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Survey of Energy Efficient Leach Protocol in WSN

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***Abstract*—Wireless Sensor Networks (WSNs) contain of large number of sensor nodes, which sense and measure physical phenomena related parameters and broadcast the measured data towards the base station by making use of neighboring nodes acting as communicate nodes. In order to expand the lifetime of a WSN application, it is essential to distribute the energy degenerate among the nodes evenly in the network and improve the overall system, Low Energy Adaptive Clustering Hierarchy (LEACH) protocol as it has established to be energy efficient. It is one between the various protocols which are very efficient in transmitting data to the BS. In LEACH, many groups or clusters of nodes are created and the data is aggregated.**

***Index Terms*— WSN, Leach Protocol, Set up phase, Cluster.**

I. INTRODUCTION

A sensor network generally consists of some tiny sensor nodes and a few powerful control nodes also called base stations or called as sink. Sensor nodes are usually thickly set up in a large area and communicate with each other in short distances through wireless communication. Though particular sensor nodes have limited number of resources, they are able to achieve valuable task of big volume when they work as a team member. Information gathered by and transmitted on a sensor network of wireless networks describes conditions of physical environments of the area where the sensor network is set up. Feng Zhao et al [3] present that sensor networks may interact with an IP network via a number of gateways. A gateway tracks the user queries or commands to appropriate nodes in a sensor network. It also directs or routes sensor data, sometimes aggregated and summarized, to users at user end who have requested it or expected to use the information. They presents that for optimization in performances and resources such as energy, we may need to reconstruct TCP/IP stack so that our needs and constraints are satisfied. Although different application demands a different set of tasks to be carried out during functioning of network, there are three basic types of tasks carry out those tasks in a sensor network: sensing, processing, and communication. Sensing task uses different types of sensors to capture different signals from the physical world of the network. All signals faces delay as they travel away from the source. A dense set up of sensors helps to avoid this delay and maintain the sensed signal. Each Individual sensor node is capable of lightweight processing. In sensor networks, processing often binds multiple sensor outputs from local neighbouring nodes. This is called as collaborative signal and data processing. Collaborative processing has the advantages that processing is more accurate and reliable, and only the aggregate of result needs to be sent to a user over the network. The sensor nodes works as a front end in a computing hierarchy and perform pre-processing for later stages [2]. WSN

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management must be automatic, i.e., self-managed with least interface with human and robust to changes in network states while maintaining quality of service (QOS) [4].

A Features and Challenges of WSN

The main features and challenges of WSN can be summarized as:

- Low cost devices
- Energy-efficient devices
- End-to-end quality of service
- connectionless operation under context changes
- Large scale of deployment
- Mobility of nodes

Mobility: Sensor nodes can be fixed or mobile. Currently most of the sensors are static and most existing work focuses on networks of static nodes, but in near future time mobility feature would be included into the Sensor networks.

B Functional Layers of WSN

As compared to traditional networks, the sensor network is more application specific. Mohammad Illyas et al [4] defined different functional layers of WSN. These layers are:

- Sensing layer: Data acquisition is carried out by this layer.
- Communication layer: Important tasks like data correlation, data dissemination, data compression and routing is carried out by this layer. Basic function of this layer is to deliver statistical observation results to the collecting center i.e. the sink. A security layer may also be inside the communication layer that deals with security.
- Data fusion layer: It processes data received from the communication layer and combines them using various signal processing, artificial intelligence, data fusion and other decision-making techniques. After the appropriate calculation and analysis by this layer, it produces the final detection results of a sensor network.
- User layer: This layer provides man-machine interface which is the uppermost layer.

C Participants in WSN

Major participants of WSN are source and sink. Whole network communication revolves around these two components source and sink.

1. Source Node

- Source that senses data in its environment.
- Source can be equipped with different sensors. E.g. Temp, pressure, brightness etc.
- Major function is reporting to sink.

2. Sink Node

- Sink receives the signals or gathers data from source nodes.
- Sink may reside either in between network or may be it can be in external network as a external device such as laptop or PDA.

In general there is one sink or base station, but multiple base stations may be present in network depending on application.

II. CLUSTERED ARCHITECTURE

In this architecture multiple no of clusters exists which are formed by Sensor nodes. And a cluster head exists in between each cluster. If these nodes want to exchange their message they have to report to cluster head for that. And these cluster heads then sends messages to BS. Clustered architecture provides the inherent suitability of data fusion because the data gathered by all members of cluster which are nosed here is fused at the cluster head, and then the resulting information needs to be communicated to the BS.

- Cluster formation and election of each cluster head must be an autonomous, distributed process.

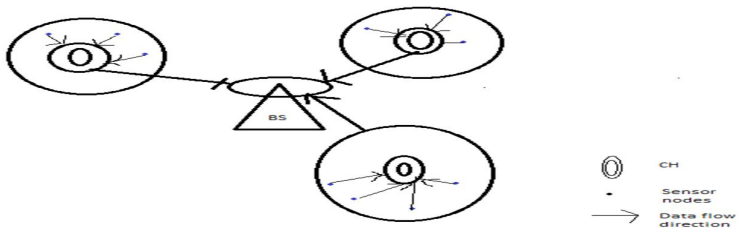

Figure 1 Clustered architecture

III. Design Factors of WSN

There are certain design factors which must be taken into consideration. These design factors for WSN is illustrated below:

A Fault Tolerance: Individual nodes are prone to unexpected failure with a much higher probability when compared with other types of networks. The network should keep alive information dissemination in spite of failures.

B Scalability: Number in the order of hundreds or thousands. Protocols should be able to range to such high degree and take advantage of the high density of such networks.

C Production Costs: The cost of a single node must be low, much less than $1.

D Hardware Constraints: A sensor node is comprised of many processing subunits (sensing, processing, communication subunit, power, location finding system, power scavenging and mobilize). All these units collected together must consume extremely low power and be contained within an extremely small volume.

E Sensor Network Topology: Must be maintained even with very high node densities.

F Environment: Nodes are operating in inaccessible locations either because of hostile environment or because they are embedded in a structure.

G Transmission Media: RF, Infrared and Optical.

H Power Consumption: Power conservation and power management are primary design factors.

IV. Working Methodology

LEACH was proposed by Heinzelman, Chandrakasan and Balakrishnan. It is a hierarchical cluster based routing protocol for wireless sensor networks. This protocol partitions the nodes in to clusters. LEACH randomly selects nodes as cluster-heads (CH) and performs periodic reelection. Cluster Head (CH) is responsible for creating and manipulating a TDMA (Time division multiple access) schedule and sending aggregated data from nodes to the BS where these data is needed using CDMA (Code division multiple access**)**. And the remaining nodes are cluster members. The operation of leach protocol is split into two phases: set up and steady.

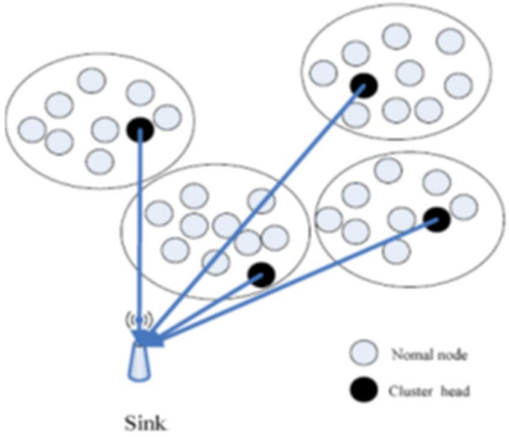

Figure 2 Architecture of leach

Two Phases of Leach: LEACH is divided into rounds; and each round is of two phase, set-up phase and steady phase

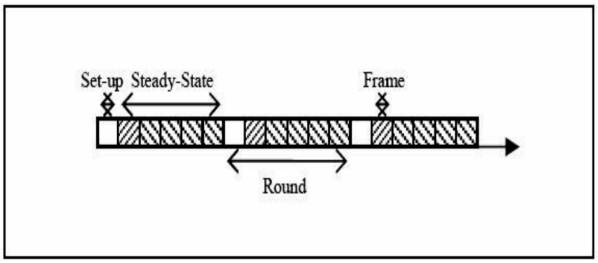

Figure 3 Leach protocol phases

Set-Up Phase:
First step is cluster head selection. At the first of each round, every node selects a random number between 0s and 1 and compares it to the threshold shown in formula. If the selected random number is less than the threshold, the node would be selected as a cluster head for the current round. The threshold T(n) is calculated as

$$T(n) = \begin{cases} \frac{p}{1-p\ (r*\mathrm{mod}(1/p))}, & \text{if } n \in G; \\ 0, & \text{else} \end{cases} \quad (1)$$

Here P is the preferred percentage of nodes which are cluster head, r is denoted as current round, and G is the locate of nodes that has not been selected as cluster-heads in the past 1/P rounds. This states that all sensor nodes finally spend equal energy. After selection of cluster head, it advertises his selection to all remaining nodes. All nodes prefer their nearest cluster head when they receive advertisement message based on the received signal strength. Then TDMA program is assigned by the CH for their cluster members or nodes. In order to avoid signal interference near the cluster, cluster head can decide the CDMA codes which all nodes used. The CDMA codes which is used in the present phase and TDMA timing information will be sent together. When nodes within the cluster receive the message, they will send data to the cluster head in their possess time slot. Algorithm will enter a stable phase. Heewook Shin et. al. [12] shows the setup phase by following diagram

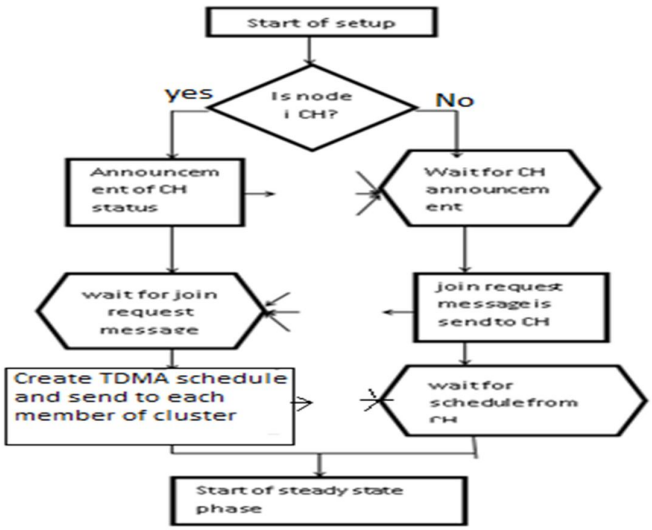

Figure 4 Set up phase in LEACH

Steady Phase:
The steady state phase is the data transmission step. During this phase, nodes in each cluster send their data based on the allocated transmission time to their local cluster heads. To reduce the energy dissipation, the receiver of all non-cluster head nodes would be turned off until the nodes' defined allocated time. After receiving all the data from the nodes, the cluster head aggregates all the data sent from the member nodes into a single signal and transfers it to the base station

V. LEACH WORKFLOW

LEACH algorithm is shown by following flowchart

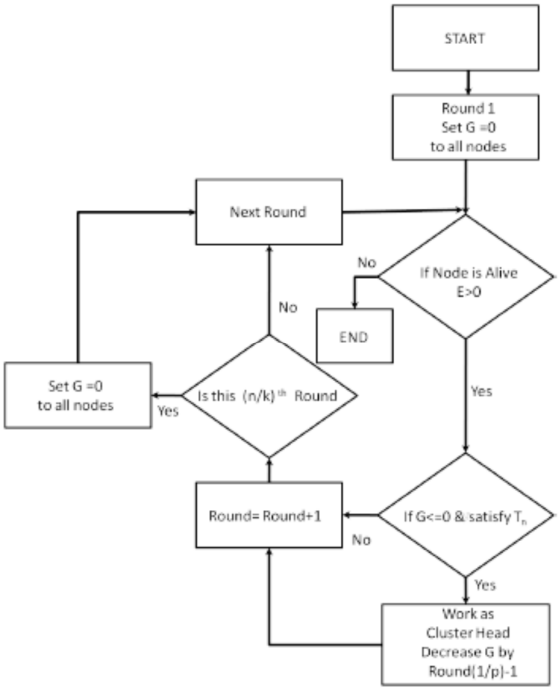

Figure 5. LEACH algorithm flowchart

A Analysis of Leach Protocol

Qing Bianet. al. [9] presents some of the advantages and disadvantages of LEACH protocol on the basis of analysis of LEACH.

Advantages: The LEACH protocol as a typical sub-cluster routing protocol has the following advantages:

- In leach protocol the hierarchy, selection of path and routing information is relatively simple, and the sensor nodes do not need to store large amounts of routing information, complex functions.
- Second advantage is the cluster head node is randomly selected, the probability of each node is equal, and the load of whole network is balance. So that nodes, which have no energy, can be randomly distributed.
- LEACH algorithm uses hierarchical structure; due to data fusion mechanism cluster head reduces the energy consumption of data transmission, and therefore compared to the general multi-hop routing protocols and static clustering algorithm, LEACH protocol minimizes energy dissipation in sensor networks. LEACH can extend the network life-cycle of 15%.[11].

Disadvantages: Shijin Dai Xiaorong Jing et. al [11] provides some problems of LEACH [11]. They said that LEACH provided many good features to the sensor network; however, it suffers from the following problems.

- It can't be applied 'to time critical applications. The nodes on the route from a hot spot to the sink might drain their energy quickly, which is known as "hot spot" problem.

VI. Conclusion

In this paper we provided a detailed study of Energy Efficient Leach Protocol in WSN. The problem of energy efficient routing in sensor networks investigate with optimization techniques in many previous works. Determining energy efficient routing schemes is a significant trouble since it extends the network life span by periodically gathering all the data at the sink. The time period between two sensing behavior of sensor nodes is known as a round and the duration is estimated in terms of rounds.

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