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Amplified Forms of LEACH based ClusteringProtocols for WSNs-A Survey

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Abstract-Wireless sensor network consists of many small, low-powered and self-adjusting nodes having limited energy, utilizes to monitor physical environmental conditions like heat, Temperature, Humidity etc. The main issue in Wireless sensor network is energy efficiency. Routing protocols are responsible for linking better routes for the communication between nodes and base station. To manage and maintain the life time, reliability and scalability of network different efficient routing protocols have been launched. LEACH is one of the most energy efficient hierarchical routing protocol. LEACH is used in large scale in Wireless sensor network. This paper reviews different amplified forms of LEACH protocol, how these protocols keep the life time and scalability better and how its performance can be increased more? Finally, we discuss its usefulness and limitations and compare different forms by their performance.

Index Terms-Wireless sensor network, routing protocols, LEACH (Low Energy Adaptive Clustering Hierarchy).

I. INTRODUCTION

Wireless sensor network [1] is the new emerging promising and interested advanced technology in the field of computer science and engineering, and making life easy. It consists of large number of low power, small and self-adjusting nodes, spread over a certain area according to the demand of the network to monitor and control physical environmental conditions like temperature, humidity, heat etc. and calculate and transfer information to a powerful base station which is responsible to manage and direct these nodes. Wireless sensor network has many other applications for infrastructure protection, battle field awareness, industrial sensing.

Energy efficiency is the main focus in wireless sensor network. As nodes are small in size having low power and energy, wireless sensor network requires proper routes for transmission of data. So routing is main challenge faced by wireless sensor network and requires best routing techniques to keep the utilization of energy minimum and maximize the network life time. Different routing protocols have been launched to route the data in wireless sensor network. Routing protocols for wireless sensor network categorized in three categories [2][3].

1. Flat routing protocols
2. Location based routing protocols
3. Hierarchical routing protocols.

All the above three categories have their own features in terms of energy consumptions of nodes but the 3rd category which is hierarchal routing protocols [4] is the efficient one. A network using cluster based hierarchical routing protocols having long life time. In cluster based hierarchical routing protocols the entire network is divided into groups called clusters. Each cluster has a leader node called cluster head and other nodes of that cluster called member nodes. The cluster head receives data from member nodes and transmit it to the base station. There are many cluster based hierarchical routing protocols have been launched making the network life time long. LEACH (Low Energy Adaptive Clustering Hierarchical) routing protocol is the fundamental energy efficient routing protocol in cluster based hierarchical routing protocols. Now many others protocols have been developed from LEACH with little amplifications called Amplified forms of LEACH protocol. In this paper we discuss cluster based hierarchical routing protocols like LEACH, A-LEACH (Assisted low energy adaptive clustering hierarchy), LEACH-B (Balanced low energy adaptive clustering hierarchy), LEACH-C (Centralized low energy adaptive clustering hierarchy), LEACH-E (Energy low energy adaptive clustering hierarchy), LEACH-F (fixed No of low energy adaptive clustering hierarchy), LEACH-M (Mobile low energy adaptive clustering hierarchy), I-LEACH (Improved low energy adaptive clustering hierarchy), Cell-LEACH (Cell low energy adaptive clustering hierarchy), Multi-hop LEACH.

The rest of the paper is organized as follow. In Section2,we discuss LEACH and its amplified forms like A-LEACH, LEACH-B, LEACH-C, LEACH-E, LEACH-F, LEACH-M, I-LEACH, Cell LEACH, and Multi-hop LEACH.In Section3, we compare features of LEACH with its amplified forms. In Section 4, we conclude our survey paper.

II. LEACH and its Amplified Forms

In this section, we present a detailed description of LEACH and its amplified forms. To the best of our knowledge, a survey dealing with amplified forms is not presented in literature.

a. LEACH

LEACH [5][6]is the first basic energy efficient routing protocol in cluster based hierarchical routing protocols which minimize the power consumption and making prolong the life time of network. LEACH works on the aggregation of data to compress the data into small and meaningful data. In LEACH protocol whole network is divided into clusters, each cluster has a cluster head and the rest of nodes called member nodes. Member nodes sense data and transfer it to the cluster head, cluster head transfer data to base station. LEACH performs selection of cluster head randomly so to give equal chance to all nodes to

become cluster head rather than the selection of static permanent cluster heads, because static cluster head will transmit data continuously and soon it will die, so to overcome this problem LEACH uses randomized selection of cluster heads. LEACH operation is based on rounds where each round based on two phases. First phase is set up phase to organize the clusters, cluster head advertisements and transmission schedule creation. In set up phase LEACH select cluster head by generating a random number (n) between zero and one. If this generated number is less than the threshold value given by threshold functionT(n), the node will be selected as cluster head.

$$T(n) = \frac{p}{1 - p * \left(r \bmod \left(\frac{1}{p}\right)\right)}, \quad if\ n \epsilon G$$
$$= 0 \qquad otherwise$$

Where p [6] is the cluster head probability and G is the set of nodes not have been selected as cluster heads in 1/p previous rounds. After the selection of cluster head each cluster head will advertise a message and some nodes will join the cluster head to form a cluster. Cluster head will make a schedule using TDMA slots for each member node. 2nd phase is steady state phase to aggregate, compress and transmit the data into base station.

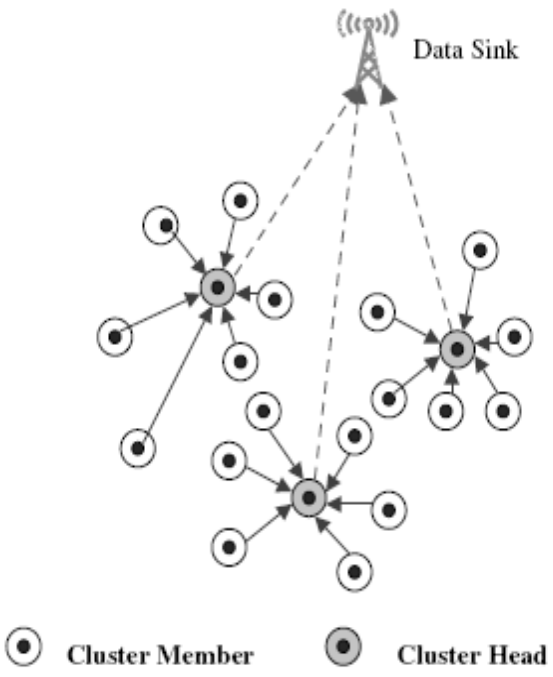

Figure 1: LEACH Hierarchical Structure

Figure 1 shows LEACH operation hierarchy which is having the following features.

I. Reduces no of transmissions through cluster heads.
II. Reduces the data using compressing, increases the life of all nodes.
III. Increases the life time of network.keeps the unused nodes silent.

b. A-LEACH

Assisted LEACH [8] is the amplified form of LEACH. The main objective of A-LEACH is to minimize the power dissipation of cluster heads by introducing a helper node called assistant node to cluster head. In A-LEACH when cluster is formed and cluster heads selected then cluster head select a helper node which is near to base station in member nodes in cluster. So by making helper node the cluster head aggregates the data and then the aggregated data is routed to base station. By performance it is better than LEACH.

c. LEACH-B

Balanced-LEACH is a de-centralized technique of cluster formation [9] in which each node knows about final destination to transmit data and its own position and having no information about other nodes. LEACH-B operation contains three steps cluster formation, cluster head selection and data transmission using multiple access. A sensor node sends data to destination node using best path having low power dissipation and selects their cluster head. LEACH-B is efficient than ordinary LEACH.

d. LEACH-C

Like ordinary LEACH have two phase but there is a difference in set up phase and high energy nodes are there in centralized LEACH. In centralized LEACH [10] the cluster heads are selected by the base station. In each round all the nodes send their information having source and destination IDs and remaining energy to the nearest high energy nodes, then high energy nodes send these information to base station then base station calculate the average energy of all nodes attempting for selection of cluster head then base station selects cluster heads which are not selected as cluster heads in previous rounds and then in steady phase member nodes send data to cluster head and cluster head sends it to base station .

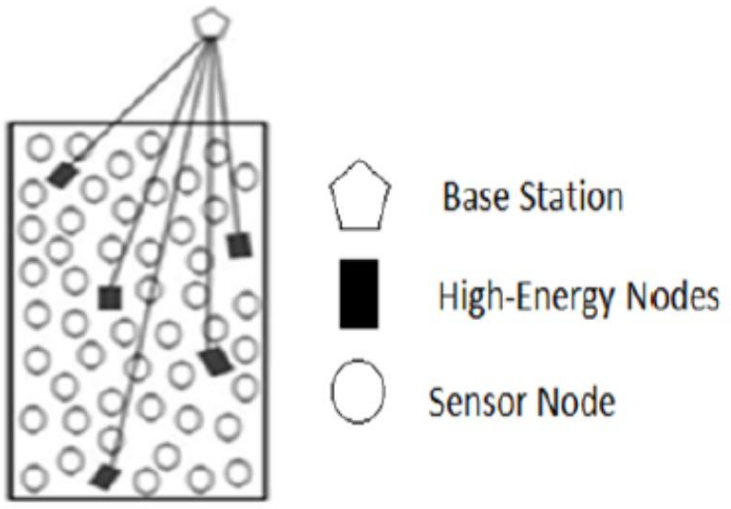

Figure 2: Detailed Operation of LEACH-C

e. LEACH-E

LEACH-E protocol improves the selection of cluster head than ordinary LEACH. In LEACH-E [12] first all the nodes having same energy and able to select as cluster head, but after first round some nodes lost some of their energy and energy level of nodes change. Then in next round the amount of remaining residual energy is used to select a node as cluster head. Nodes having high amount of residual energy will be selected as cluster head node than other nodes. LEACH-E makes the life of network long than ordinary LEACH.

f. LEACH-F

LEACH-F uses centralized approach [12] but once the base station forms clusters then there is no re-clustering process in next rounds. The clusters are selected permanently for whole network and only clusters heads are changed in rotation within cluster. The steady state is same as LEACH. In ordinary LEACH in each round re-clustering is performed but LEACH-F removes the re-clustering process. LEACH-F is not flexible as once clusters are formed then they cannot change their behaviour on node dying.

g. LEACH-M

LEACH considers all nodes are homogenous with respect to energy which is not a good idea. More mobility is another issue in LEACH. LEACH-M [13] overcomes these issues. LEACH-M allows mobility of member nodes and cluster head nodes during the setup and steady state phase and also consider remaining residual energy of node in cluster head selection. Here Cluster heads are selected on the basis of attenuation model, minimum mobility of node and less attenuation of the node.

h. I-LEACH

I-LEACH protocol [14] performs two functions, detection of twin nodes and assignment of sub cluster head node. When nodes are deployed randomly, there is a high chances that two nodes are deployed at same locations and captured same event by these twin nodes. Then it is necessary to keep one node sleep and one so that to save power of one node. Therefore I-LEACH has a uniform distribution of cluster heads so that it does not run out of energy while taking communication over long distance. This protocol uses threshold approach for managing member nodes for cluster heads in the network at a time.into seven sections called cells. Cells consists several sensor nodes from which one sensor is selected as cell head. There is no re-clustering process once formed. Cell nodes sends data to the cell head in its given TDMA slot. Cell head performs aggregation and sends processed data to the cluster head. Cluster head performs the same process again and sends data to the base station.

i. Cell LEACH

Cell LEACH [15]is the new version of LEACH in which whole network is divided into number of clusters where each cluster is further divided into small cell as shown in Figure 3.

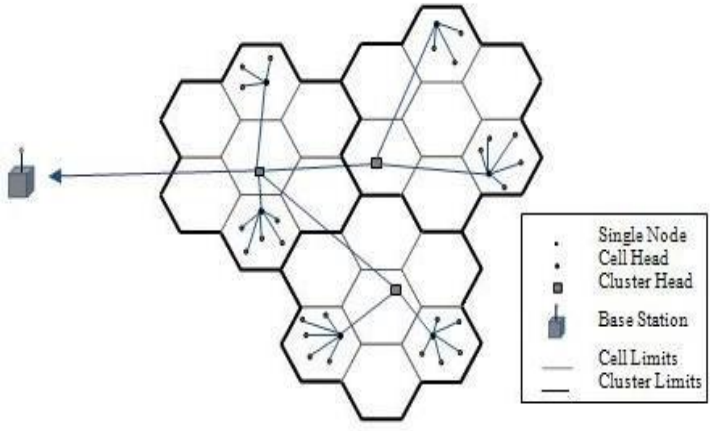

Figure 3:Structure of cell-LEACH

j. Multi-hop LEACH

When the size of network is increased and when crossed a certain level, the distance between the cluster head and base station increased, which creates problems using single hop communication in LEACH. Another amplified form of LEACH, Multi-hop LEACH [16-24] solved these issues. Multi-hop LEACH increases the energy efficiency of the network. In multi-hop LEACH nodes select themselves as cluster head and other nodes join cluster heads as member nodes in set up phase. In steady state phase the member nodes sense the data and send it to cluster heads, and cluster heads send processed data into base station.

III. Performance comparisons between LEACH and its amplified forms

A clear comparison between LEACH and its amplified forms are shown in below Table 1. The table clearly indicates that amplified forms have better performance than ordinary LEACH.

Table 1: Comparisons between LEACH and its amplified forms

Clustering routing protocol	Mobility	Scalability	Self-organization	Distributed	Hop count	Homogeneous	Use of location information
LEACH	Fixed BS	Limited	Yes	Yes	Single-hop	Yes	No
A-LEACH	Fixed BS	Good	Yes	Yes	Single-hop	Yes	No
LEACH-B	Fixed BS	Good	Yes	Yes	Single-hop	Yes	Yes
LEACH-C	Fixed BS	Very good	Yes	No	Single-hop	Yes	Yes
LEACH-E	Fixed BS	Very good	Yes	Yes	Single-hop	Yes	Yes
LEACH-F	Fixed BS	Limited	No	No	Single-hop	Yes	Yes
LEACH-M	Mobile BS and nodes	Very good	Yes	Yes	Single-hop	Yes	Yes
I-LEACH	Fixed BS	Very good	Yes	Yes	Single-hop	Yes	Yes
Cell-LEACH	Fixed BS	Very good	Yes	Yes	Multi-hop	Yes	Yes
Multi-hop LEACH	Fixed BS	Very good	Yes	Yes	Single-hop	Yes	Yes

IV. Conclusions

In wireless sensor network energy efficiency is the main focus. The purpose to design efficient routing protocolis to minimize the utilization of energy minimum and keep the network life time long. LEACH is one of the most efficient routing protocol. In this survey we covered LEACH protocol, theirboth phases, set up phase and steady phase and also covered its amplified forms. Finally we compared LEACH with its amplified forms and found that they were better in performance than LEACH. Still it is needed to design better energy efficient technique so that to keep the sensor nodes alive for long time.

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