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A Comparative Study of Leach Protocol for Wireless Sensor Network

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***Abstract*—**

Wireless sensor network (WSN) is a self-organized network composed by a large number of micro-sensors that are randomly deployed in monitoring regional through wireless communication. In wireless sensor networks (WSNs), due to the limitation of nodes' energy, energy efficiency is an important factor should be considered when the protocols are designing. So designing efficient routing for reducing energy consumption is the important factor. This paper also reviews the most energy efficient protocol named LEACH along with its advantages and disadvantages. Finally this paper concludes with some comparison of descendents of LEACH with LEACH protocol.

Keywords*— *Sensors, Sink, Energy Efficient, Wireless Sensor Network, LEACH.

I. INTRODUCTION

In the twenty-first century Wireless Sensor Networks (WSNs) are being widely considered as one of the most important technologies for many real time applications [1]. The Wireless Sensor Network (WSN) is composed of a collection of sensor nodes, which are small energy constrained devices. Wireless Sensor Networks consist of tiny sensor nodes that and these sensor nodes are consist of sensors (temperature, light, humidity, radiation, and more), microprocessor, memory, transceiver, and power supply [2]. Sensor nodes rely on battery power supply, their communication capability and energy storage capacity are very limited, so how to utilize the energy of nodes efficiently, balance the network energy consumption and extend the network lifetime has become a primary design objective for wireless sensor network. These smart sensor nodes are deployed in a physical area and networked through internet and wireless links, which provide unprecedented opportunities for a variety of civilian and military applications, for example, environmental monitoring battle field surveillance, and industry process control [1]. Sensors are deployed in an ad - hoc manner in the area of interest to monitor events and gather data about the environment. They have the ability of sensing, data processing [3] and communicating with each other in the network environment. WSNs are not a centralized network scenario as there is possible of peer-to-peer communication between the nodes. Therefore there is no requirement of prior established infrastructure to deploy the network. WSN gives flexibility of adding nodes and removing the nodes as required. But this gives rise to many drastic changes to deal with in the network topology such as updating the path, or the network tree, etc. In a WSN the node that gathers the data information refers to sink. The sink may be connected to the outside world through internet where the information can be utilized within time constraints.

The main problem in using these networks is limited battery life. This is due to fact that the size of a sensor node is expected to be small and this leads to constraints on size of its components i.e. battery size, processors, data storing memory, all are needed to be small. So any optimization in these networks should focus on optimizing energy consumption in the network [4].

The basic goals of WSNs are as follows [5]:

- Determine the value of physical variables at a given location.
- Detect the occurrence of events of interest, and estimate parameters of the detected event or events.
- Classify a detected object & also track object.

I.I Routing Challenges and Design Issues in WSNS

There are various parameters which provides a very challenging criterion in routing for WSN and they are as follows [6],

- Node deployment in the sensor network.
- Scalability of the network.
- Network Dynamics.
- Energy Consumption in the network should occur without losing of accuracy of the network.
- Data Reporting Method should be configured in the network.
- Node/Link Heterogeneity of the network.
- Transmission Media should be fault tolerance.
- Coverage area of different sensor nodes in the network.
- Data Aggregation process within the clusters in the network.
- QOS policies of the network.

II. LEACH- CLUSTER BASED HIERACHICAL ROUTING PROTOCOL

The current researches, the clustering routing technology is the most widely influential. Low-Energy Adaptive Clustering Hierarchy (LEACH) is a classical clustering routing in wireless sensor networks [5]. LEACH is the first and most

popular energy efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption and also to increase the lifetime of the network [1, 2]. LEACH performs self-organizing and reclustering functions for every round. Sensor nodes organize themselves into clusters in LEACH routing protocol [7]. This protocol facilitates the nodes with more residual energy have more chances to be selected as cluster head. In order to extend the lifetime of the whole sensor network, energy load must be evenly distributed among all sensor nodes so that the energy at a single sensor node or a small set of sensor nodes will not be drained out very soon [4]. In every cluster one of the sensor node acts as cluster-head and remaining sensor nodes as member nodes of that cluster. Only cluster-head can directly communicate to sink and member nodes use cluster-head as intermediate router in case of communication to sink [7]. Cluster-head collects the data from all the nodes, aggregate the data and route all meaningful compress information to Sink. Because of these additional responsibilities Cluster-head dissipates more energy and if it remains cluster-head permanently it will die quickly as happened in case of static clustering. LEACH tackles this problem by randomized rotation of cluster-head to save the battery of individual node. In this ways LEACH maximize life time of network nodes and also reduce the energy dissipation by compressing the date before transmitting to cluster-head [2]. Leach is completely distributed which requires the global knowledge about the network. In order to achieve the design goal the key tasks performed by Leach are as follows [8],

- Randomized rotation of the cluster heads and the corresponding clusters.
- Global communication reduction by the local compression.
- Localized co-ordination and control for cluster setup and operation.
- Low energy media access control.
- Application specific data processing.

A. Phase of LEACH

LEACH protocol uses round as unit, each round is made up of cluster set-up stage and steady-state stage, for the purpose of reducing unnecessary energy costs, the steady state stage must be much longer than the set-up stage.

1) Setup Phase:

- The setup phase starts with the self election of nodes to cluster heads.
- Cluster heads inform their different individual cluster members with an advertisement packet.
- Transmission of the schedule that has been created during the setup phase only.

2) Phase Of Leach:

- The process of data aggregation within the different clusters of the network.
- Compression of the sensed information that is being sensed by the sensor node into its different cluster head within the cluster only.
- Transmission of the compressed data to the sink via different cluster heads.

B. Advantages of LEACH

The different advantages that the LEACH protocols having are as follows [4, 9],

- The advantage of LEACH is that each node has the equal probability to be a cluster head, which make the energy dissipation of each node be relatively balanced.
- It provides scalability in the network by means of limiting most of the communication inside the different clusters of the network.
- The cluster heads aggregates or fuses the information that is been collected by the sensor nodes and this helps in to limit high amount of traffic generated within the network.
- In LEACH protocol we can able to save the energy of the network if single-hop routing is possible from sensor node to cluster head.
- LEACH increases the lifetime of network in three phases. First, it distributes the role of CH (which consumes more energy than normal sensor nodes) to the other nodes in the cluster. Second, it gathers the sensed information by the CHs. Finally, it puts most of the sensor nodes in the sleep mode, by using the process of TDMA which is been assigned by the CH to its members.
- It is well-suited for applications where constant monitoring of the environmental information is needed and data collection process occurs periodically to a centralized location of the network. It gives the dynamic clustering approach.

C. Disadvantages Of Leach

The different disadvantages that the LEACH protocols having are as follows [6, 8],

- The cluster heads are elected randomly, so the optimal number and distribution of cluster heads cannot be ensured.
- 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 [8].Due to this it incurs robustness issues like failure of the cluster heads.

- 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.
- In LEACH CHs are not uniformly distributed within the cluster that means CHs can be located at the edges of the cluster.
- It does not work well with the applications that require large area coverage along with multi-hop inter-cluster communication.

III. IMPROVEMENT of LEACH PROTOCOL

There are many protocols that have been proposed by many authors that described the improvement of the LEACH protocol in many factors to overcome from the disadvantages which are there in the LEACH clustering protocol. Some of the improvement of LEACH protocol is mentioned below:

A. Leach-A (Advanced Low Energy Adaptive Clustering Hierarchy)

In LEACH-A, the data is been processed using mobile agent technique which is based on LEACH protocol. This protocol proposed a heterogeneous energy protocol for decreasing the node's failure probability and for prolonging the time interval before the first node dies which called as stability period. Routing in A-LEACH works in rounds and each round is divided into two phases, the Setup phase and the Steady State; each sensor knows when each round starts using a synchronized clock. The maximum energy nodes are selected as cluster head for each cluster and these nodes are called as CAG node (nodes selected as cluster heads or gateways), and the as normal nodes. Leach-A protocol having the following advantages compared to LEACH [10, 11],

- Self-configuration of clusters is independent of the base station.
- The fusion of the data is done to reduce the amount of information that been transmitted to the base station.
- Maximum energy can be saved by using TDMA/CDMA techniques that allows hierarchy and makes clustering on several levels.
- The CAG nodes continue to send data to the sink after the death of other normal nodes also.
- The CAG node decrease probability of failure nodes and prolong the time interval before the death of the first node and increasing the lifetime in heterogeneous WSNs.

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

- In LEACH-B for the cluster formation purpose it uses the de-centralized algorithms in which each sensor node only knows about its own position and the destination no deposition where actually the information will going to receive, and it does not know about any other sensor node position.
- In LEACH-B, Cluster formation and data transmission are done with the help of multiple accesses to different nodes.
- After this how much the energy is been dissipated in the path between destination node and originating node is being calculated and based on this only each of the sensor nodes would choose its own cluster heads. Compared to LEACH efficiency of LEACH-B is much higher [8, 10, 11].

C. Leach-C (Centralized Low Energy Adaptive Clustering Hierarchy)

- LEACH-C uses a centralized clustering algorithm and same steady-state protocol as LEACH. During the setup phase of LEACH-C, the base station receives information regarding the location and energy level of each node in the network.
- Using this information, the base station finds a predetermined number of cluster heads and configures the network into clusters.
- The cluster groupings are chosen to minimize the energy required for non-cluster- head nodes to transmit their data to their respective cluster heads, whereas in LEACH the number of CHs would varies from round to round because of the lack of global coordination between different nodes in the network [4, 5, 6].

D. Leach-E (Energy Low Energy Adaptive Clustering Hierarchy)

- LEACH-E protocol would improve the CH selection process compared to LEACH protocol. The LEACH-E is divided into different round that is same as LEACH protocol.
- In the first round all the sensor nodes would having the same probability to be CH of the cluster.
- After the first round of transmission the residual energy of each node would got different and based on this, the node who would have the high residual energy would be chosen as CH of the cluster and other nodes in the cluster would became the cluster member who would having the less energy [8, 9, 11].

E. Leach-F (Fixed No. Of Cluster Low Energy Adaptive Clustering Hierarchy)

- In LEACH-F clusters are formed at the beginning of the network setup and after that are being fixed. The cluster head position rotates among the nodes within the cluster that is same as LEACH.
- The advantage of this process compared to LEACH is that, there is no set-up overhead at the beginning of each round.

- For clusters formation, LEACH-F uses centralized cluster formation algorithm that is same as LEACH-C.
- The disadvantage of this protocol is that the fixed clusters in LEACH-F do not allow new nodes to be added to the network and do not adjust their behaviour when any node dies in the network [1, 6, 8].

F. Leach-M (Mobile Low Energy Adaptive Clustering Hierarchy)

- LEACH-M is been proposed to overcome from the mobility issue which is an important issue in LEACH protocol.
- During the setup and steady state phase, LEACH-M provides mobility to the non-CH nodes along with CH.
- In LEACH-M the nodes' location assumed to be gain by the GPS process along with the characteristics of the nodes to be assumed to be homogeneous.
- The CHs are being chooses on the basis of minimum mobility of the node and lowest attenuation mode of the node. After this process the status of the CHs are being broadcasted within its transmission range [7].

IV. COMPARISON OF LEACH PROTOCOL WITH ADVANCES LEACH PROTOCOL

Brief comparisons of a numbers of protocols that are the enhanced version of the conventional LEACH routing are shown in Table 1. All these hierarchical routing protocols have showed better performance than the conventional LEACH routing protocol.

Table 1.

Routing Protocol	Classification	Scalability	Energy Efficiency
LEACH	Hierarchical	limited	high
LEACH-A	Hierarchical	good	very high
LEACH-B	Hierarchical	good	very high
LEACH-C	Hierarchical	very good	very high
LEACH-E	Hierarchical	very good	very high
LEACH-F	Hierarchical	limited	very high
LEACH-M	Hierarchical	good	very high

V. CONCLUSION

The main purpose of designing energy efficient routing protocol in WSN is to efficiently use the energy of the network so that the network lifetime get increased. Now-a-days many energy efficient routing protocols are available in WSNs. One of the most efficient routing algorithms everyone uses is the LEACH routing protocol. In this paper we studied briefly about LEACH protocols, its advantages and disadvantages. This paper also gives the comparison of various improved version of LEACH protocol in Table 1. Finally, it can be concluded that for an energy-efficient and prolonged wireless sensor networks, still it is needed to find more efficient, scalable and robust clustering scheme for better result

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