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Clustering Based Routing Protocol LEACH and Its' Variants: A Review

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Abstract— In clustering technique LEACH is refer as an important protocol of the hierarchical routing protocols that is applied to decrease the loss of energy in disseminating and collecting. This paper is related with definite hierarchical routing protocols that are generated from the LEACH. This paper presents some main points of few problems and drawbacks in LEACH and explained how to recover via the sections of LEACH. In this paper various properties are compared, also accomplishment and problems of all hierarchical routing protocols are compared. In this it is also discussed regarding the LEACH and its several protocols that are depend on hierarchal routing protocol.

Index Terms — LEACH, Energy, Cluster, Energy Efficient, MANET.

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I.   INTRODUCTION

Low Energy Adaptive Clustering Hierarchy (LEACH) protocol for the wireless networks is mostly used that consists devices of less battery powered, such as wireless sensor networks (WSN). And when the battery power is consumed in these terminals/devices then network cannot be get used and all the terminals waste maximum of the energy during transmitting the data. Hence, to raise the network's lifespan, every terminal has to do only short work for data transmission. In WSN, LEACH protocol is extremely used, due to in low level this protocol spend the energy.

In the wireless networks, Routing are classified into 3 kinds depend on the framework of the network. They are Hierarchical Routing, Location Depend Routing and Flat routing, [1]. All the terminals in flat routing, of the network operate the same range of capabilities and do work together to generate/collect the data and routing to destination. The Directed Diffusion protocol and Sensor Protocols for Information via Negotiation (SPIN) protocol are related to flat network routing. The entire network in the hierarchical routing is divided into several clusters to enhance the scalability and consume the energy of the terminals effectively. Such as LEACH routing protocol. In Location dependent routing, details of location for every terminal are controlled continuously to detect the path of routing for communication. Devices of Global Positioning System (GPS) are used with network terminals. For example: Geographic Adaptive Routing (GRS).

All the terminals in LEACH protocol are combined to form groups into the clusters, and in every cluster one of the terminals is allocated as a Cluster Head (CH). CH gathers the data from the neighbor terminals and sends it to the base station. Normally, starting allocation of CH is random and the work of CH is revolves for every fixed time so that every terminal will work as a CH at least for once in its life span. LLEACH algorithm may have two phases. One is set up phase and another one is steady state phase. To select a CH Setup phase is used and steady state phase is for to manage the CH while the data transmission. A terminal n is choosing as a CH in next round depends on implementing the below formula. If $T(n)$ is 1 then the terminal n will be the CH in coming next round.

$$T(n) = \begin{cases} \dfrac{p}{1 - p \times \left(r \times \bmod \dfrac{1}{p} \right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

where, p is the probability of terminal n being used as a CH, r denotes the current round number and G is the set of terminals which are not used as a CH in the last $1/p$ rounds.

The basic idea of LLEACH protocol is to split the complete wireless sensor networks into various clusters. The cluster head terminal is alternatively choose, the chance of every terminal to be get selected as cluster head is equal, and consumption of energy for whole network is normal. Hence, LEACH can continue life-cycle of network. LEACH algorithm is repetitive; it gives a understanding of round. LEACH protocol works with several rounds. Every round includes two states: one is cluster setup state and another one is steady state. In cluster setup state, it creates cluster in self-adaptive pattern; and in steady state, the data get transferred.

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At the time of second state is normally larger as compared to the time of first state for saving the payload of protocol.

The issues in the basic LEACH protocol are:
1) The cluster head terminal is casually get selected in LEACH. Also there are few weak points, because of which the chances of every terminal to be get selected as cluster head is equal. After many rounds, the terminal with maximum left energy and the terminal with minimum left energy have equal chances of getting selected as cluster head. If the terminal that has minimum energy is chosen as cluster head, it will work out energy and expires quickly, so that the robustness of network will be get affected and lifetime of network will be get short.

2) The fundamental LEACH Protocol splits clusters randomly, also provides to irregular distribution of clusters easily. Ultimately the detached clusters may not be always the best. For sometimes, few clusters have maximum terminals as compare to others, and some clusters have less terminals. Some of the cluster heads in the comparatively central of clusters, and some of the clusters heads may be in the boundary of clusters that are far away from members. These experiences can produce raise in consumption of energy and influences the whole performance of the network.

3) In steady state, the cluster head transmits the data to sink data directly, but this did not get considered the allocation of cluster heads is not constant. Cluster head that are beyond from the sink get communicate with the sink directly should consume huge energy. It will also get crash very soon due to the reason as it works out of energy. Particularly, accompanied the extension of the scale of network, therefore these changes are more noticeable and seriously influences the life of network.

II. LEACH

LEACH (Low-Energy Adaptive Clustering Hierarchy), an energy-conserving routing protocol for wireless sensor network, was proposed by Heinzelman, Chandrakasan and Balakrishnan [2].

It is a hierarchical based protocol that is energy efficient as compared to traditional protocols. It's the first network protocol which adopted hierarchical structure. In LEACH network is divided into clusters based on the signal strength of sensors. CH selection is done randomly and they die quickly. All the nodes in LEACH have same energy level. It operates in two phases: first is setup phase in which CHs are created; second phase is steady phase in which CHs collects data from the sensor nodes in their respective clusters and delivers this data to the sink.

The idea is to form cluster of sensor nodes based on signal strength and use the cluster-head as a router to forward data of other nodes in cluster to the base station. The data processing is performed at cluster-heads. LEACH is a dynamic clustering mechanism. Time is divided in rounds/intervals with equal length. At the beginning of the round, cluster-heads is generated randomly among the nodes which have remaining energy higher than the average remaining energy of all the nodes.

After becoming cluster heads, the nodes broadcast messages to all nodes to inform the status of them. Non cluster-head nodes decide which cluster head to join based on the receiving signal strength of these messages.

The cluster-heads create schedules and send to all the nodes in the clusters. For the rest of the round, the nodes send data to their respective cluster head nodes, then the cluster heads aggregate and send the data to the base station.

After each round, clusters-heads are re-generated to form new clusters. The cluster-head rotation allows network to spend energy equally between sensor nodes and hence it can lengthen the sensor network life time.

The major drawback of LEACH is that no consideration is given to the energy consumption while selecting a node as a CH. A node with small residual energy can become a CH, which will lead to early death of the CH and shorten the network lifetime. It is not suitable for large size networks [3][4].

III. VARIANTS OF LEACH
LEACH B (Balanced)

This protocol takes into consideration the residual energy of the CH and solves the problem of fluctuation of number of CHs in LEACH. It improves LEACH by introducing a second selection of the CHs based on residual energy every round to keep the number of CHs constant and near-optimal. It leads to balance of energy consumption and minimize the total energy dissipation of the sensors. LEACH B enhances the energy efficiency as compared to LEACH and the network lifetime is increased as well [5].

LEACH C

CHs are chosen randomly based on the energy threshold. Sensor nodes with energy above the average are selected. The information of the nodes location and value of its residual energy are send to the BS at the starting of every iteration. Next the BS broadcast to the network the selected group of CHs using the simulated annealing. If a node receives its own ID, then it becomes the

CH. Otherwise this node transfer data to the CH. LEACH C improves the network lifetime as compared to conventional LEACH [4].

EEE LEACH (Energy Efficient Extended)

This is an improvement over LEACH protocol. It is a multiple level clustering technique to decrease communication distance between sensor nodes. Master CHs are introduced along with CHs. It have double layer of cluster formation. First layer consists of cluster construction based on the nodes which transfer data to their respective CHs. CH aggregates this data. In the second layer master CHs formation takes place. Then CHs examine the nearest MCHs by computing the distance among them and send their aggregate data to the particular MCHs. The MCHs aggregate all received data and delivers it to the BS. As the number of clusters increase, the communication distance decreases. This leads to greater energy efficiency of this protocol and increased network lifetime [6].

MG LEACH (Multi Group based)

This protocol takes the deployed redundant nodes under. which major fraction of energy depletion in the network is covered. This is energy efficient routing protocol based on LEACH. Lots of redundant data exists in WSNs because of extensively deployed nodes. This redundancy of sensor nodes is used as a benefit for enhancing network life time. It overtook LEACH as it helps to increase the Network life time.
This approach consist three steps. Two of the steps are same as in LEACH, which are Setup phase and steady state phase. Set building phase is used before set up phase. This is done at the time of deployment and after every "x" rounds by BS. In set building phase, nodes are distributed into Sub Groups depending upon their positions. Every node that is provided with GPS forwards location information to BS directly. BS will utilize this information for each Set building phase. As this is done just once, it does not put away much of the energy [7].

MOD LEACH (Modified)

This protocol modifies LEACH, as it introduce an effective CH replacement technique and dual transmitting energy levels. The CH is changed at each round. In each round, CHs are changed and entire cluster formation procedure is repeated. If CH has not used up much power and has more power than the threshold, it will become

CH for the following round also. By this method, power lost in routing data for new CH and cluster formation is saved. Otherwise, it will be changed in the same way as in LEACH. Further, soft and hard thresholds are used to enhances the performance even more [8].

PR LEACH (Percentage)

The main idea of this approach is to uniformly distribute the load of network among all the nodes to balance energy dissipation and increase network lifetime. CH is selected on the basis of residual energy. Energy is preserved by inter cluster transmission. Data transmission for members is done at every round randomly [9].classes.

IV. LITERATURE REVIEW

Limited energy resources of sensor nodes create challenging issues on the improvement of routing protocols for WSN. Introducing clustering into network's topology reduces number of transmissions in the network. Hence, clustering can provide energy efficiency as CHs aggregate data from their respective member nodes as well as reducing multiple transmission enhancing the network lifetime.

Heinzelman introduced a clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH). The algorithm randomly selects cluster heads, and the other nodes are divided into groups depending on strength of the received signal from the cluster head. LEACH defines a "wheel" (Round) concept, and each wheel is made from the two stages of cluster stability and the establishment.

LEACH protocol employs a distributed algorithm to form a cluster, each node independently decides whether to act as the cluster head node in the current round. For each node 'n' must be randomly generated which is a random number between 0 and 1. If the random number is less than the threshold T (n), then the node is selected as the current round of the cluster head node. T(n)defined

$$\text{as:} \begin{cases} \dfrac{p}{(1-p)\times\left(r \bmod\left(\frac{1}{p}\right)\right)} & n \in G \\ \\ 0 & \end{cases}$$

Authors of [10, 11] states that nodes having high initial energy will be selected as cluster heads (in case of heterogeneous sensor networks). While according [12, 13, 14] any node that lie within network can be elected as a cluster head. Stable Election Protocol (SEP) gives weighted

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probability to each node of becoming a cluster head [12]. In DEEC [13] existing energy in node is election criteria of a node to become a cluster head. TEEN [15], SEP [12], DEEC [13] and EGASIS [16] are prominent routing techniques for wireless sensor networks. Main procedure of electing a cluster head was given by LEACH and that is further enhanced by SEP and DEEC.

TEEN introduces the concept of thresholds that gives good results in network life time by showing reactive nature. These thresholds can be implemented in any routing protocol to enhance its performance with respect to utility or application. Considering LEACH, the algorithm is divided into three parts, i.e. advertising phase, Cluster Set up phase and Scheduling phase.

Based on LEACH, SEP and DEEC, numerous protocols are proposed. Q-LEACH [17] optimize network life time of homogenous wireless sensor network. [18] gives a detailed comparison analysis on different variants of LEACH as A-LEACH, S-LEACH and M-LEACH in terms of energy efficiency and applications. A very interesting comparison analysis between LEACH, Multi level Hierarchal LEACH and Multi hop LEACH is undertaken in [19]. Authors of [20] enhances SEP in terms of heterogeneity. They propose a model that gives three level heterogeneity. Whereas [21] gives a new protocol that works better than SEP in terms of network stability and life time having two level heterogeneity. T.N. Qureshi *et.al* [22] modified DEEC protocol in terms of network stability, throughput as well as network life time.

Heinzelman et al. (2000) [23] has proposed a protocol for homogeneous WSN. It is Low-Energy Adaptive Clustering Hierarchy (LEACH). Homogeneous WSN is the one which has all nodes at same energy level. In LEACH every node depends on its individual probability to become a CH. It equally assigns the energy load among the sensor nodes by the use of randomized alternation of cluster-heads. M.Tong and M.Tang (2010) [5] has introduced an improvement over conventional LEACH protocol. It balance of energy consumption and minimize the total energy dissipation of the sensors, so it is named as LEACH B. it takes into account the residual energy of the nodes. S.Shi et al. (2012) [4] proposed another protocol called LEACH C to overcome the drawbacks of LEACH. CHs are chosen randomly based on the energy threshold. Sensor nodes with energy above the average are selected. This approach prolongs the network lifetime. M.Sharma and K.Sharma (2012) [6] has proposed an energy efficient extended (EEE) LEACH which is an improvement over LEACH. It is a multilevel clustering approach to reduce

communication distance within sensor nodes. Master CHs are introduced along with CHs and arranged in two layers. This leads to greater energy efficiency of this protocol and increased network lifetime. M.Haneef et al. (2012) [7] takes the redundancy of the deployed nodes as an advantage to prolong network lifetime. It has an extra step as compared to LEACH, set building phase which is used before set up phase. It does not put away much of the network energy. This approach is called MG LEACH. D.Mahmood et al. (2013) [8] introduce an effective CH replacement technique and dual transmitting energy levels which modifies LEACH and it is named MOD LEACH. CH changes at each round. If CH has not used up much power and has more power than the threshold, it will become CH for the following round also. Energy wasted in routing data for new CH and cluster formation can be saved. Then soft and hard thresholds are applied on MODLEACH. This enhances the performance of this protocol. M.Salim et al. (2014) [9] proposed a scheme called percentage LEACH that improves cluster-head selection approach oh LEACH. It uniformly distributes load among nodes and balances energy dissipation by considering the nodes residual energy and this increase network lifetime.

V. CONCLUSION

In this paper, the drawbacks and problems addressed of LEACH protocol and how such issues are overcome through the various versions of the LEACH have been discussed. Every routing protocol possesses its own advantages and being to the fundamental LEACH routing protocol. This article also compares various features and performance level of different hierarchical clustering routing protocol There are few disadvantages in LEACH protocol which required to removed and these are discussed with few variants of LEACH protocol like C -LEACH ,M-LEACH,E-LEACH. These points are explained in this survey paper and which could lead to make LEACH protocol highly efficient.

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