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Energy Efficient Clustered Routing Protocols of LEACH

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Abstract-- Sensor node has a limited amount of battery in sensor network. To prolong the overall lifetime of the network, development of energy efficient routing protocol is a major issue in Wireless Sensor Network. Clustering protocols are one of the approaches to serve this purpose. LEACH is a well-known routing protocol based on clustering, but it has several problems like short network lifetime. Due to inefficient energy consumption several variants have been proposed to overcome these problems in LEACH. Here analysis of variants of LEACH namely LEACH-C, Multi-hop LEACH, Energy LEACH is done. LEACH-C can be chosen when centralized and deterministic approach covering entire network is expected still bringing in increased network lifetime and desired number of clusters. When network's diameter is increased beyond a certain level, distance between CH and BS is increased enormously Multi-hop LEACH is chosen. Energy-LEACH tries to achieve efficient energy utilization. Simulation results show that our protocol outperforms the LEACH in terms of the parameters under consideration.
Keywords- Wireless Sensor Network; Routing, Clustering, LEACH, LEACH-C, Multi-hop LEACH, Energy-LEACH.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) consist of many sensor nodes. The typical configuration of such a sensor node in a WSN includes single or multiple sensing elements, a data processor, communicating components and a power source. Normally, the sensing elements perform measurements related to the conditions existing in its surrounding environment. These measurements are transduced into corresponding electric signals and are processed by the data processor. Sensor networks may consist of many different types of sensors such as seismic, low sampling rate. magnetic, thermal, visual, infrared, acoustic and radar. A sensor node makes use of its communicating components in order to transmit the data, over a wireless channel, to a base station (a sink node).Wireless sensor networks have the following characteristics:
The node distribution is extremely dense.

The node's capacity of processing ability, electrical power and storage is very limited.

In the network, nodes are mostly static, and poor working conditions will make a high probability of node failure.

As the resources of sensor nodes in WSN, such as energy, computing capability and transmission bandwidth etc., are very limited, it is critical to employ superior routing protocol in order to reduce resource consumption. This can help in achieving extended network life cycle, which is also the major objective of WSN routing design. Currently, WSN routing protocols can be mainly divided into two categories, i.e., flat routing protocols and hierarchical routing protocols. When deploying the large-scale WSN, the communication overhead, delay and management complexity of flat routing protocols will retard response of WSN as well as excess power consumption. However to a certain extent, the above problems can be solved by hierarchical routing protocol. In a relatively optimal hierarchical structure, the neighbouring nodes are clustered and then a cluster head node, which is responsible for managing nodes in the cluster and communicating with the base station, can be chosen. Such a hierarchical structure can not only reduce the communication cost, but also utilize the cluster head node with higher energy to collect the data in the cluster's coverage, so as to save energy and prolong the life of the network. Hierarchical routing protocols are LEACH (Low Energy Adaptive Clustering Hierarchy), TEEN (Threshold Sensitive Energy Efficient Sensor Network Protocol), PEGASIS (Power - Efficient Gathering in Sensor Information System) etc.. In this paper simulation and performance evaluation of LEACH and chosen variants using MATLAB will be presented.

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II. 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.

A. Leach

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.

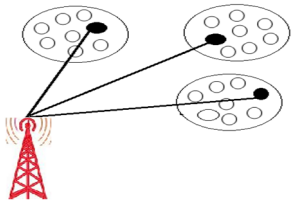


Fig. 1. Topology structure of LEACH

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.

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

Where p is the expected cluster head node in all the percentage of sensor nodes, r is the number of rounds that carried out, G is in the last 1 / p rounds are not served as a set of cluster head nodes.

After the cluster head node is selected as cluster head nodes, each cluster head will broadcast the information that it become to cluster head(ADV),other non-cluster head node according to signals received by the broadcast information to determine the cluster to be added, and send a join request to the cluster head. When the cluster head node receives the "Registration" message from the members, it generate a TDMA time slot table for slot allocation of each member based on the number of members of the node, thus ensuring there is no conflict between the data sources, when each node knows own time slot then enter the stable work.In a stable stage, the members of the nodes that belong to its own time slot send data to the cluster head, while the rest of the time the radio module can be turned off and enter the sleep state, which is one main method to save energy of LEACH. After Cluster head node receives data collected by the members of the node, it will be fusion the data and send it to the sink node.

B. Mobile Leach

The LEACH considers all nodes are homogeneous with respect to energy, which is not realistic approach. In particular round uneven nodes are attached to multiple Cluster-head. In this case cluster-head with large number of member node will drain its energy as compared to cluster-head with smaller number of associated member nodes. Furthermore mobility support is another issue with LEACH routing protocol. In order TO mitigate these issues, Mobile LEACH variant has been proposed.

C. Leach-B(Balanced Low Energy Adaptive Clustering Hierarchy)

LEACH-B uses the decentralised algorithms for cluster formation where each sensor node only knows about its own position and the final receiver and does not know about the position of all the sensor nodes. LEACH-B involves the following techniques: Cluster head selection algorithm, Cluster formation and data transmission with multiple access. By evaluating the energy dissipated in the path between final receiver and itself, each of the sensor node chooses its cluster head.

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D. Security Leach

It is the first modified version of LEACH with cryptographic protection against outsider attacks called Security LEACH(S-LEACH). It suggests that each node has two symmetric keys, a pairwise key shared with BS and the last key chain held by BS. S-LEACH is meant to protect only against outsider attacks. S-LEACH protects against selective forwarding, sinkhole and HELLO flooding attacks by preventing intruder to become CH. It also prevents intruder to send bogus sensor data to the CH and CH to forward bogus message.

E. K- Leach

K-LEACH protocol improves the clustering and cluster head selection procedure. For the first round of communication, in setup phase we use the K-medoids algorithm for cluster formation, which ensures uniform clustering. 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 always gives most energy efficient solution in WSN. From second round onwards cluster heads are selected based on the next nearest node to the first round cluster head and so on.

III. RELATED WORK

In this PAPER, 3 variants of LEACH that is LEACH-C(LEACH-Centralized),Energy-LEACH Multi-hopLEACH, are considered. When network's diameter is increased beyond a certain level, distance between CH and BS is increased enormously and Multi-hop LEACH is used. LEACH-C uses centralized clustering algorithm. Energy-LEACH algorithm find maximum of all energy values and determines who the next cluster head to be selected.

A. Leach-C (Leach-Centralized)

LEACH-Centralized (LEACH-C) is similar to the LEACH Protocol as far as formatting clusters at the beginning of each round is designed to improve the performance of LEACH. However, instead of nodes randomly self-selecting as a CH, the sink in LEACH-C performs a centralized algorithm[1]. The sink collects location data from the nodes, and then broadcasts its decision of which nodes are to act as CHs back to the nodes. The overall performance of LEACH-C is better than LEACH by dispersing the cluster heads throughout the network. However, LEACH-C is sensitive to the sink location. Once the energy cost of communicating with the sink becomes higher than the energy cost for cluster formation, LEACH-C no longer provides good performance. Sinks may be located far from the network in most WSN applications. So, the dependence on the sink location is a major disadvantage of LEACH-C[1]. First of all, in any round of the cluster head selection stage, the base station must know the remaining energy of all nodes as well as the location information[2]. Based on this information, the base station uses a specific method to select the cluster head and divides all nodes to these clusters, which can easily figures out the better segmentation approach of the clusters[2]. Thus we can enhance the performance of the LEACH protocol by solving those limitations which the LEACH protocol has.

B. Multi-Hop Leach

When network's diameter is increased beyond a certain level, distance between CH and BS is increased enormously. This scenario is not suitable for LEACH routing protocol in which BS is at single-hop to CH. In this case, energy dissipation of CH is not affordable. To address this problem, Multi-hop LEACH is proposed [3]. It is also complete distributed clustering based routing protocol. Like LEACH, in Multi-Hop LEACH some nodes elect themselves as CHs and other nodes associate themselves with elected CH to complete cluster formation in setup phase[4].

In steady state phase CH collects data from all nodes of its cluster and transmit data directly or through other CH to BS after aggregation. Multi-Hop LEACH allows two types of communication operations; inter-cluster and intra-cluster. In former type of communication, when whole network is divided into multiple clusters, then each cluster posses one CH. This CH is responsible for communication for all nodes in the cluster. CH receives data from all nodes at single-hop, aggregates and transmits directly it to sink or through intermediate CH. In later type of communication, when distance between CH and BS is large then CH uses intermediate CH to communicate with BS. Randomized rotation of CH is similar to LEACH. Multi-Hop LEACH selects best path with minimum hop-count between first CH and BS[3].

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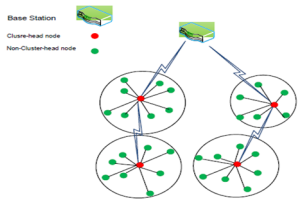


Fig.2.Multi-hop LEACH

C. Energy-Leach

Energy-LEACH algorithm find maximum of all energy values and determines who the next cluster head to be selected. Here maximum of all energy values is calculated by using list of all energy received by the cluster head. Node with maximum energy is selected as next cluster head. Current cluster head sends task handover message next cluster head. Next cluster head generates schedule for its cluster nodes and sends it to them. Node send data at their respective time till next change time. These are the steps involved in this algorithm

IV. SIMULATION RESULT

In this section, we mainly use simulations to analyze and evaluate the performance of the algorithm. Here MATLAB is used as tool to simulate all the method. To verify the improved algorithm proposed, we will compare the results with LEACH. The basic simulation parameters for our model are mentioned in Table I. The experiment is carried out by using the same energy source whose initial energy is 0.5J. The fusion coefficient is 0.5. Every node transmits a *k* bits data packet per round to its cluster head. The size of a control packet *L*ctrl is 100 bits.

Table 1 TRANSMISSION PARAMETERS VALUE

Description	Symbol	Value
Number of nodes	*N*	100
The initial node energy	*E*initial	*1J*
Energy consumed by the amplifier to transmit at short distance	*Efs*	$10pJ/bit/m^2$
Energy consumed by the amplifier to transmit at longer distance	*Emp*	$0.0013pJ/bit/m^4$
Data packet	*k*	4000 bits
Control packet	*Lctrl*	100 bits
Data aggregation energy	*Eda*	*5pJ/bit*
The cluster probability of LEACH	*p*	0.05
The sensing area	MxM	100m x 100m

We have considered following parameters for evaluating peformance of LEACH and its variants:
Rounds v/s No of data signals received at BS
Rounds v/s Number of nodes alive
Base station location v/s Network Lifetime
Number of nodes v/s Network Lifetime
Time v/s Total energy dissipation
Rounds v/s Number of nodes dead.

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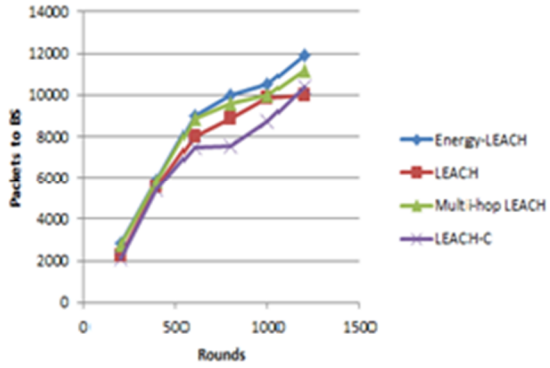


Fig.3.Rounds v/s Packets to BS

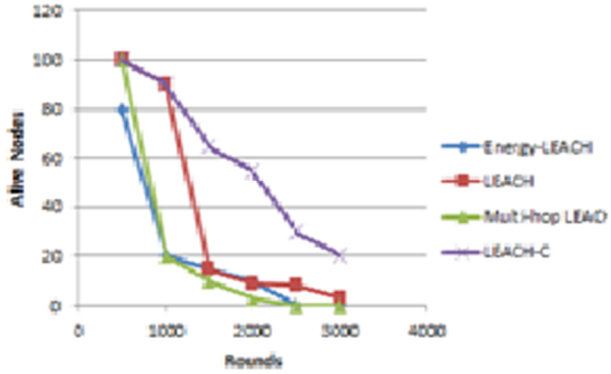


Fig.4.Rounds v/s Alive Nodes

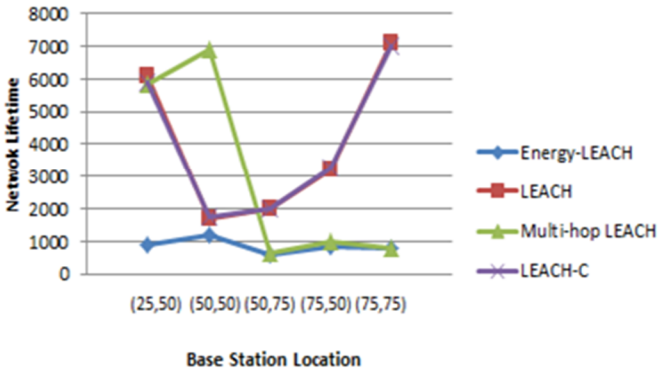


Fig.5. Base station location v/s Network Lifetime

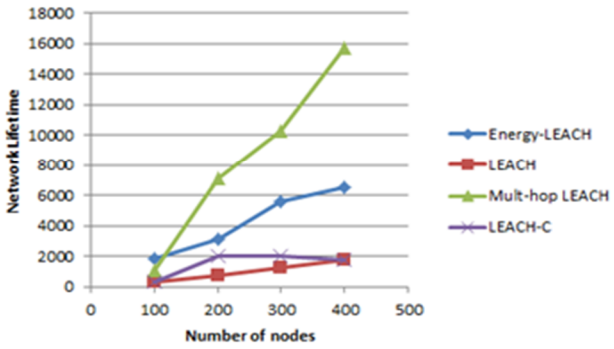


Fig.6. Number of nodes v/s Network lifetime

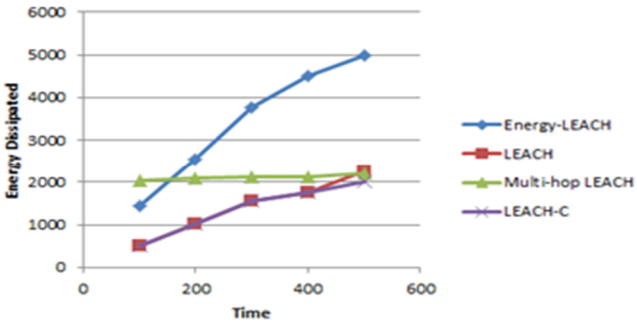


Fig.7. Time v/s Total Energy Dissipated

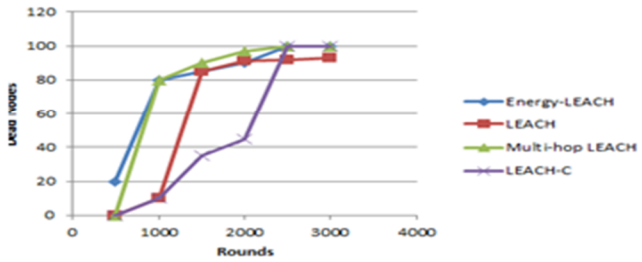


Fig.8.Rounds v/s Dead nodes

V. ANALYSIS OF RESULTS

It is observed from the graph in Fig. 3 that Multi-hop LEACH has better network lifetime due to efficient communication between hops and it selects best path with minimum hop-count between first CH and BS. Fig 4 conveys that location of BS also influence the network lifetime. As BS moves far from network, distance between node and BS increases, network lifetime will be decreasing. Fig 5 shows that number of live nodes decreases slowly in LEACH-C compared to that in LEACH and other variants due to uneven distribution and unnecessarily Higher number of cluster heads. It is observed from the graph in Fig. 6 that as the number of rounds increases, packets received at BS through Energy-LEACH linearly increase compared to others because node with maximum energy is selected as next cluster head. Current cluster head sends task handover message to next cluster head. so more number of packets are sent to BS. From Fig 7 we can infer that in Energy LEACH nodes will die soon. Graph in Fig 8 shows that total energy dissipated is less in LEACH-C, because BS creates desired number of cluster heads and evenly distribute them so that appropriate

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cluster sizes can be formed and hence minimizing total energy dissipation.

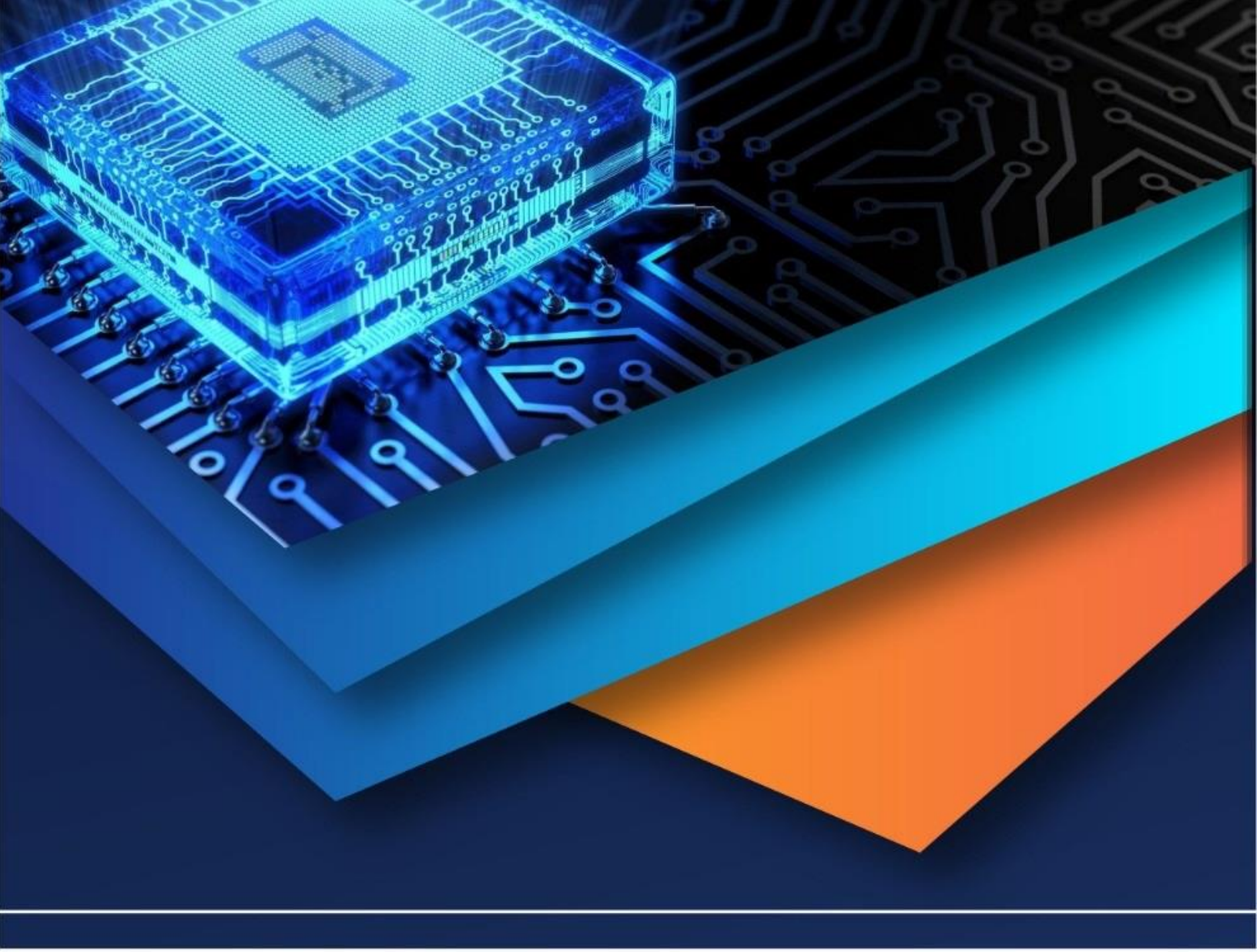
VI. CONCLUSION

Wireless Sensor Networks, which may be spread over vast geographical area, are finding applications in many areas. In this context, there is need of approaches which can manage these WSNs in better way. In this regard, this paper, presented need for clustering to overcome several limitations of WSNs. Chosen clustering protocols, namely LEACH, LEACH-C, Multi-hop LEACH and Energy LEACH are presented. This paper also presented the simulation, results, and analyses of the same. As a conclusion of observation from results, it can be mentioned that LEACH can be preferred if localized coordination of nodes in clustering; and LEACH-C can be chosen when centralized and deterministic approach covering entire network is expected still bringing in increased network lifetime and desired number of clusters. When network's diameter is increased beyond a certain level, distance between CH and BS is increased enormously Multi-hop LEACH is EFFICIENT. Energy-LEACH tries to achieve efficient energy utilization.

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