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A Survey on Low Energy Adaptive Clustering Hierarchical Protocol in WSN

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ABSTRACT: WSN play an important role in many field like environment monitoring, transportation security, military, catastrophic area, health, medical, industry so on. However, the most noticeable feature of WSN is energy consumption. There are whopping papers about WSN and maximum papers have focused on how to save the energy of WSN. Among all the researches, the most traditional algorithms are LEACH. Researchers have developed routing protocol that extended the life time of WSN which affects that data transfer is increase. In this paper we survey the LEACH protocol which is based on hierarchical routing protocol and we focus on life time and energy consumption of WSN through this protocol and also discuss different type of LEACHs

KEYWORDS: Cluster head; energy consumption; hierarchical routing; wireless sensor network; LEACH, network lifetime; data collection; WSN.

I. INTRODUCTION

Wireless Sensor Network is network which is deployed in an unattended environment with small sensor nodes in large number for collecting the information that is impossible for human being to reach [5]. It is very useful because they are wireless in nature and can easily gather information. Each sensor node has a capability to gather information in analog form and forward to ADC (Analog to Digital Converter) which is an internal part of sensor node, that ADC convert analog data into Digital for processing and storing. Each sensor node has four modes - transmit, receiving, sleep, idle. During transmission sensor in transmit stage and receiving sensor in receiving stage. Whereas after transmission, it goes into sleep mode to save energy and when sensor get weak due to limited power it gets into idle stage or dormant stage. During transmission data, energy consume by sensors is more than during receiving data. The main work of WSN is to gather information and that work is done by each sensor nodes which deployed in the sensor field (area where sensors are deployed). In sensor field sensor nodes are deployed with different architecture, hierarchical architecture is one of them which are very popular due to energy consumption of sensor nodes. In hierarchical there are number of routing protocol such as LEACH, PEGASIS, TEEN, APTEEN. In this paper we discuss about **LEACH.**

LEACH is hierarchical based protocol in which sensors nodes transmit data to the clusters, and these clusters aggregate and compress the data and forward it to the base station (sink). Cluster/hierarchical based protocol saves energy because in cluster based protocol some nodes choose one representative/coordinator which collects data from sensor nodes, then cluster either directly forward to the base station or forward to cluster head which directly link with base station, in this way the cluster system works. Through Cluster base WSN data deliver properly to the base station and data replications are not happening which directly benefit to the sensors energy, in Fig. 1, cluster base WSN. In hierarchical base network, cluster heads work like a hop mean they receive data from related cluster and forward to the base station. In hierarchical structure there are number of clusters. These clusters aggregate data in such manner that replica of data is not possible.

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LEACH provide scalability, traffic load, location information dynamic clustering, sleep mode. Each node uses an algorithm at each round to determine whether it can become a cluster head in this round. LEACH assumes that each node has a powerful radio signal, which is enough to forward data directly to the base station or the nearest cluster head, but for the entire time cluster is not capable to forward data to base station or nearest cluster head due to limited power energy. Nodes that have been cluster head cannot become cluster head again for P rounds, where P is the desired percentage of cluster heads. Thereafter, each node has a 1/P probability of becoming a cluster head in each round.

At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster. The cluster head then creates a schedule for each node in its cluster to transmit its data. All nodes that are not cluster heads only communicate with the cluster head in a TDMA (Time Division Multiple Access) manner. According to the schedule created by the cluster head, the non cluster heads use the minimum energy needed to transmit data to the cluster head and only need to keep their radio signal on, during their time slot. After gathering all the data from different clusters, then cluster head aggregates the data and sends that aggregated data to the Base station.

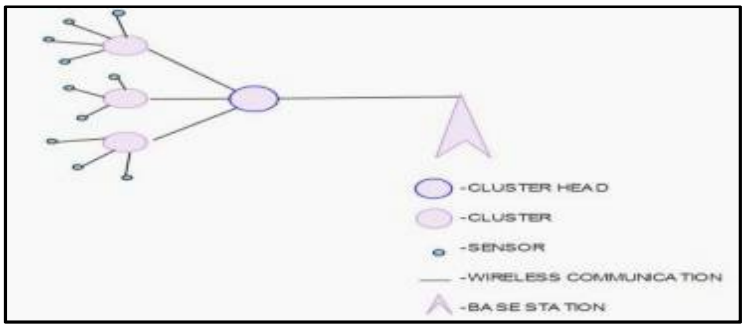

Fig. 1. Cluster base WSN

The basic operations of LEACH are organized in two phases as shown in figure.
(1)Setup phase: In this phase, cluster-head selection and cluster formation by sensors nodes.
(2)Steady-state phase: In this phase data collection from sensor nodes, aggregation by clusters and data delivery to the base station by clusters.

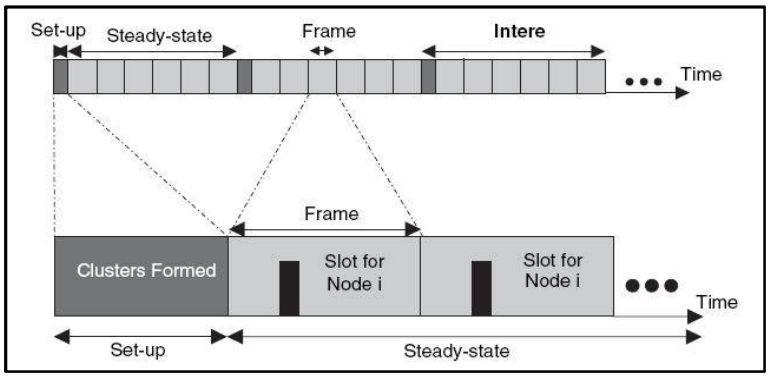

Fig. 2. LEACH [17]

After certain time network goes back to set-up phase again and enter another round. The operation of LEACH protocol operation is divided into rounds, where the round start with a set-up phase, when the cluster are organized , followed by the steady-state phase as shown in Fig. 2.

WSN can be deployed in different places in different ways with different architectures after deployed LEACH protocol works. There are four main phases of LEACH**.**

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a) Advertisement phase

Initially, each cluster node decides it become a cluster-head. This decision is based on the priority and the number of times the node has been a cluster-head. This decision is made by selecting the node n choosing a random number between 0 and 1. If this is less than threshold T (n), the node becomes cluster-head for the current round. The threshold level is set by:

$$T(n) = \begin{cases} p/\left(1 - p\left(r \bmod \frac{1}{p}\right)\right), & n \in G \\ 0, & n \in G \end{cases} \qquad \text{eq. (1)}$$

Where p is ratio of cluster-heads, r is the current number of round and G is the cluster node set which has not been selected as cluster head in the last 1/p round [4].

b) Cluster Set-up Phase

As there are number of cluster heads in WSN. So, in this phase after it is decided that which nodes which become cluster head, the other cluster would request to cluster-head to be part of that cluster head.

c) Schedule Creation

In the schedule creation phase cluster-head receives all the messages from the cluster-node. It is based on the number of nodes in cluster. It creates a TDMA schedule to tell when it can transmit. This phase of schedule is broadcasted back to nodes in that cluster.

d) Data Transmission

When TDMA schedule is fixed, the data transmission begins .The information is collected and compressed before transmitting to the base station. This is the steady state operation of sensor network using LEACH protocol. After some time these four phases would be repeated.

II. RELATED WORK

LEACH protocol vastly used in WSN and their extended version is as follows.

A. LEACH-B

LEACH-B (Balanced) is extended version of LEACH by finding the number of Cluster-Heads. There is a second stage of selecting Cluster-Heads in LEACH-B. The residual energy of Cluster nodes become Cluster- Heads, which modifies the number of Cluster-Heads in the set up phase considering the residual energy of nodes. The LEACH-B protocol saves energy consumption by ensuring that the clusters are balanced. The work is similar to LEACH, But LEACH-B introduces another selection stage: All the Cluster-Heads that are elected will be ordered dissentingly according to their residual energy, and only (n*p) of them, (where n is totalling number of cluster nodes, and p is the percentage of Cluster-Heads) will be considered as Cluster Heads and the remaining are cluster nodes [8].

B. LEACH-C

In LEACH –C (LEACH centralized) the base station is used to develop the cluster head instead of cluster nodes and will be configured themselves into the cluster-heads.

To do this firstly, the Base Station obtain data as per the location and energy Level of every node in the network .On the second stage it will find a recent number of cluster head and then after that it will be organized the network into the clusters. It is completed with respect to the energy contained. It is mandatory for cluster nodes to convey information to particular cluster-head. The Base Station uses its universal knowledge of the network to create cluster in WSN that is necessary to consume less energy for data broadcast. In LEACH-C the number of Cluster-Heads in each round equals a prearranged optimum value [7], [16].

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C. LEACH-CC

LEACH-CC (LEACH-Centralized with Chain) using a central control algorithm to form the cluster may produce better clusters by dispersing cluster head nodes throughout the network [1],[2]. Then a chain routing between cluster-Heads is established to reduce the amount of cluster nodes, which communicate with the base station. Further improvement in energy cost for data gathering can be achieved if only one cluster-head transmits to local neighbour cluster-heads in the data fusion phase [17].

D. LEACH-SM

It introduced another concept of managing spare cluster nodes for the primary Cluster-Heads. There are two demerits in LEACH protocol. One is the hotspot problem which is occurred due to additional overload of Cluster-Heads. The second demerits are redundancy of data transmissions to Cluster-Heads. These two problems are identified when spare cluster nodes are used. When the primary Cluster-Head loses its entire energy, the spare cluster node takes the responsibility and thus avoiding the discontinuation in getting the data. LEACH-SM protocol also elects the appropriate spare cluster nodes and decides how long the spare cluster nodes should be in idle condition. The, life time of LEACH can be extended up to 50% by using this protocol [9].

E. OPTIMIZED LEACH (OP-LEACH)

It introduced another concept Optimized LEACH (Op-LEACH). It is an optimized version of LEACH. In this protocol TDMA slots are utilized wisely. LEACH uses a TDMA based MAC protocol to maintain balanced energy consumption [6]. But it distributes the slots uniformly. OP-LEACH is an event driven after the cluster formation, when the sensor node does not have any data to send, and then the TDMA slot is allotted for some other sensor nodes to sends its data which affect latency of the overall network is reduced. For increasing lifetime of a network it is better when sensor has no work it would goes into sleep mode.

F. AIR QUALITY MONITORING LEACH (AQM-LEACH)

It is another developed concept in LEACH protocol that is called AQM-LEACH. This protocol specifically for Monitoring the Air Quality [4]. In the LEACH, the cluster nodes do not send data continuously to the Base Station at every round. This is an event driven protocol in which mostly cluster nodes are in sleep mode. When any abnormality occurs in the Air Quality, the cluster nodes send details to the Base station regarding the abnormality .This protocol measures the air quality to indicate the level of pollution in the surrounding. This protocol also forecast the level of danger for human health. The value is different for different countries. When any one of the senor nodes senses the event which is abnormal, at that time data is collected. Since most of the time the cluster node being in sleep stage, lifetime of network is more.

G. V-LEACH

Another type of LEACH protocol introduced is called V-LEACH protocol. In V-LEACH the hierarchical structure contain a vice-cluster head and cluster nodes. In original LEACH the cluster head always receives data from cluster node after receiving data from cluster nodes, aggregates these data and then sends data to Base Station. The cluster head die earlier than cluster node due to heavy workload .When the cluster head die the cluster will become isolated because the data gathered by cluster nodes will never reach to the base station. In V-LEACH protocol having a cluster head in the cluster, there is a vice-cluster head that takes the role of the cluster head when the original cluster head dies [14]. The vice-cluster head works similar to cluster head. In V-LEACH there is no need of election for a new cluster head because vice-cluster is available to perform their work. This will be extended network life.

H. *ENERGY EFFICIENT LEACH PROTOCOL*

It introduced another protocol that is called EELP. This protocol is practical protocol this is not designed for adhoc wireless sensor networks. This is specially designed for the network of sensor nodes, whose locations are pre-determined. General application of EELP is to identify the hazardous gases in residential or commercial buildings. EE-LEACH Protocol has two thresholds 1). Lower-Threshold (LT) value, 2). Higher-Threshold (HT) value [10]. If the sensed data is below the LT (Dangerous Level) then data is not sent to the base station; otherwise the sensed data i.e.

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(HT) is sent to base station directly, and there is no need to wait for cluster head. Aspect of EELP uses XOP operation for eliminating duplicate data sensed by nearby cluster nodes.

I. *MULTI-HOP LEACH*

In Multi-Hop Leach, when the diameter of network is increased in certain level, then LEACH protocol becomes inefficient. In LEACH protocol energy dissipation of cluster-Head is not affordable. In Multi-Hop LEACH protocol, some cluster node elects themselves as cluster-Head to complete the cluster information in the setup phase. In the next phase steady state phase, the cluster head collects data from all the cluster nodes and send directly to the Base Station after aggregation. This protocol allows two types of communication operation [15].

(1) Inter-Cluster communication.
(2) Intra-cluster communications.

In multi-Hop LEACH protocol, intra-cluster communication in which whole network is divided into multiple clusters, each cluster has one cluster-Head. This cluster-Head is responsible for communication between all the cluster nodes in the cluster. And it receives data from all the cluster nodes at a single-Hop distance and aggregates and transmits the data directly to the base station, or through intermediate Cluster-Heads. In Multi-hop inter-cluster communication in which when the distance between the cluster heads and the Base Station is large, the Cluster-Head uses intermediate cluster heads for communicate to the Base Station [15].

J. *LEACH-TLCH (LEACH with TWO LEVELs CLUSTER HEAD)*

It is better than normal LEACH as we know selection of cluster head and cluster is same in LEACH protocol. If cluster head energy is lower than average energy and distance between the cluster head and base station is larger than the average distance for communication, then the common node with maximum energy in the WSN will be selected as cluster in this protocol [3].

K. *ENERGY EFFICIENT WEIGHT CLUSTERING BASED ON LEACH*

It uses some metric to select a cluster head such as First: distance between the cluster heads, nodes and base station. Minimum distance of cluster head to clusters and base station will select as a cluster head. Second: Node degree, Nodes having more vicinity save energy through data transfer from cluster heads to base station. Third: Residual energy, higher the residual energy will have higher chance to make cluster heads. It also uses channel modes such as free space and multipath fading with d^2 and d^4 power loss respectively [18].

L. *LEACH-A (ADVANCE LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY)*

In LEACH, normally cluster head consumes more energy than others sensor nodes. To notice this issue LEACH-A used to increase the lifetime of nodes. Each sensor knows the starting of each round. let n be the total number of nodes and m be the fraction of n that have energy greater than other nodes called CGA nodes(nodes selected as gateway or cluster head) the rest of (1-m)*n nodes act as a normal nodes [19],[21],[22].

M. *W-LEACH (WEIGHTED LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY)*

In this new data aggression technique is used. It handles different sensors nodes distribution. In this each cluster heads selected on the bases of weight. Weight based on two factors: first is remaining energy (after some rounds) and second is density (the ratio of number of alive sensors to the total number of sensor). Also sensor nodes which have more weight situated near the cluster heads. It chooses only x% of sensors near the cluster heads that forwards data to the cluster heads [20].

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III. SIMULATION RESULTS

We implement LEACH protocol using MATALAB Tool. The parameter to implement this in the below table.

Table 1.

Network Size	100m x100m
Number of Nodes	100
Maximum round	9999
Election probability (p)	0.1

In this we take two type of nodes Normal and Advance Node. Only 10% percent of total nodes are advance node. Advance nodes represented with "**+**", Normal nodes with "**0**" and Cluster head represent with "*****". On the other side energy label for advance nodes is "1" and "0" for normal nodes. Initially 10 nodes as an advance node. Energy level "0.5" set for every node and if energy level less than equal to zero it would be consider as a dead node in the sensor field. In the sensor field dead node represented with "**.**" red dot. In this there is a reference point at (50, 50) x-axis which is in center represented with "**x**". Election of cluster head possible with the help of above eq. (1).

In the simulation 100 nodes were deployed randomly within the area. The Fig 3 and Fig 4, Illustrates the environment of 100 nodes. In this X and Y coordinates measured in meters. In these fig Circles shows live nodes and dotted shows dead nodes.

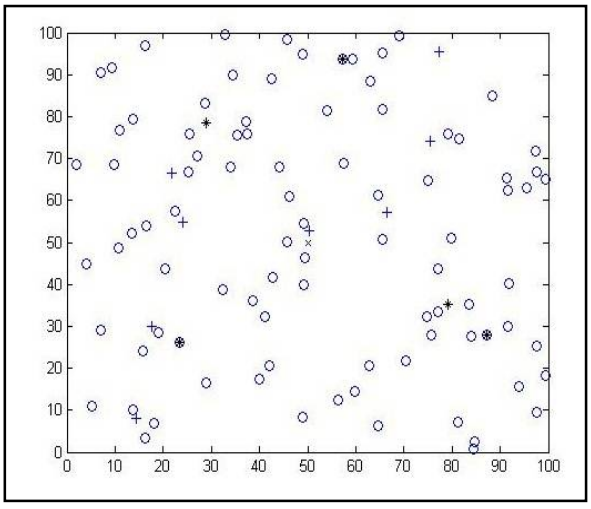

Fig. 3. LEACH protocol-I

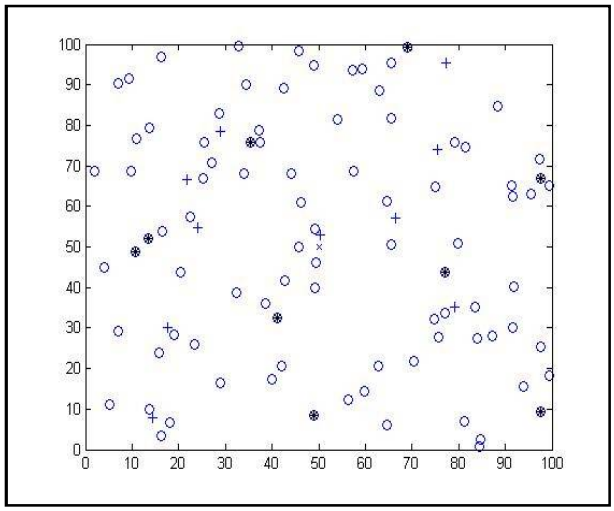

Fig. 4.LEACH protocol-II

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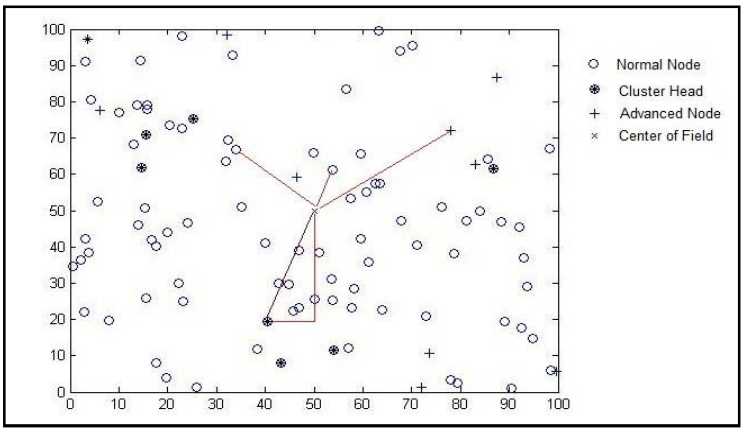

Fig 5. Election process of LEACH

In Fig 5, election process of LEACH is shown, using eq. (1) and minimum distance formula, each node calculate distance with reference point. On the basics of that calculation Cluster head election performed in LEACH protocol.

IV. CONCLUSION

As WSN uses number of routing protocol, different application require different protocol and we discussed LEACH protocol which is low energy consumption and data aggregation using clusters but LEACH has some problems such as- No clarity about the sensor nodes and cluster in the sensor field , life span of each cluster. As cluster head consume more power because clusters head collect data and forward to base station continuously. Also cluster head totally depends on clusters. If any sensor gets weak or destroys, there is a minute effect on WSN but if any cluster node which collects data from their related nodes gets damaged it affect on sensor field and if cluster head dies, whole network get dumped. Also there are number of clusters in the sensor field. Different cluster, collect different types of data. If any cluster node get die, how it's related sensor nodes forward data to the base station. And there is no clarity about capacity of clusters to handle other sensors nodes data.

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