be saved by using TDMA/CDMA techniques which allow hierarchy and does clustering on different levels.

L. LEACH-M (Mobile-Low Energy Adaptive Clustering Hierarchy)

LEACH-M is designed for mobility support in the Leach routing protocol. In Leach-Mobile protocol, during the set-up and steady state phase, cluster head nodes and non cluster head nodes can move [8]. In Leach-M the nodes are homogeneous and utilise their location information through GPS. Base station is considered to be fixed [3]. The cluster head selection is done on the basis of minimum mobility and lowest attenuation mode, which broadcast the CH status to all other nodes within its transmission range. Another criterion for the cluster-head selection is mobility speed. In the steady state phase of the original LEACH protocol, another cluster head is selected if nodes move away from the clusterhead or cluster-head moves away from its member nodes which results into inefficient cluster formation. To tackle this problem M- LEACH provides a handover mechanism for nodes to switch on the new cluster-head [3], [8].

M. LEACH-S (Solar Aware Centralized LEACH)

For the applications where Energy harvesting is essential, solar-aware LEACH (LEACH-S) has been proposed, where solar power can prolong the network lifetime of the wireless sensor network. Both LEACH and LEACH-C is the extension of LEACH-S [8].

1. **Solar-Aware Centralized LEACH:** In LEACH-S, base station uses improved central control algorithm for cluster head selection. In LEACH-S, nodes transmit its solar status to the base station along with the energy and nodes with maximum residual energy are selected as cluster head. The sun duration prolongs the network lifetime and also increases the performance. If the sun duration is smaller cluster head handover is done in LEACH-S [7], [8].
2. **Solar-aware Distributed LEACH:** In this LEACH-S, cluster head selection is preferred by solar driven nodes whose probability is higher than battery-driven nodes [3].

N. I-LEACH (Improved Low Energy Adaptive Clustering Hierarchy)

In I-LEACH protocol it serves two functions, a) Detection of Twin nodes and b) Assignment of Sub-Cluster Head (SCH) nodes. Twin nodes are the two nodes closer to each other. It is necessary to keep one of the two twin nodes in sleep mode until the first node runs out of energy because both the nodes can sense the same information. The uniform distribution of CH in the network allows CH not to run out of energy for longer transmission distance. It also manages the threshold number of cluster members by every CH [9].

O. K-LEACH

The K-LEACH protocol improves the cluster formation and cluster head selection procedure. For the first round of communication, in setup phase the K-medoids algorithm is used for uniform cluster formation. The cluster formation by K-medoids algorithm ensures best clustering and selection of cluster head using Euclidian distance at the nearer or at the center of cluster that results in most energy efficient solution in WSN. In second round, cluster heads are selected based on the next nearest node to the first round cluster head and so on. The process of clustering is done till the smallest cluster nodes are not considered. If duplicate cluster heads are identified due to dynamic clustering, switch to random selection of cluster head nodes from the alive nodes [10].

P. Ex-LEACH

In Ex-LEACH the BS receives location information as well as the residual energy for each sensor node and the average remaining energy can be calculated. If the sensor node remaining energy is higher than average remaining energy, then that sensor node is selected as cluster head. The algorithm used here is based on k-means algorithm in order to make an ideal allocation for sensor node clusters. There are two major steps involved in this protocol: set-up and steady-state phases [11].

IV. CONCLUSION

In this paper, the most important challenge in designing routing protocols for Wireless Sensor Networks is energy efficiency to increase the lifetime of sensor nodes. Sensors mainly consume energy during data transmission and reception. Therefore, routing protocols should be energy efficient to enhance not only the individual node lifetime, but also extend the lifetime of the whole of the wireless sensor networks. LEACH protocol is selected to give the better performance in both the energy efficiency and the network lifetime. LEACH protocol has both the advantages and disadvantages. Thus, to overcome from these disadvantages and to make it energy efficient many descendants of LEACH protocol are introduced and some of them like E-LEACH, TL-LEACH, M-LEACH, LEACH-C, CELL-LEACH, Ex-LEACH, I-LEACH,LEACH-F,LEACH-S and V-LEACH are described in this paper. Some of these improved protocols consider different ways for cluster formation and cluster head selection since, cluster head nodes consumes maximum energy than any other node in whole of the network. This descendant or improved LEACH gives better result than original LEACH.

REFERENCES

[1]Vivek Katiyar Narottam Chand Surender Soni ”Improving Lifetime of Large-scale Wireless Sensor Networks through Heterogeneity” ICETECT **2011**

[2]W.Heinzelman, A.Chandrakasan, and H.Balakrishnan, ”Energy-efficient Routing Protocols for Wireless Microsensor Networks,” in Proc. **33rd** Hawaii Int. Conf. SystemSciences (HICSS), Maui, HI, Jan.**2000**.

[3]J.Gnanambigai, Dr.N.Rengarajan, and K.Anbukkarasi, ”Leach and Its Descendant Protocols: A Survey,”

International Journal of Communication and Computer Technologies (IJCCT), vol. **01**, issue **02**, no.**3**, pp. **15-21**, September **2012**.

[4] Jia Xu,Ning Jin, Xizhong Lou,Ting Peng,Qian Zhou,Yanmin Chen"Improvement of LEACH protocol for WSN" IEEE, **2012**.

[5] Jamal, N.; E. Kamal, A.-K.A. Routing techniques in wireless sensor networks: A survey. IEEE Wirel. Commun. **2004**, **11, 6-28**.

[6] Arezoo Yektaparast, Fatemeh-Hoda Nabavi, Adel Sarmast " An Improvement on LEACH Protocol (Cell-LEACH) "

[7] P. Manimala1, R. Senthamil selvi2, International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN **2250–2459**, ISO **9001:2008** Certified Journal, Vol. **3**, Issue **12**, December **2013**).

8] M. Aslam1, N. Javaid2, A. Rahim3, U. Nazir4, "Survey of Extended LEACH-Based Clustering Routing Protocols for Wireless Sensor Networks" [cs.NI] **11** July **2012**.

[9]Heena Dhawan, Sandeep Waraich," A Comparative Study on LEACH Routing Protocol and its Variants in Wireless Sensor Networks: A Survey" International Journal of Computer Applications (**0975 – 8887**) Volume **95**– No.**8**, June **2014**.

[10] Parul Bakaraniya, Sheetal Mehta, "K-LEACH: An improved LEACH Protocol for Lifetime Improvement in WSN" International Journal of Engineering Trends and Technology (IJETT) – Volume **4** Issue **5**- May **2013** ISSN: **2231-5381** http://www.ijettjournal.org Page **1521**

[11]Pallavi Zambare, ShitalDabhade, " Improved Ex-LEACH Protocol based on Energy Efficient Clustering Approach" International Journal of Computer Applications (**0975 – 8887**) Volume **67**– No.**24**, April **2013**.

[12] Ravneet Kaur, Deepika Sharma and Navdeep Kaur, "Comparative Analysis Of Leach And Its Descendant Protocols In Wireless Sensor Network" International Journal of P2P Network Trends and Technology- Volume**3**Issue**1**- **2013**.

[13]Tripti Agrawal, Rajendra Singh Kushwah, " A Survey on Leach and its Enhanced Protocols in WSN" International Journal of Computer Applications® (IJCA) (**0975 – 8887**) National Seminar on Recent Advances in Wireless Networks and Communications, NWNC-**2014**.

[14] Divya Prabha and Vishal Kumar Arora, " A Survey on LEACH and its Descendant Protocols in Wireless Sensor Network" International Conference on Communication, Computing & Systems (ICCCS–**2014**).

[15] I. F. Akyildiz and W. Su and Y. Sankarasubramaniam and E. Cayirci, \Wireless sensor networks: a survey," Computer Networks, Vol.**38**, pp. **393**{**422**, March **2002**.