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(Review article)

Energy and Throughput of Hierarchical Routing Protocol Leach and Leach-C for WSNS: A Review

Navneet Verma[a]*, Devendra Prasad[a], Mukesh Chawla[b]

[a]MMU,Mullana, [b]NIT Hamirpur

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Abstract

This review paper presents that how performance of LEACH-C is better than LEACH in case of energy constrained and throughput. LEACH-C is the variant of low energy adaptive clustering hierarchy (LEACH) protocol for WSNs. The sensor nodes are generally battery powered and also equipped with transceiver, once they are deployed, it is difficult to recharge or replace them from the network area. So, efficient utilization of energy for a sensor node is an important issue for the lifetime of sensor nodes in WSNs.

***Keywords**: Wireless Sensor Networks, Minimum Transmission Energy, Cluster Head, Base station Data aggregation.*

1. Introduction

A sensor network is composed of tens to thousands of sensor nodes which are distributed in a wide area. These nodes form a network by communicating with each other either directly or through other nodes. One or more nodes among them will serve as sink(s) that are capable of communicating with the user either directly or through the existing wired networks. Each node typically consists of the five components: sensor unit, analog digital convertor (ADC), central processing unit (CPU), power unit, and communication unit. The sensor unit is responsible for collecting information as the ADC requests, and returning the analog data it sensed. ADC is a translator that tells the CPU what the sensor unit has sensed, and also informs the sensor unit what to do. Communication unit is tasked to receive command or query from, and transmit the data from CPU to the outside world. CPU is the most complex unit. It interprets the command or query to ADC, monitors and controls power if necessary, processes received data, computes the next hop to the sink, etc. With a sensor network, a user should be able to task some sensors to monitor specific events, and know when interested events happen in the interested field. Thus, the sensor network builds a bridge between the real world and computation world. Some important properties for a good sensor network protocols are:

a) Ease of deployment: In WSNs nodes are generally deployed in remote areas once they are deployed they are not easy to replace or access easily. So we require that the nodes can communicate in the absence of established network also.
b) System lifetime: As the system life depends upon the battery [2] backup. So the selection of hardware and software for the protocol must be selected as extremely energy efficient.
c) Latency: Data accessed by nodes are time sensitive, so communication between nodes and base station should be timely manner.
d) Quality of service: The quality of service depends upon the aggregation technique used. Because, the base station needs only important data according to the requirement.

WSN's differ from traditional wireless communication networks in several of their characteristics; one of them is power awareness. The routing protocols developed for WSNs can be classified in several categories:

i) Flat routing architecture: This is the first category of routing protocols. In flat routing, each node typically plays the same role and sensor nodes collaborate to perform the sensing task. Due to the large number of such nodes, it is not feasible to assign a global identifier to each node. This consideration has led to data-centric routing, where the BS sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute-based naming is necessary to specify the properties of data.

*Corresponding author's email: navneet_713@yahoo.com,

ii) Hierarchical routing architecture: Hierarchical or cluster-based routing methods, originally proposed in wire line networks, are well-known techniques with special advantages related to scalability and efficient communication. As such, the concept of hierarchical routing is also utilized to perform energy efficient routing in WSNs.

iii) Location based routing architecture: In this kind of routing, sensor nodes are addressed by means of their locations. The distance between neighboring nodes can be estimated on the basis of incoming signal strengths. Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors. The location of nodes may be available directly by communicating with a satellite using GPS if nodes are equipped with a small low-power GPS receiver. To save energy, some location-based schemes demand that nodes should go to sleep if there is no activity. More energy savings can be obtained by having as any sleeping nodes in the network as possible.

Under these architecture and requirements, number of WSNs protocols has been proposed, which are mentioned in the figure below.

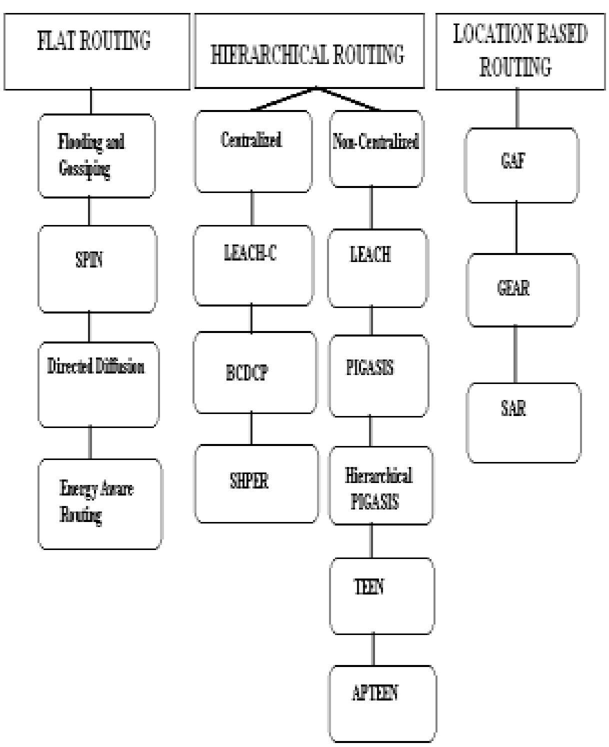

Figure 1: Routing Protocols for WSNs

Some important applications of WSN's are listed as:

- Habitat monitoring
- Military environment
- Medical and health care
- Weather forecasting
- Nuclear, biological and radiological etc.

2. Data aggregation

Aggregation or fusion techniques are used to reduce the size of data communicated with in WSNs, thus conserving battery power. Periodically, individual sensor node senses the data like temperature or humidity in its network area and processed further.

In hierarchical approach sensor nodes send their values to certain special nodes such as cluster head nodes. Each cluster head node then reduces the data to prevent redundancy. In terms of bandwidth and energy consumption, aggregation is beneficial as long as the aggregation process [9] is not too CPU-intensive. The aggregating nodes can either be special, more powerful nodes then regular sensor nodes. The term aggregation requires only a few simple arithmetic operations, such as addition or multiplication. Aggregation requires all sensor nodes to send their sense data to the cluster head within the same cluster. One natural and common way to aggregate data is to simply add up values as they are forwarded towards the base station. This type of aggregation is useful when the base station is only interested in certain statistical measurements, for example, the mean or variance of all measured data.

Some WSNs applications require all sensor data and therefore cannot benefit from aggregation techniques. Similarly, applications requiring boundary values, for example, min and/or max are obviously not a good match for additive aggregation. With additive aggregation, each cluster head node sums all values that it receives from its child nodes (in the cluster head-rooted spanning tree) and forwards the sum to its parent (base station). Eventually, the base station obtains the sum of all values sent by all sensor nodes. By dividing the sum by the total number of sensors, it computes the average of all measured data. This simple aggregation is very efficient since each aggregating node only performs arithmetic additions. It is also robust, since there is no requirement for all sensor nodes to participate, as long as the base station gets the total number of sensors that actually provided a measurement.

3. Leach protocol

This review paper is built on the work mentioned in [1], [2]. LEACH comes under the family of proactive network protocols, with small changes. In proactive protocols [3] the node sense and send it to the base station periodically. Whereas reactive network protocols like TEEN performs instantaneously for critical data. For achieving the design goal for LEACH protocol, the following techniques are required.

i) Randomized and self-configuring cluster formation
ii) Data aggregation
iii) Local control on data transmission.

LEACH is the first hierarchical cluster based routing protocol, distributed algorithm is used to form clusters in network area. For each cluster there is a cluster head node which is responsible for data aggregation and sends the important data in its TDMA (Time Division Multiple Access) slot [7] to the base station, where these data is needed using CDMA (Code Division Multiple Access). Few numbers of nodes become the cluster head which act as the router to the base station. Energy dissipation is less as data transmission is done by only cluster head node. Data aggregation technique [6] is used, because there is a possibility of correlated data in neighboring nodes of the same cluster. So data is processed locally in LEACH protocol.

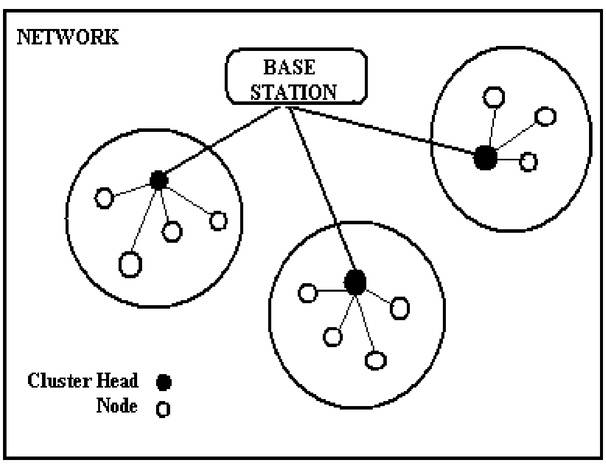

Fig. 2 LEACH Protocol

The working of LEACH protocol is divided into rounds where each round has two phases:

- Set-up Phase-In LEACH we assume that every node begins with equally distributed energy. So randomly, one node becomes the CH which has not already been CH before and remaining nodes become the member nodes of the cluster. To become a CH, is an energy intensive function. If there is k numbers of nodes present in the network, then for the next round k-1 nodes have the probability to become next CH node.
- Steady State Phase- In steady state phase data transmission begins. The member nodes of cluster send their sensed data to the CH node in its TDMA slot. After the computation and data aggregation the cluster head send it to the base station.

4. Leach-C protocol

LEACH-centralized protocol uses a centralized clustering algorithm and the same steady state phase as in LEACH protocol. LEACH-C produce better clusters by dispersing the cluster head nodes throughout the network. In setup phase of LEACH-C each node sends its geographical location (using GPS technique) and the residual energy level to the base station. By this information, base station computes the average energy level of the nodes and the nodes having the energy below this average energy level cannot be the cluster head for the current round. The remaining nodes have the probability of becoming the cluster heads. Once the cluster and concern cluster head finalized for the network area, the base station broadcast the ID of CH's node to the remaining nodes in that cluster. If the ID, broadcasted by base station matches with node ID, the node is a cluster head. Otherwise, the nodes doing the data sensing task. The steady state phase is same as for the LEACH protocol. Due to this centralized approach base station has the global knowledge of the network area, so less energy is consumed by the complete network.

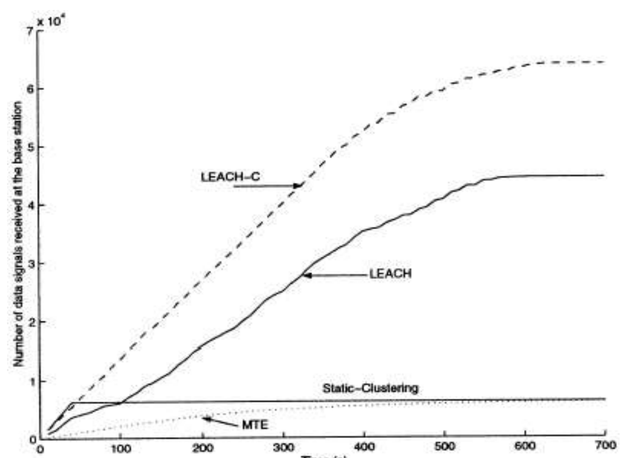

Fig.3 (a) Total amount of data received at the base Station over time.

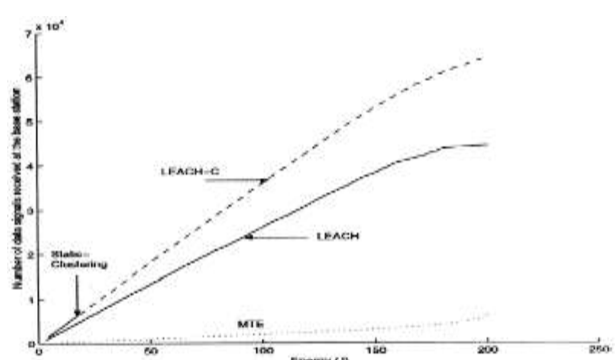

Fig. 3(b) Total amount of data received at the base Station per given amount of energy.

Figure 3 shows[3] that LEACH-C delivers more data per unit energy then LEACH because in LEACH-C base station has the global information of the location and energy level of each node in the network, so it produce better clusters that require less energy for data communication.

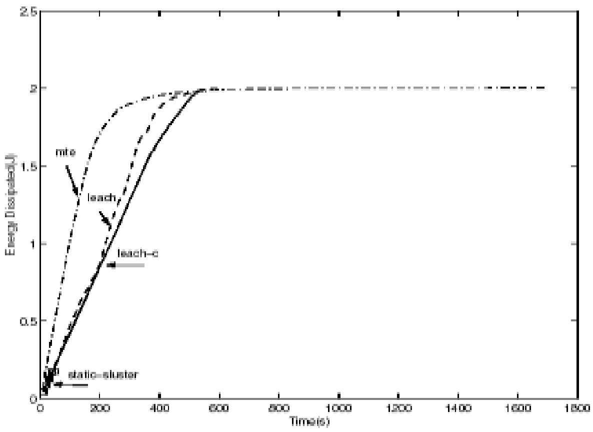

Fig. 4 Energy Dissipation

Figure 4 shows [3] that LEACH-C dissipates lesser energy as compare to LEACH and MTE routing [4], [5]. MTE requires more time to send data from nodes to base station because in MTE each message traverses several hops.

5. Leach drawbacks

Although LEACH can increase the lifetime of the network but it has some drawbacks also- In LEACH we assume that the cluster head selection is random [8] so it does not help in account of less energy consumption and it cannot cover the large area.

The assumption of Homogeneous distribution of nodes in the network area in LEACH is not realistic. Whereas in LEACH-C, the base station has the global knowledge of the network, so it dissipates less energy for selecting cluster head and covers its complete network area. Also the efficient aggregation in WSNs becomes challenging when end-to-end privacy of data is required.

Conclusion

As power sources have limited power supply in WSNs and due to the importance of sensing data, it should be transmitted periodically.

In this review paper, we analyzed that the performance of LEACH-C is better than LEACH protocol due to centralized clustering algorithm approach. According to the fig. 3(a) and fig. 3(b), in equal time slot and equal amount of energy dissipation for both LEACH and LEACH-C protocol the more amount of data is received at the base station in case of LEACH-C protocol.

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