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A Survey of LEACH Protocol and its Modified Versions in Wireless Sensor Network

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Abstract— Wireless sensor network is a wireless network of sensor node and become one of the most interesting area of researches .routing technique is one of the most challenging issue in wireless sensor network. In Wireless sensor network routing among various routing technique energy consumption is one of the most important criteria. LEACH protocol which is one of the energy efficient clustering protocol .leach is effective in prolonging the network life time by consuming a small percentage of the total dissipated energy in the system. the paper present survey of LEACH protocol and various LEACH-Based hierarchal routing protocols like LEACH-C ,M-LEACH,E-LEACH ,V-LEACH.

Keywords— clustering leach, network, routing wireless sensor network.

I. INTRODUCTION

A wireless sensor network [1], [2] with a large number of tiny sensor nodes can be used as an effective tool for gathering data in various situations. One of the major issues in wireless sensor networks is developing an energy-efficient routing protocol which has a significant impact on the overall lifetime of the sensor network. Sensor nodes measure the ambient conditions from the environment surrounding them. The applications of WSN are various from health monitoring to battle field. The practice of remote sensing has become greatly simplified by useful and affordable sensors as well as required software packages. Additionally, users can monitor and control the underlying environment from remote location. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. Routing protocols in WSNs might differ depending on the application and network architecture. One of the interesting techniques is the Hierarchical Routing, which introduces the concept of cluster creation and assigning special tasks to selected sensor node within the cluster called cluster head (CH). Hierarchical Routing is an efficient technique to reduce energy consumption by doing data aggregation and fusion in order to reduce the number of transmissions to the Base Station (BS). The first hierarchical protocol is the Low Energy Adaptive Clustering Hierarchy (LEACH) that was introduced in [3].The idea of LEACH is to form clusters of the sensor nodes based on the received signal strength and use local cluster heads (CHs) as routers to the sink. This enhances the energy consumption since the transmissions will only be done by the cluster heads rather than all sensor nodes. Many hierarchical protocols were emerged based on the idea of LEACH. Our goal is to provide a recent survey of LEACH based protocols. The rest of the paper presents the LEACH protocol and various LEACH-Based hierarchal routing protocols like LEACH-C, M-LEACH, E-LEACH, V-LEACH and compare these protocols.

II. INTRODUCTION

An LEACH is one of the most popular clustering algorithms [3]for WSN. It forms clusters based on the received signal strength and uses the CH nodes as routers to the base-station. All the data processing such as data fusion and aggregation are local to the cluster. LEACH forms clusters by using a distributed algorithm, where nodes make autonomous decisions without any centralized control. Initially a node decides to be a CH with a probability p and broadcasts its decision. Each non-CH node determines its cluster 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 in order to balance the load. The rotation is performed by getting each node to choose a random number ‘‘T(n)’’ between 0 and 1. Refer to equation (1). A node becomes a CH for the current rotation round if the number is less than the following threshold

$$T(n) = \frac{p}{1 - p * \left(r \bmod \frac{1}{p} \right)} : \text{if } n \in G \qquad (1)$$

$$T(n) = 0 \qquad : \text{Otherwise}$$

Where p is the desired percentage of CH nodes in the sensor population, r is the current round number, and G is the set of nodes that have not been CHs in the last 1/p rounds. Since the decision to change the CH is probabilistic, there is a good chance that a node with very low energy gets selected as a CH. When this node dies, the whole cell becomes

dysfunctional. Also, the CH is assumed to have a long communication range so that the data can reach the base station from the CH directly. This is not always a realistic assumption since the CHs are regular sensors and the base station is often not directly reachable to all nodes due to signal propagation problems, e.g., due to the presence of obstacles. LEACH also forms one-hopintra- and inters cluster topology where each node can transmit directly to the CH and thereafter to the base-station. Consequently, it is not applicable to networks deployed in large regions. This protocol is divided into rounds; each round consists of two phases:

Set-up Phase

• Advertisement Phase

• Cluster Set-up Phase

Steady Phase

• Schedule Creation

• Data Transmission

A. Setup Phase

Each node decides independent of other nodes if it will become a CH or not. This decision takes into account when the node served as a CH for the last time (the node that hasn't been a CH for long time is more likely to elect itself than nodes that have been a CH recently). In the following advertisement phase, the CHs inform their neighborhood with an advertisement packet that they become CHs. Non-CH nodes pick the advertisement packet with the strongest received signal strength.

In the next cluster setup phase, the member nodes inform the CH that they become a member to that cluster with "join packet" contains their IDs using CSMA. After the cluster setup sub phase, the CH knows the number of member nodes and their IDs. Based on all messages received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members. After that steady-state phase begins.

B. Steady-state Phase

Data transmission begins; Nodes send their data during their allocated TDMA slot to the CH. This transmission uses a minimal amount of energy (chosen based on the received strength of the CH advertisement).

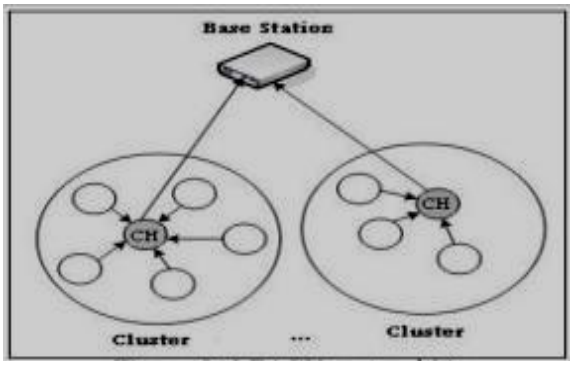

Figure 1 basic LEACH protocol

III. DISADVANTAGES OF THE LEACH PROTOCOL

CH selection is randomly, that does not take into account energy consumption .The nodes with low remnant energy have the same priority to be a cluster head as the node with high remnant energy. Therefore, those nodes with less remaining energy may be chosen as the cluster heads which will result that these nodes may die first.. The cluster heads communicate with the base station in single-hop mode which makes LEACH cannot be used in large-scale wireless sensor networks for the limit effective communication range of the sensor nodes Leach cannot support moment of nodes

IV. LEACH -C

The disadvantage to LEACH is that the number of cluster head nodes is little ambiguous to count. LEACH-C. has been proposed to clarify this problem. LEACH-C provides an efficient clustering configuration algorithm, in which an optimum cluster head is selected with minimization of data transmission energy between a cluster head and other nodes in a cluster. In LEACH-C, the base station receives information about residual node energy and node positions at the set up phase of each round. The received data can compute an average residual energy for all nodes. The nodes with less than average energy are excluded in selection of cluster heads. Among the nodes that have more than average energy, cluster heads are selected with use of the simulated annealing algorithm. The base station sends all nodes a message of the optimum cluster head IDs (Identifiers). The node, the ID of which is the same as the optimum cluster head ID, is nominated as a cluster head and prepares a TDMA schedule for data transfer. Other nodes wait for the TDMA schedule from their cluster heads [9]. Although LEACH-C solves the problem of uncertainty on the number of cluster-head at each round in LEACH, it still has problems such as pre-selection cluster-head, equal opportunities for cluster-head selection mechanism, and the unbalancing energy loads. This phenomenon means that nodes with less energy remaining may be also become cluster-heads. However, once these nodes become cluster-head, their energy will soon exhaust. In the later periods of the network, even the phenomenon of the cluster-head is dead where it have not energy to forward the information may occurred. Therefore, the selection mechanism of cluster-head affects the performance and lifetime of the

entire network. Besides, through the analysis of the node residual energy distribution, the network lifetime has direct relation to whether the energy utilization is balanced[6]

V. E-LEACH

E-LEACH is based on LEACH protocol to balance the energy consumption of sensor nodes in order to solve the overload energy consumption problem. The E-LEACH adopts the same round concept with the original LEACH. In hierarchical routing protocols, the number of cluster-heads is a key factor that affects the performance of routing protocols. If the number of cluster-heads is less, each cluster-head needs to cover larger region, this will lead the problem that some cluster-members get far from their cluster-heads and consume much more energy. As the communication between cluster heads and the base station needs much more energy than common nodes, the excessive number of cluster-heads will increase the energy consumption of the whole network and shorten the network lifetime. Therefore, it is necessary to select optimal cluster head number to make the energy consumption minimum. In the E-LEACH minimum spanning tree between cluster heads is used, choose the cluster head which has largest residual energy as the root node [5].

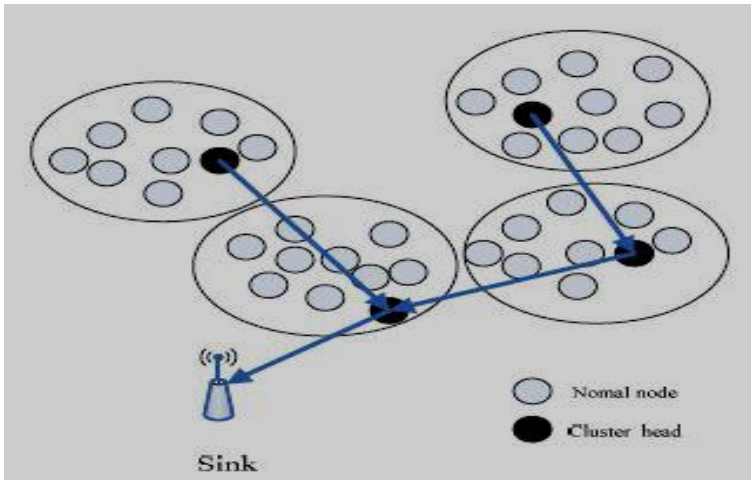

Figure 2 E-LEACH

VI. **M-LEACH**

In LEACH protocol the information is transmitted from cluster head (CH) to base station (BS) node through single hop communication no matter the distance between BS and CH. Energy consumption will be more if distance is far. This M-LEACH protocol modifies LEACH allowing sensor nodes to use multi-hop communication within the cluster in order to increase the energy efficiency of the protocol. This work extends the existing solutions by allowing multi-hop inter cluster communication in WSNs in which the direct communication between CHs or the sink is not possible due to the distance between them. Thus, the main innovation of the solution proposed here is that the multi-hop approach is followed inside the cluster and outside the cluster. CHs can also perform data fusion to the data receive, allowing a reduction in the total transmitted and forwarded data in the network [4]

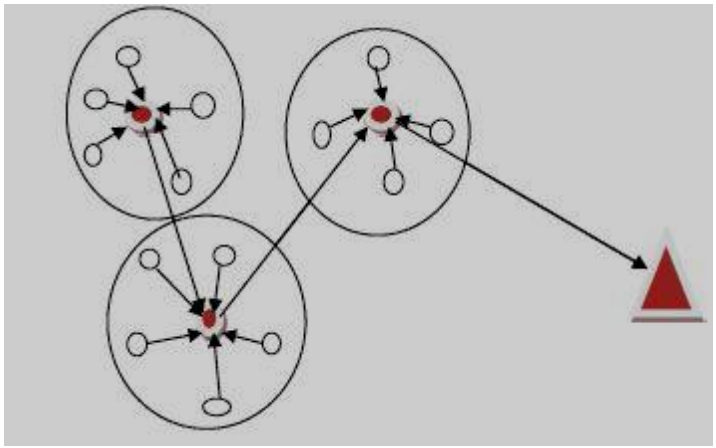

Figure 3 M-LEACH

VII. **V-LEACH**

New version of LEACH protocol, the cluster contains; CH (responsible only for sending data that is received from the cluster members to the BS), vice-CH (the node that will become a CH of the cluster in case of CH dies), cluster nodes (gathering data from environment and send it to the CH).

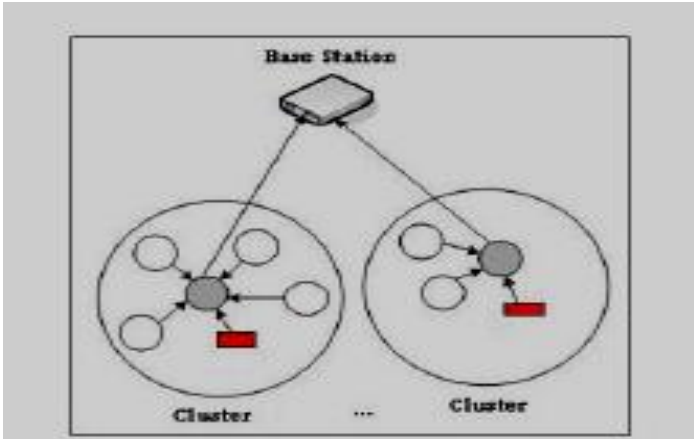

Figure 4 V-LEACH

In the original LEACH, the CH is always on receiving data from cluster members, these data and then send it to the BS that might be located far away from it. The CH will die earlier than the other nodes in the cluster because of its operation of receiving, sending and overhearing. When the CH die, the cluster will become useless because the data gathered by cluster nodes will never reach the base station. In V-LEACH protocol, besides having a CH in the cluster, there is a vice-CH that takes the role of the CH when the CH dies because the reasons we mentioned above by doing this, cluster nodes data will always reach the BS; no need to elect a new CH each time the CHdies. This will extend the overall network life time. The main problem with LEACH protocol lies in the random selection of cluster heads. There exists a probability that the cluster heads formed are unbalanced and may remain in one part of the network making some part of the network unreachable. This problem is resolved by using the concept of V-Leach. V Leach uses the concept of alternate Cluster Head called Vice Cluster Head. As a Cluster Head dies it is replaced by the Vice Cluster Head. But in case of Vice Cluster Head Dies, it does not provide solution for that and the network start reducing the energy very fast and finally the network dies completely. Now in V- leach The decision of the Cluster head and Vice Cluster head selection is on the basis of Energy, Distance and Residual Energy. The v-leach will improve the network life and total communication over the network

VIII. CONCLUSION

In this paper, a well-known protocol in wireless sensor networks called LEACH is described. LEACH is first low energy protocol introduced in WSN which save energy and increase lifetime of the sensor networks. With the number of advantages of LEACH protocol it also comes with some disadvantages. To overcome those disadvantages and make LEACH more efficient many descendants of LEACH protocol are introduced and some of them like C -LEACH ,M-LEACH,E-LEACH and V-LEACH are described in this paper that how these protocol overcome the disadvantage of the LEACH protocol and make the sensor networks more efficient

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