

# Wireless Sensor Network with Modified Low Energy Adaptive Cluster Hierarchy using Cluster Head Leach Protocol

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**Abstract**—To deploy Wireless Sensor Network (WSN) in various applications like Medical analysis, Climate change observation, Military support applications, mechanical stress in bridges and building etc., more energy efficient WSN is required for seamless performance of such tasks. In this paper we will discuss WSN and its Components, usage and characteristics which would help us to understand the importance of Routing Protocols in WSN especially the Hierarchical Routing Protocols that are designed for energy efficient WSN. Additionally, this paper surveyed upon the significance of Cluster Head (CH) in Hierarchical Routing Protocols and most importantly on the LEACH Protocol with its phases and Specifications etc. We would analyse LEACH Protocol to improve it in Modified CH-LEACH (MODCH-LEACH), later summarizing their comparison and show effectiveness of cluster formula on network time period, cluster head selection, and normal nodes of a network.

**Keywords**—WSN and its Components, Routing Protocols, Hierarchical Routing Protocol, Cluster Head (CH), LEACH Protocol, MODCH-LEACH

## I. INTRODUCTION

Any global sensory information as per the requirement could be used by the WSNs as its raw data. WSN applications are huge wirelessly connected structure that work as a platform to gather these sensory-information using their implemented sensor nodes by sensing various environmental or physical elements, as discussed before.

WSN work as a detector network for data acquisition and broadcasting in the environment which could be open like in the fields, forest settlements enclosed in shipboard, home.

A sensor of WSN would work as a smart detector by combining the technologies used for sensing, processing and communication/broadcasting.

## II. WIRELESS SENSOR NETWORK (WSN)

### A. Overview

The network of heterogeneous sensor networks with an efficiency of sense, enumeration and communication form the WSN. These heterogeneous sensor networks consist of a huge number of self-organized wireless sensor nodes, additionally, the core of these sensor nodes has an ultra-small, limited-power, low-cost microprocessor. Thus, these sensing nodes usually have limited storage and reduced processing operations along-with power/battery limitations. The sensing nodes of WSN are also known as remote sensing nodes.

### B. Components

A WSN could be structured or unstructured with less infrastructure.

The main components of WSN, as shown in figure, are:

- Sensor Network(s)
- Base Station(s)
- Internet/Satellite
- User Interface(s)
- Power Unit

Additionally, the major functional units of sensor nodes of a WSN are:

- Sensor Integrate(s)
- Processor(s)
- Trans-receiver(s)

### C. Usage

Sensor networks may consist of many different types of sensors such as thermal, mechanical, electrical, seismic, visual, acoustic, SONAR, RADAR etc. The function of these sensors is to sense the dynamically changing environmental or physical elements such as sound, light, temperature, humidity, acidity, pressure, vibration, pollutant concentration and so on. Thus, the usage of WSN are wide that could range from everyday activities to the national security, from field activities to industrial work which is possible by observing the dynamically changing environmental or physical surroundings. It seems to have great importance in military surveillance, agriculture, industry.

### D. Characteristics

The below listed features of WSN raised its importance as compared to a wireless network such as MANETs:

#### 1) Network Topology:

WSN is featured with dynamic network topology due to following possibility that:

- a new node can get added or
- an existing node can get removed or
- a nodal energy depletion or
- The occurrence of a nodal failure or the gradual channel fading.

#### 2) Specification:

A specific application requirement decides designing of the sensor nodes/networks.

#### 3) Requirement:

Energy budget and cost of communication are the important parameters that decide WSN design as portable sensor nodes are featured with low energy, storage and computational capacities.

#### 4) Configuration:

Planned organization of wireless sensors might not be possible due to its random deployment. So, once the sensor nodes get organized then only they mechanically configure themselves into the WSN.

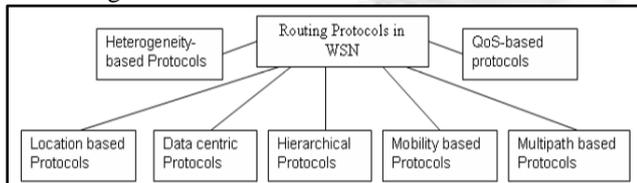
### III. ROUTING PROTOCOLS IN WSN

Routing protocols in WSN have to meet strict energy constraints unlike conventional routing due to:

- Unreliable wireless links
- Lack of infrastructure
- Failure of sensor nodes

In wireless network, static sensor nodes generally have table driven routing protocols. However, in reactive protocols, a significant amount of energy is used in route discovery and setup.

All major routing protocols classified into seven main categories shown below:



Various representative algorithmic protocols under routing protocols in WSN are classified in below shown tabular form:

Sr. No.	Types	Representative Protocol
1	Hierarchical Protocols	LEACH, PEGASIS, TEEN, APTEEN
2	Data-centric Protocols	SPIN, Directed Diffusion, Rumor Routing, Gradient-Based Routing, Energy-aware Routing,
3	Location-based Protocols	MECN, SMECN, GAF, GEAR, TBF,
4	Multipath-based Protocols	Sensor-Disjoint Multipath, Braided Multipath, N-to-1 Multipath Discovery
5	Heterogeneity-based Protocols	IDSQ, CADR, CHR
6	QoS-based protocols	SAR, SPEED

The most commonly used routing models of a WSN are focused majorly on three basic Routing Protocols that are:

#### A. Location- Based Routing Protocol

Routing protocols that need the location information of the sensor nodes are placed under Location-based routing protocols of WSN. These protocols usually obtain location information from:

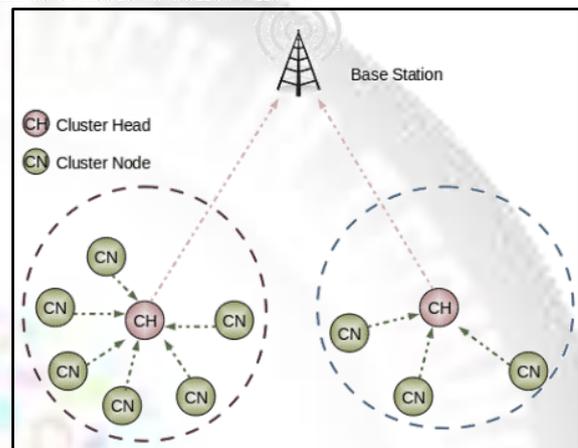
The strength of received radio signals orGNSS (Global Navigation satellite system) signals such as GPS (Global Positioning System) signals

#### B. Data-Centric Routing Protocol

Query-based protocols are categorized under data-centric routing protocols of WSN based on the naming of the required data that helps to eliminate the most of the redundant transmissions. The first data-centric protocol was SPIN. In data-centric protocols, queries are sent by BS to a region for certain specific information thus, attribute-based

naming is needed to mention the data properties. Later, BS waits for the responds from the sensor nodes of that particular area. Once the sensor nodes gather the particular information from the area as per the requested query then, they transmit it to BS. This entire procedure helps to reduce the data transmission rate.

Hierarchical Network Routing Protocol This thesis is majorly focused on the energy efficient routing protocols and the Hierarchical routing protocols are meant to work efficiently on energy saving parameters in which the higher energy nodes in the hierarchy are used to send and process the information whereas the lower energy nodes work as sensors to collect the data.



In Hierarchical routing protocols, sensor nodes are bunched into the clusters unlike flat routing protocols which works well with peer sensor nodes that have individual distinctive universal addresses. Each cluster in hierarchical network has a cluster head, of which election is established on the different election algorithm.

Uses of cluster head are:

- 1) decreasing the overhead of the transportation,
- 2) Advanced level of communication.

Each level comprises similar level of communication so that the clustering can be drawn-out to the more than just two levels. This method surely has a lot of positive points such as the size reduction of the routing tables, increase of the scalability and so on.

Although any increase in the density of the sensor nodes/networks might cause overloaded gateway by the cluster point networks. This would result a latency in the delivery of event status. Therefore, a multipoint clustering has been proposed to allow WSN to deal with a huge population of sensor nodes/networks and hence, it would be able to cover comparatively a larger area.

The focus of the hierarchical routing is to handle the energy consumption of the WSN efficiently by data aggregation and fusion to decrease the number of transmitted packets and to establish the multi-hop communication within a particular cluster. So, this thesis aims to survey on the WSN lifespan in which power consumption criteria could be achieved by an implementation of Low-Energy Adaptive Clump Hierarchy (LEACH) algorithmic program at intervals in WSN routing protocol. Heinzelman, Chandrakasan and Balakrishnan (2000) introduced original work on first hierarchical routing protocol viz. LEACH protocols which showed remarkable

improvement of the WSN network lifespan, thereafter, various research conducted on LEACH algorithm such as:

- V-LEACH by Al-zou'bi, Khamyseh, Yassein and Mardini, 2009
- E-LEACH (Energy-LEACH) by Yulin and Xiangning, 2005
- TL-LEACH (Two-Layer-LEACH) by Loscri, Morabito and Marano, 2005
- C-LEACH (Centralized-LEACH) by Heinzelman, Chandrakasan and Balakrishnan, 2002

In this research work performance comparison were introduced to show enhancement of LEACH Igorithm. Similar characteristics were maintained in the simulated network in majority of updated implemented WSN although, advanced parameters and characteristics could be surveyed to improve the consumption of energy in WSN. Hence, study and investigation of LEACH algorithm is required to build the simulation test-bed and also to perform the simulation on the existing algorithm by reviewing the literature. Later, further modification of LEACH is performed on the simulation test-bed. Additionally, an analysis and evaluation could be done over the widely used simulation environment.

#### IV. LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY (LEACH) PROTOCOL

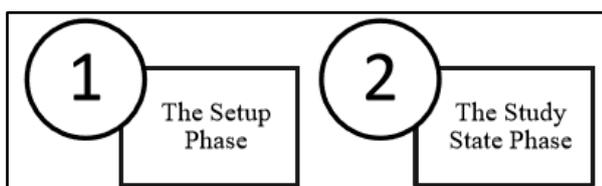
Cluster-based LEACH protocol is one of the first hierarchical protocols that forms distributed cluster. It acts as an energy routing protocol, however, it lacks certain issues of security. This paper integrated authentication algorithm to ensure authenticity, integrity and availability of information by an energy improved secure routing protocol termed as Lightweight-secure LEACH (or LS-LEACH). Moreover, this research shows improvement in terms of measuring the impact of overhead energy consumption along-with the parameter of security measure as compared to that over LEACH protocol.

LEACH protocol works when the node in the network fails or its battery stops working. So, LEACH is a self-organizing, adaptive clustering protocol in which nodes will arrangement is in the form of clusters and Cluster Head (CH) is selected by cluster members (non-CH) to avoid excessive energy consumption and to perform data aggregation/compression that reduces the count of the messages sent to the base station (BS). The selected CH guides its respective cluster.

The basic operation of LEACH is organized in two distinct phases,

- Setup Phase and
- Steady-State Phase

#### V. OPERATIONS IN LEACH PHASES



##### A. Set-up phase

- Network organization into clusters

- Advertisement of CHs
- Transmission schedule creation.

To choose the CH for a cluster, a random number,  $n$ , is produced between 0 and 1. A node would act as CH in case  $n$  is not over the brink worth. So, the threshold value is formulated under the operate  $T(n)$ .

$$T(n)_{Leach} = \begin{cases} \frac{P}{1 - P \left( R \bmod \frac{1}{P} \right)} & \text{if } n \in G \end{cases}$$

Where,

$P$  = Probability of CH.

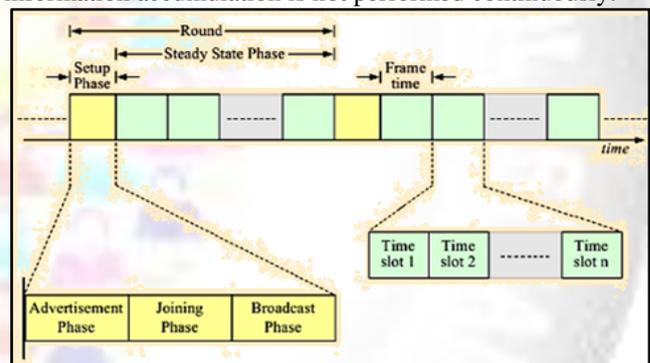
$R$  = Current Operational Round of the processes.

$G$  = Group of non-CH nodes in the previous  $1/P$  rounds.

##### B. Steady State phase

- The data aggregation/Compression
- Transmission to the sink

Every CH forms and distributes the TDMA plan after cluster arrangement that shows the distributed time spaces for every individual node in that cluster. Additionally, each CH could choose a CDMA code that could be dispersed to all individual nodes to its respective cluster. To minimize the Bury Group Obstruction, the CDMA code needs to choose as much precisely as possible. The start of the steady state phase is signified by the consummation of the setup phase in which the non-CH nodes collect the data and send it to the CH by bringing into service their dispensed openings. This information accumulation is not performed continuously.



##### C. Specifications in Leach Operation

- LEACH reduces energy consumption by switching off the CHs as much as possible.
- All sensor nodes transmit data directly to the CHs using single hop routing.
- LEACH is not applicable for the WSN deployed in large regions.
- LEACH offers scalability by limiting most of the communications within the clusters of the WSN.

#### VI. LITERATURE REVIEW

- 1) Narasimha et al. (2006) described various sensor network routing in comprehensive manner that are needed for efficient functioning of a WSN in a wireless environment. The issue is to relay on the data that needs to fetch from remote sensor nodes to a base station of a WSN which require effective routing protocols for the sensor nodes. Additionally, severe resource constraints in terms of limited computation, storage and power make an aim to achieve an energy-efficient routing protocols more challenging. The thesis proposed

routing algorithms of the WSNs and tried to explore the space of sensor network routing. A comparative data of the distinct categories of the routing protocols along with their respective merits and demerits in the thesis helped to understand their operations and trade off that are helpful for future researchers to get a reference to make more robust and smarter routing techniques.

- 2) Brijbhushan and SakshiAnand (2015) surveyed on various routing protocols that are categorized based on their structure as location based, multipath based, hierarchical, QOS-based, heterogeneity-based, data centric protocols. Since, the routing protocols focused to increase the life period of sensor nodes in order to operate them in a WSN as long as possible. So, the energy-efficiency parameter(s) is one of the major challenges of the WSNs such as in LEACH operational phases. LEACH is basically a self-organizing, adaptive clustering protocol based on hierarchical protocol with two phases. In the first phase, Setup phase, the sensor nodes arrange themselves into cluster and the cluster head (CH) is chosen by cluster member to avoid over-usage of energy thus, aggregate data to reduce the bulk of sending information to base station in its second phase called Steady-state phase. So, this thesis discussed ways to reduce energy consumption.
- 3) Zain ulAbidinJaffiri et al. (2014) discussed about energy efficient techniques of hierarchical routing protocols of WSNs along with the Network Lifetime. As a Network Lifetime gives a vital information of any Energy-efficient routing techniques so, the focus is laid on the sources of energy wastes in WSNs. Moreover, the hierarchical protocols try to produce a scalable, effective and efficient result by splitting the network into “clusters” and perform “data aggregation and fusion” to maintain energy consumption. So, a WSNs with a heavy load and wide coverage area are well suited with hierarchical protocols. At the end, a comparison of different hierarchical routing schemes with respect to mobility, scalability, metric routing and robustness gave the contrasting information of the respective schemes’ benefits and drawbacks.
- 4) Aslam, M., et al (2012) discussed about the way to extend routing protocols add order to extend the life time, and quality of routing protocol is improved for wireless sensing element network. In hierarchical routing protocols complete network is divided into multiple clusters. One node in each cluster play leading rule. Cluster head is the only node that may communicate to base station in bunch routing protocols. This significantly reduces the routing overhead of traditional nodes as a result of traditional nodes have to transmit to cluster-head solely.
- 5) Kumar & Pal (2013) discussed about assisted LEACH of (A-LEACH) achieve lessened and uniform distribution of dissipated energy by separating task of routing and knowledge aggregation. It introduces the concept of helper nodes that assist cluster heads for multi-hop routing. A new algorithm was developed to facilitate energy economical multi-hop setup for helper nodes to succeed in base station. The proposed protocol extends the time of the network, minimizes overall energy dissipation in the network and distributes among

cluster heads, sensor nodes and helper nodes via LEACH. This is substantiated by simulation results. Helper nodes assisted LEACH(A-LEACH) protocol has improved the period of the network by reducing the energy dissipation throughout the nodes. Theoretical analysis and simulation results substantiate this.

- 6) Fang, S.et al.(2007) discussed about overhead fully distributed bunch algorithm rule is projected to decompose wireless sensing element networks, where nodes square measure initializes with either equivalent or completely different capacities, into a two-tier clustered hierarchical structure. Energy rich nodes square measure assured to act as cluster heads (CH), and CHs are distributed equally over the network. The purpose if the energy distribution is understood prior to, slotted waiting Energy-Efficient Time (SWEET) priorities energy rich nodes in CH competition. A CH utilizes a local transmission vary to recruit its members and drive undermining CH Contenders aloof from its cluster radius, so that cluster size is often restricted and CHs square measure less probably to huddle. A CH candidate running slotted waiting period Energy Efficient Time driven bunch algorithm rule (SWEET) merely waits and listen to alternative neighbors, until it has to become CH, so the overheads throughout the bunch method square measure cut out. Even SWEET is AN overhead-free methodology, it performs better than representative bunch schemes in extending system period of time and enlarging network knowledge capability.

## VII. CONCLUSION

The entire survey is made on the Routing Protocols of WSN to understand Hierarchical Routing better. Although, Hierarchical Protocols have number of energy efficient representative protocols, we majorly focused on LEACH protocol to approach for any further modification or study with similar two operational phases. In order to work for future study or any kind of modification purpose, LEACH threshold equation is shown with a comprehensive survey of its both operational phases.

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