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DESIGN AND SIMULATION OF CLUSTERING ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS

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Master’s Thesis

Supervisor

Asst. Prof. Dr. Ayça Kurnaz TURKBEN

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The thesis titled DESIGN AND SIMULATION OF CLUSTERING ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS prepared by MUSTAFA ABDULSATTAR JEBUR JEBUR and submitted on 17/08/2022 has been **accepted unanimously** for the degree of Master of Science in Electrical and Computer Engineering.

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ABSTRACT

DESIGN AND SIMULATION OF CLUSTERING ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS

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Ongoing advances in remote innovations has prompted the improvement of portable remote sensor organizations. Notwithstanding portability of sensors, sensors in the organization are minimal expense and have restricted measure of battery. As to principal qualities of these organizations they are more pertinent. Among various attributes of these organizations they have numerous applications, for example, search and salvage tasks, wellbeing and ecological observing and insightful traffic light frameworks. According to the application requirements with regard to the act that mobile wireless sensor nodes are energy limited equipment's, which saving energy is one of the most important issues in the designing of these networks. In the task ideal bunching in multipath and multi-jump convention has been proposed which means to ease energy utilization and increment the organization of remote sensor organization. This is proposed for a round region encompassing a sink one jump correspondence between the sink is supplanted by an ideal multi bounce interchanges. The ideal number of bunches is registered and the energy utilization is improved by apportioning the organization into almost the equivalent size of groups. The simulation results have showed the increase in the network lifetime comparatively with other clustering techniques.

Keywords: WSN, The Mobile Sink Node, Lifetime of the Network, Routing Protocol.

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ABBREVIATIONS

BS	:	Base Station
CHs	:	Cluster Heads
IoT	:	Internet of Things
WSN	:	Wireless Sensor Network
PSO	:	Particle Swarm Optimization
PDR	:	Packet Delivery Rate

1. INTRODUCTION

With the development of technology, sensor networks comprise small sensing devices equipped with a wireless radio transceiver for environmental monitoring. The key benefit of the small device is to observe the atmosphere and it failed to need the infrastructure like electric mains. The sensor hubs notice the climate by gathering the data from the environment and communicate the information to the base station for examination. A Wireless Sensor Network (WSN) is a remote organization with various spatially dispersed sensors to analyze the natural circumstances.

A WSN system includes a gateway that presents wireless connectivity back to the distributed node. WSN comprises a number of small sensors for environmental monitoring, battlefield monitoring, and distortion detection. It comprises new technology that received great attention in industry and academia. Sensor networks are employed for attractive applications where sensor networks lifetime gets increased and energy gets optimized. The essential problem of the sensor node is energy utilization. For minimizing the energy consumption, low power devices are employed in WSN. The data are transmitted from one node to another node with higher energy consumption. The key idea of data aggregation is to gather the data with minimal energy consumption. WSN present new data gathering methods in the distributed scheme and dynamic access by means of wireless connectivity.

1.1 WIRELESS SENSOR NETWORK

WSN is regarded as a crucial method for the twenty-first century. WSN drew a lot of attention from both academia and industry. WSN includes sensor nodes that are low-cost, low-power, and multifunctional, with sensing and computation capabilities. To achieve the goal, the sensor nodes communicate within transmission range via a wireless medium. The capability of each sensor node is insufficient, but the network's aggregate power is sufficient for the required mission. Sensor node deployment in WSN applications is done haphazardly and without planning. After deployment, the sensor nodes categorize themselves to form the wireless communication network [5].

Every sensor senses the environment condition and transmits the data to the destination. Every sensor node is provided with the low-cost computational module because of minimum battery lifetime and low-cost. The collected data is distributed to the static control point termed the data sink in the network through node-to-node multi-hop data propagation. During the routing protocol execution, the sensor device utilizes a large amount of energy and increases the implementation complexity. The structure of the wireless sensor is described in Figure 1.1.

A WSN is a self-organizing system represented by a large number of sensors that consumes very little energy. They are used to monitor the sensing field and gather data from the physical environment. The sensors send the collected data to the central location via a network. The sensor node is compact and has limited computational and memory capacity. The sensor node's lifetime is determined by the battery's lifespan.

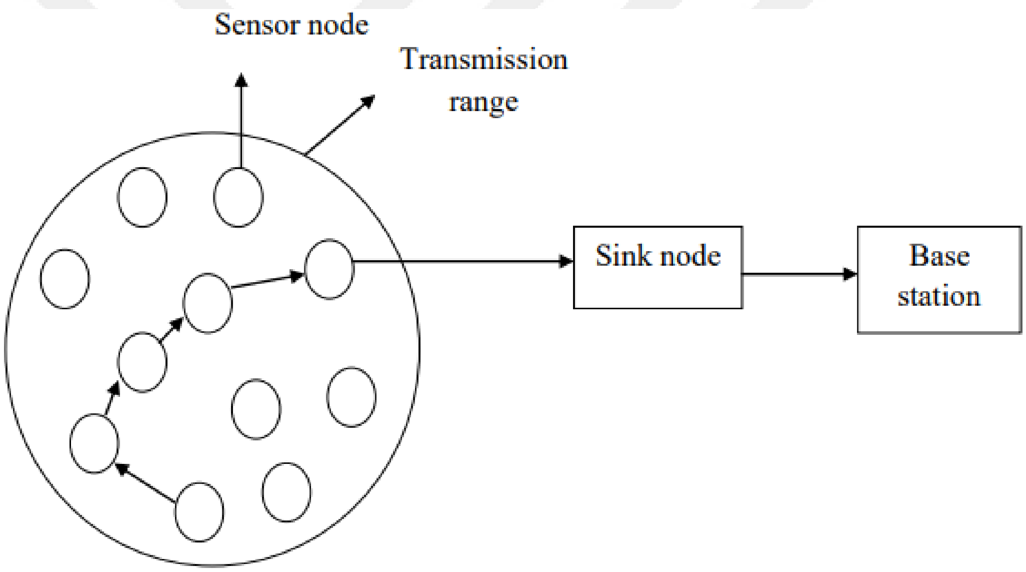

Figure 1.1: Wireless Sensor Network [5]

WSNs are arranged with the thick degrees of sensor hub organization, more prominent flightiness of sensor hubs and memory constraints. The unmistakable highlights and impediments present different difficulties for WSNs application. Since sensor hubs have restricted energy, network conventions are expected to perform many organizations control and the executives capacities like synchronization, hub limitation, and organization security. Flooding is another strategy wherein a hub communicates the information and control parcels got from the other organization's hubs. The interaction is rehashed until the last objective hub is reached. Flooding is a blind method that causes duplicated packets to circulate throughout the network. The sensors collect duplicated packets, which cause implosion problems. When two sensors detect the same area and send data about it at the same time, neighbors obtain the duplicate packets. For addressing the flooding issues, the gossiping technique is introduced. In gossiping, sensor selects one of their neighbors and transmits their packet to it. The similar process gets repeated until all the sensors collect the packet. By means of gossiping, sensor gathers any one of the sent packets.

1.2 WIRELESS SENSOR NETWORK CHARACTERISTICS

WSN has many features Node deployment:

Sensor nodes are strewn about. Deployment can be either deterministic or self-organizing. The deterministic method involves physically locating nodes and transmitting messages via predetermined minimal distant paths.

Battery-powered sensor nodes: Sensor nodes are functioned by the battery. It is deployed in an environment where it is hard to recharge the batteries.

Energy, calculation, and capacity limitations: Sensor hubs have restricted energy, handling, and capacity abilities. Self-configurable: Sensor network hubs are coordinated and arrange themselves. Temperamental sensor hubs: Because they are sent in the environment, sensor hubs are inclined to disappointment. It is conniving.

Data redundancy: The nodes are densely arranged and combined to perform the sensing process. The data sensed through many sensor nodes includes a certain redundancy level.

1.3 ISSUES AND CHALLENGES IN DESIGNING SENSOR NETWORK

Sensor Networks has certain design issues owing to the following basis:

i- Sensor Networks failed to have the infrastructure. All routing and its maintenance algorithms are distributed.

ii- Nodes in a sensor network are organized and failed to fall under topology. It failed to need human intervention

iii- The hardware component of sensor nodes considered the energy efficiency as a primary objective.

iv- Nodes synchronize with other nodes in a distributed manner.

v- Available energy of sensor nodes is considered a key issue while designing protocols.

1.4 ROUTING IN WSN

Steering is the most common way of deciding the best way between a source and an objective. Directing is a troublesome issue because of the attributes that recognize it from other correspondence and ad hoc networks. Because there are a large number of sensor nodes, routing cannot be used to design the overall problem solving scheme. All sensor network applications require data flow from multiple sources to the Base Station (BS). Sensor nodes are constrained in terms of energy, processing and storage capacity, and transmission power. Sensor location information is critical because data collection is dependent on location [17]. Data traffic redundancy occurs when multiple sensors in the neighborhood generate similar data.

With limited communication range and high density of sensor nodes, packet forwarding is carried out by means of multi hop data transmission. There are numerous limitations during the routing process in WSN. The first limitation is route reliability. Every node performs as a router. Whenever a hub doesn't distinguish the way, it communicates the Route REQuest (RREQ) message in the course revelation technique. Subsequent to getting RREQ bundle, adjoining hubs accomplish the QoS boundaries across ways like position and development data. The subsequent constraint is delay across the connections in WSN. The boundary is a significant one for sight and sound applications in WSN. The delay parameter eradicates the redundant broadcasting of RREQ messages and congestion in the network [20]. Through considering the delay across every link in the path, the throughput level gets enhanced. The third constraint is battery power. With the battery utilization in every node, energy is an essential one in WSN. In the route discovery process, energy computation across every node in the network is calculated and routing decisions are made. Several novel protocols were presented for routing data in sensor networks. Every routing protocol is categorized under suitable class as described in Figure1.2.

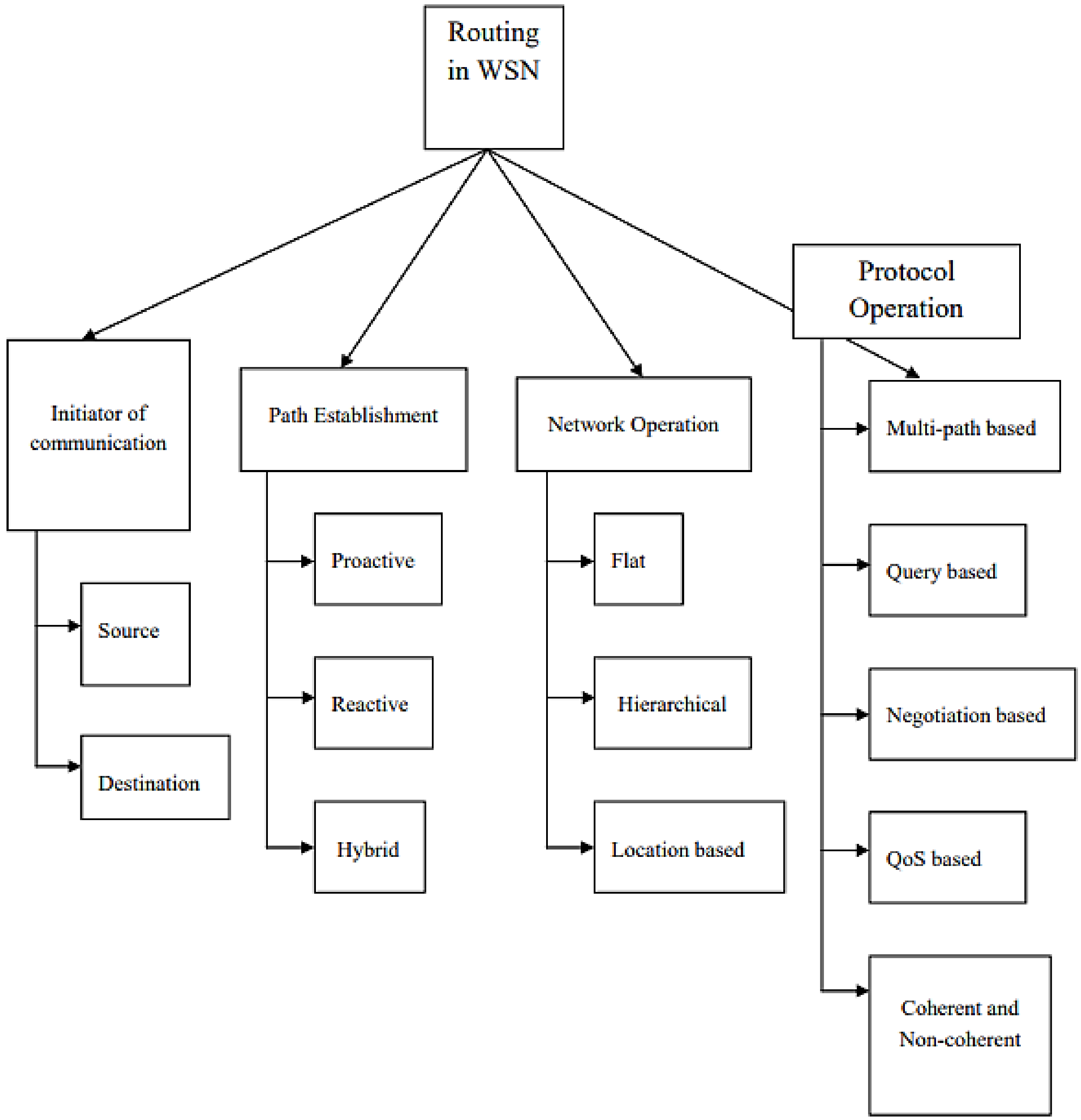

Figure 1.2: Classification of Routing [20]

1.4.1 Path Establishment Based Protocols

Directing ways are grouped into three kinds: proactive, responsive, and crossover. Proactive conventions distinguish all ways before they are required and store courses in every hub's steering table. At the point when a course changes, the change is communicated to the whole organization. WSN has an enormous number of hubs, and every hub's it is gigantic to defeat table. The main issue with proactive protocols is that maintaining unused paths consumes a lot of bandwidth when the network topology changes frequently. When a subset of routes is accessible, reactive protocols preserve the routes and reduce network load. Hybrid protocols like ZRP join proactive routing and reactive routing to enhance the efficiency and scalability. A combination of routing plan maintains currently employed routes and limits the topological variations tolerated within time.

1.4.2 Network Structure Based Routing Protocols

The network structure is an essential part of the operation of a routing protocol. In flat routing, every node executes similar flow and sensor nodes are joined for sensing task. It is not viable to allot the global identifier to each node. To resolve this issue, information driven steering is performed where BS communicates the inquiries to specific locales and sits tight for information situated specifically areas. Since the information is mentioned by means of inquiries, characteristic based naming is expected to recognize the information. The main layer of various leveled steering chooses the bunch heads, and the subsequent layer plays out the directing system. It is known as group based steering. Clusters are formed, and tasks such as data collection and fusion are assigned to them. Hierarchical routing improves the scalability, lifetime, and energy efficiency of the system. In the hierarchical structure, nodes with higher energy are used to transmit information, whereas nodes with lower energy are used for sensing tasks near the target.

1.4.3 Protocol Operation based Routing Protocols

To further develop network execution, numerous way it are utilized to defeat conventions. At the point when the way between the source and the objective comes up short, a substitute way should be available for adaptation to non-critical failure. It is achieved by protecting various ways among source and objective, which increments energy utilization and traffic age. The substitute ways are to be dynamic by communicating messages to further develop network unwavering quality. Query Based Protocols rely on data queries being sent and received. The destination nodes send the data query, and the node with the data sends it back to the node that matches the query. Negotiation Based Routing avoided the needless data transmission with advanced data descriptors. The protocols take communication decisions based on the available resources. For balancing the energy consumption and data quality, the network needs to convince QoS parameters such as delay, energy, bandwidth, etc. Incoherent data processing, data is sent to the aggregators. Minimum processing comprises tasks such as time stamping, duplicate suppression etc. In non-coherent data processing, before transmitting the data to other nodes, it is gets functioned locally.

1.5 PROBLEM FORMULATION

Like different kinds of remote gadgets, the sensor hubs experience the ill effects of numerous limits like untrustworthy correspondence joins, restricted recurrence groups and security issues. Another test for sensor hubs is that since the sensor hubs ought to be cheap, little and light, the memory limit, CPU power and particularly battery size is incredibly restricted. Experiencing the same thing, the battery substitution (on the off chance that certainly feasible), is extremely challenging. Subsequently, planning an energy effective correspondence convention for WSNs is inescapable.

From the above discussion, it can be inferred that enhancing the network lifetime remains to be the primary objective while designing routing protocols for WSNs. Energy efficient routing plays an important role in achieving this objective. Although many energy-efficient clusters based routing protocols have been proposed in the literature, still following are the open issues that need due consideration:

i- An efficient selection of cluster head is required for increasing the network lifetime.

ii- The location of the cluster head for multi-hop data transmission should be revised.

iii- Cluster boundaries need to be computed carefully to reduce the interference between clusters. Unbalanced clusters may put an overhead and hence increase the energy consumption.

Most of the routing protocols consider sink as well as sensor nodes as stationary. However, for many of the WSN applications, it is desirable to have mobile nodes in the network. It becomes challenging to design energy efficient routing protocols for frequently changing network topology.

Inspired by the need of issue analysis in remote sensor organizations, the deficiencies of this issue finding method and focusing on the examination headings, it's been understood that there exists sufficient extension to upgrade the conclusion execution. During this proposition, the proposed conclusion calculations lessen the analysis upward while keeping up with high location precision, low admonition rate, low finding idleness and low correspondence and energy upward;

1.6 MOTIVATION

Recent advancements in wireless technology have resulted in the creation of mobile wireless sensor networks. Aside from sensor mobility, sensors in the network are low-cost and have a limited battery life. They are more applicable in terms of the fundamental characteristics of these networks. These organizations have a wide scope of uses, including search and salvage activities, wellbeing and natural checking, and savvy traffic signal frameworks. According to the application requirements with regard to the act that mobile wireless sensor nodes are energy limited equipment's, which saving energy is one of the most important issues in the designing of these networks. Alongside each of the difficulties brought about by the versatility of the sensor hubs, we can note to the directing and dynamic grouping. Concentrates on show that group models, which have customizable boundaries have critical effect in limiting energy utilization and broaden the lifetime of the organization. Subsequently, the principle objective of this examination is to present and choose the shrewd way involving transformative calculations for grouping in portable remote sensor networks for expanding Lifetime of the Network and right conveyance of bundles.

1.7 OBJECTIVES OF RESEARCH WORK

As it is widely indicated from the present research works, existing solutions destined to scale back power consumption during a sensor environment might not suit the wants of another sensor environment. This research work aims at improving the lifetime of a sensor network from the energy perspective. The scope of the research work ascends from lack of generalization and obscurity in performance objectives. Unlike traditional ad-hoc networks, WSNs place many complex scenarios and encourage novel research ideas to emerge. Dynamic nature of the sensor application requirements makes many existing solutions obsolete and triggers the necessity for tuning and redefining these solutions.

The target of this theory is to think about homogeneous and heterogeneous sensor networks according to the perspective of the general organization cost by considering the above energy-equipment exchange of. Thus, most of the current clustering algorithms are homogeneous schemes, such as LEACH, PEGASIS, and HEED. The LEACH protocol handles the dissipation of the energy by rotation of the cluster heads among other clusters and timely formation and dissolution of the clusters.

1.8 CONTRIBUTION

By joining the elements of energy mindful directing and multi-jump intra group steering, the Optimal Clustering in Circular Networks (OCCN) directing convention was made [21]. The OCCN convention is partitioned into adjusts, with each gather starting with a set-together stage in which the bunches are coordinated. The stream outline underneath gives an outline of the convention. At first, the client should give input as the quantity of hubs.

The places of the produced hubs are allocated and shown indiscriminately. After the hubs are sent, the neighbor disclosure calculation is utilized by every hub to find its neighbors. Group heads are browsed among the hubs utilizing the bunch head determination calculation. These bundle heads broadcast the advertisement message to their bordering centers as a rule, achieving bunches with a nice bound size. Each center in the gathering keeps a guiding table in which the centers' overcoming data is revived. The DRAND strategy (disseminated randomized schedule opening task calculation) is utilized [9].

1.9 THESIS OUTLINE

The rest chapters of the thesis are prepared as follows:

Chapter 2: This chapter presents detailed review of literature of some existing methods explained in the fault diagnosis WSNs.

Chapter 3: This chapter gives the detailed overview of proposed OCCN algorithm to diagnose hard faults. This chapter also gives the implementation details of proposed algorithm and comparison is presented with standard LEACH algorithm.

Chapter 4: This chapter concludes the proposed work and gives direction to future work

2. LITERATURE SURVEY

This section starts with an outline of Wireless Sensor Networks and afterward centers around Energy-productive Routing Algorithms [1]. Moreover, we portray the parts of WSNs as well as an energy-proficient steering convention in Wireless Sensor Networks.

2.1 WIRELESS SENSOR NETWORK CIRCUIT

A Wireless Sensor Network (WSN) [2] [3]is comprised of countless sensors and no less than one base station. The sensors are independent little gadgets with restrictions, for example, battery power, calculation limit, correspondence reach, and memory. They are additionally furnished with handsets that gather data from their environmental elements and communicate it to a particular base station, where the deliberate boundaries can be put away and made accessible to the end client. As a rule, the sensors that contain these organizations are sent aimlessly and left unattended, with the assumption that they will do their main goal accurately and productively. Because of this heedless arrangement, the WSN [3] commonly has changing levels of hub thickness all through its area. Sensor networks are likewise energy compelled on the grounds that the singular sensors that include the organization are additionally incredibly energy obliged. These sensors' specialized gadgets are little and have restricted power and reach. Both the probable distinction in hub thickness across certain districts of the organization, as well as the energy imperative of the sensor hubs, make hubs bite the dust gradually, making the organization become less thick. Besides, it is very considered normal to send WSN [3] in cruel conditions, which makes numerous sensors become inoperable or broken. Thus, these organizations should be issue lenient to diminish the requirement for upkeep. Regularly, the organization geography is continually and progressively changing, and renewing it by mixing new sensors rather than drained ones is certainly not a helpful arrangement. Carrying out directing conventions that perform productively and use as little energy as workable for correspondence among hubs is a genuine and suitable answer for this issue. The WSN is comprised of two significant parts:

2.1.1 Sensor Nodes

Sensor hubs [6] are ordinarily made out of a couple of sensors and a bit unit, as represented in Figure 2.1. A sensor is a gadget that recognizes data and communicates it to a bit. Sensors are normally used to gauge changes in actual ecological boundaries like temperature, pressure, stickiness, sound, and vibration, as well as changes in an individual's wellbeing boundaries, for example, circulatory strain and heartbeat. Sensors in view of MEMS have tracked down broad application in sensor hubs [7]. A Sensor Node is comprised of a bit and a sensor [8]. A sensor network is an impromptu remote organization of sensor hubs. Every sensor hub can uphold a multi-jump directing calculation and go about as a forwarder for information parcels to be handed-off to a base station [40].

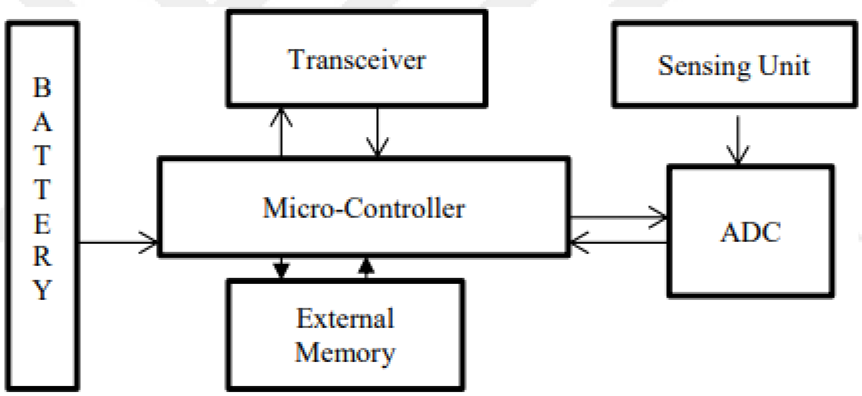

Figure 2.1: Block diagram of sensor node [40]

2.1.2 Base Station

A base station [9] interfaces one organization to the sensor organization. It is comprised of a processor, a radio board, a receiving wire, and a USB interface board. It comes pre-introduced with low-power network organizing programming for speaking with remote sensor hubs. In a remote sensor organization, base station arrangement is basic since all sensor hubs send information to the base station for handling and direction. During the sending of a base station in a sensor organization, energy preservation, sensor hub inclusion, and unwavering quality issues are addressed [3]. By and large, base stations are thought to be static, yet in certain situations, they are thought to be portable to gather information from sensor hubs [55].

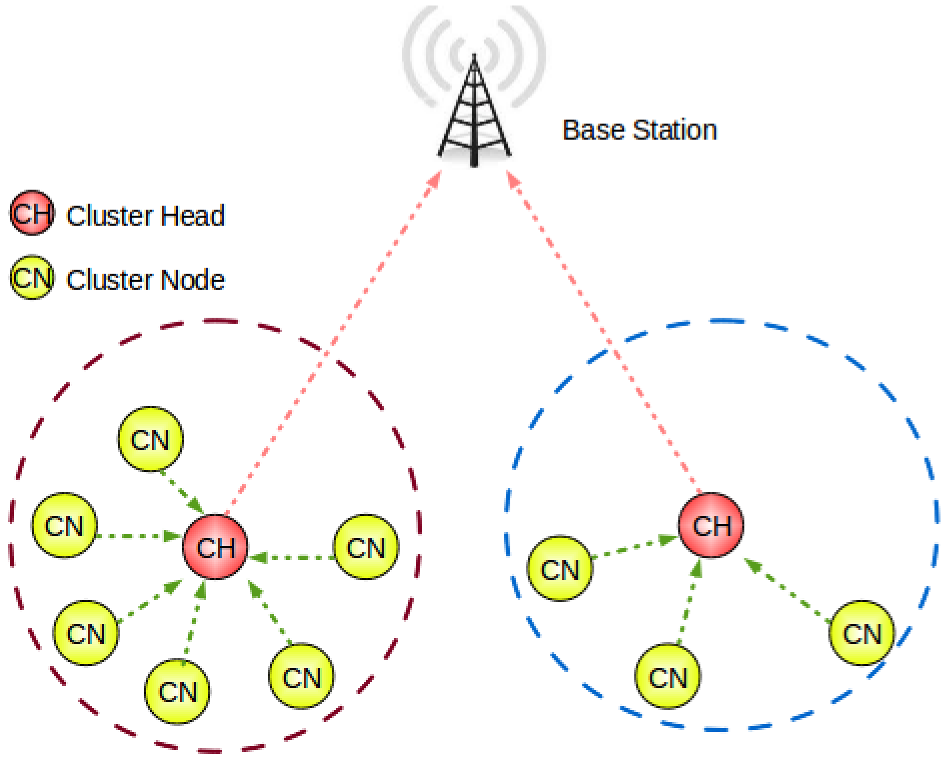

Figure 2.2: Base Station Node [55]

2.1.3 Radio Model

We utilized a similar radio model [10] that was utilized in past works. As displayed in Figure 2.3, the transmitter disperses energy to drive the transmitter radio equipment and power enhancer, while the recipient dissipates energy to control the get radio contraptions.

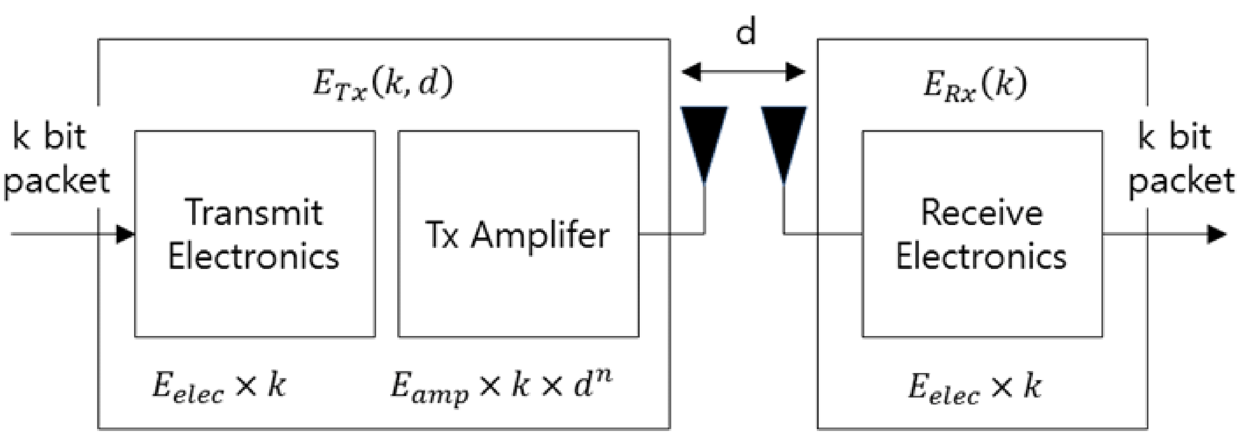

Figure 2.3: Radio Model [2]

2.2 ENERGY-EFFICIENT ROUTING ALGORITHMS

Energy productive directing calculations [13] are ordered into three sorts: information driven steering calculations [14], area based directing calculations [5], and various leveled steering calculations [15]. To kill repetitive information transmission, the information driven directing calculation utilizes meta information to track down the course from source to objective before any genuine information transmission. Each sensor hub should give exact area data to the area based directing calculation. The organization is isolated into groups by the progressive directing calculation [15]. Each group chooses a bunch head (CH). CH [16] accumulates information from its individuals, totals it, and sends it to sink. This strategy saves energy yet is more hard to execute than different techniques.

2.2.1 Data Centric

Information driven conventions [14] are question put together and depend with respect to the naming of the ideal information, bringing about less repetitive transmissions. The BS [9] sends inquiries to a particular region for data and hangs tight for reactions from the hubs around there. Since information is mentioned through questions, trait based naming is expected to determine the information's properties. Sensors gather explicit information from the area of interest in view of the question, and this particular data is simply expected to communicate to the BS, diminishing the quantity of transmissions. for example, the principal information driven convention was SPIN.

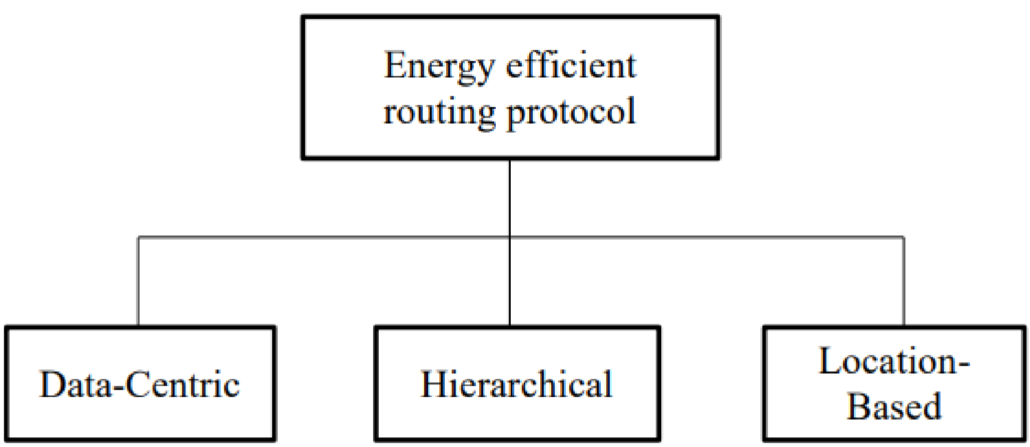

Figure 2.4: Classification of Routing in WSNs [14]

2.2.2 Hierarchical

Moderate coordinating [15] is utilized to perform energy proficient routing [13], i.e., higher energy centers can be utilized to process and send information, while low energy center points are utilized to perform identification in the space of interest. Channel [17], TEEN, and APTEEN are a couple of models.

2.2.3 Location Based

Sensor node location information is required by location-based routing protocols. Location can be determined using GPS (Global Positioning System) signals, received radio signal strength, and other sources. Using location information, an optimal path can be formed without the use of coding techniques. For example, Geographic and Energy-Aware Routing (GEAR).

2.2.4 Clustering

In a proper organization association, the information is coordinated and summarized by social occasion and gathering the sensors. These gatherings are called groups. As a general rule, each group has a bunch head which arranges the information gathering [19] and collection process in a specific group. Bunching in WSNs ensures fundamental execution accomplishment with an enormous number of sensor hubs. As such, grouping works on the adaptability of WSNs. Grouping overall limits the requirement for brought together control. The grouping conventions fundamentally center around two angles which include the choice of the bunch head and afterward pivoting this group head to adjust the energy utilization of the sensor hubs in the organization. These bunching calculations don't think about the area of the base station. Because of weighty transfer traffic, bunch heads [20] situated close to base stations will quite often kick the bucket sooner than group heads situated a long way from the base station. Some inconsistent bunching calculations have been proposed in the writing to stay away from this issue. In inconsistent bunching, the organization is partitioned into groups of changing sizes, with bunches nearer to the base station being more modest than groups further away from the base station [37] [39].

WSN [13] challenges emerge in the execution of a few administrations; there are so many controllable and wild boundaries that can truly influence the execution of a remote sensor organization, like energy preservation. As is notable, the little size of a sensor hub requires the utilization of a little battery with a restricted accessible energy spending plan. Whenever the remote sensor network [12] supplanted single full scale sensors, it acquired a benefit in detecting range, adaptation to internal failure, precision, and cost over its ancestors. Nonetheless, as the quantity of hubs in the WSN fills to increment inclusion reach and precision, energy the executives turn into a significant requirement since these hubs are battery fueled. Furthermore, experiencing the same thing re-energizing or supplanting of the battery is incomprehensible.

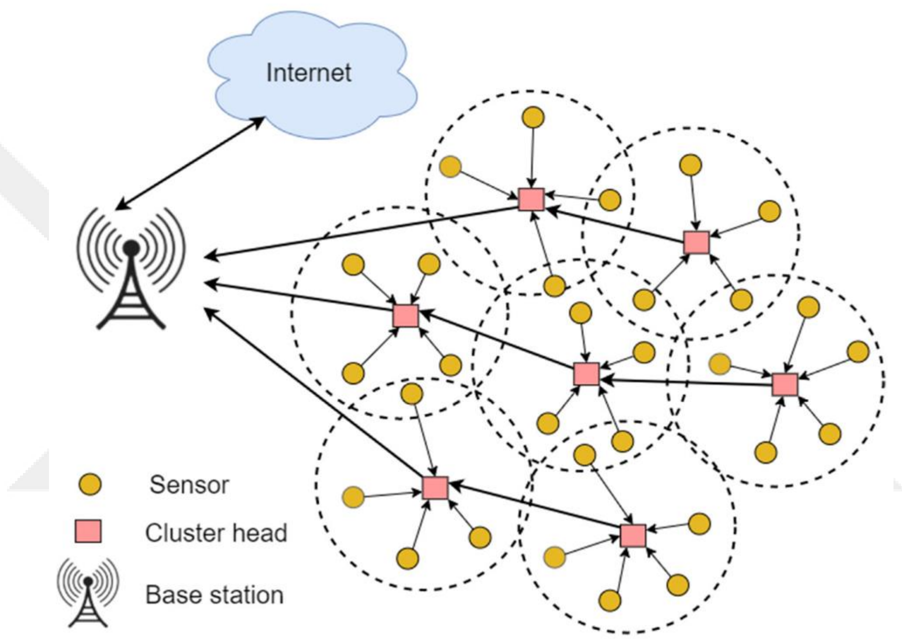

Figure 2.5: Clustering [18]

2.2.5 Heterogeneous and Homogenous Clustering

Bunched sensor organizations can be characterized into two wide sorts; homogeneous and heterogeneous sensor organizations. In homogeneous associations, all sensor centers are undefined as far as battery power and gear intricacy. With totally static clustering (bunch heads picked once, serve for the whole lifetime of the association) in a homogeneous association, clearly the bundle head center points will be over-stacked with significant distance transmissions to the remote base station, as well as the extra taking care of expected for data assortment [19] and show co-arrangement. Thus the group head hubs lapse before different hubs. Anyway it is attractive to guarantee that every one of the hubs run out of their battery at about a similar time, so very little lingering energy is squandered when the framework terminates. One method for guaranteeing this is to turn the job of a bunch head arbitrarily and intermittently over every one of the hubs as proposed in LEACH [17] [22]. Nonetheless, the disadvantage of utilizing a homogeneous organization and job pivot is that every one of the hubs ought to be fit for going about as group heads, and thusly ought to have the fundamental equipment capacities.

Then again, in a heterogeneous sensor organization, at least two distinct kinds of hubs with various battery energy and usefulness are utilized. The inspiration being that the more mind boggling equipment and the additional battery energy can be installed in not many bunch head hubs, consequently lessening the equipment cost of the remainder of the organization. Anyway fixing the bunch head hubs implies that job revolution is as of now not conceivable. Whenever the sensor hubs utilize single jumping to arrive at the bunch head, the hubs that are farthest from the group heads generally burn through more effort than the hubs that are nearer to the group heads. At the point when centers use multi-skipping to arrive at the gathering head, the centers nearest to the gathering head have the most raised energy inconvenience due to giving off. Subsequently, there is typically a non-uniform energy [1] squander model in the association. Thus, a sensor association enjoys two unmistakable benefits: lower gear expenses and uniform energy leakage. While heterogeneous associations accomplish the first, the homogeneous organizations accomplish the last option. Anyway the two elements can't be fused in a similar organization. The target of this paper is to analyze homogeneous and heterogeneous sensor networks according to the perspective of the general organization cost by considering the above energy-equipment exchange of. Accordingly, a large portion of the ongoing bunching calculations are homogeneous plans, like LEACH, PEGASIS, and HEED. The LEACH convention handles the dispersal of the energy by turn of the group heads among different bunches and ideal development and disintegration of the bunches [41] [53].

2.3 SUMMARY

The writing study offers a comprehension of Wireless Sensor organizations and various approaches to improving the functional season of the organization. The ordinary energy safeguarding techniques have upward in message transmission and intricacy in bunch development and update exercises. The proposed strategies limit message transmission upward utilizing AI methods. They work on the development of bunches and improve the replastering of the organization utilizing the update cycle determined with the assistance of fluffy derivation framework. The proposed techniques additionally broaden the lifetime of Wireless Sensor Networks by joining rest booking as an energy saving system

3. PROPOSED SYSTEM

Bunching is the errand of relegating a bunch of objects to gatherings (likewise called classes or classifications) so the articles in a similar group are more comparative (as indicated by a predefined property) to one another than to those in different groups. In systems administration, the organization region is partitioned into little regions, called groups. In each group, a hub is chosen as the bunch head (CH) and is liable for intra-bunch and between bunch correspondences. In correspondence conventions in light of bunching idea, time is discrete and consequently separated into schedule openings in which any non-group head hub (non-CH) sends accumulated information to its bunch head.

3.1 LEACH

W. Heinzelman, introduced a different evened out batching computation for sensor associations, called Low Energy Adaptive Clustering Hierarchy (LEACH) [24]. Channel figures out the middle focuses in the relationship into little packs and picks one of them as the social affair head. Focus at first perceives its objective and a brief time frame later sends the important data to its group head. Then, at that point, the social gathering head totals and packs the information got from the center spots overall and sends it to the base station. From this time forward LEACH uses erratic turn of the center points expected to be the bundle heads to consistently fitting energy use in the association.

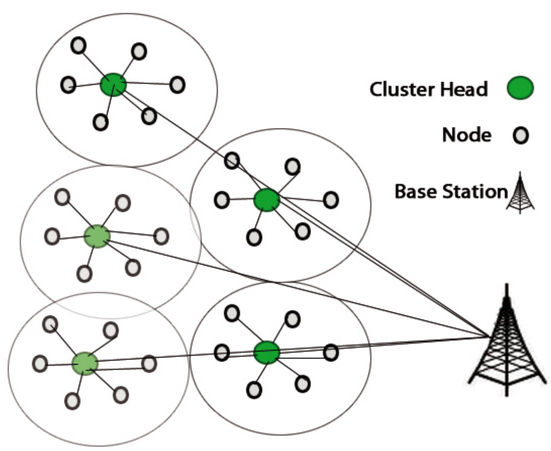

Figure 3.1: Clustering in Leach [24]

LEACH operations can be divided into two phases:

Setup phase: During the arranging stage, a foreordained number of centers, p, pick themselves as gathering pioneers. This is finished by a cutoff esteem, T. (n). As shown by G, the breaking point is still up in the air by the best rate to turn into a gathering head-p, the current round r, and the game plan of centers that needy individual turn into the gathering head in the previous 1/p changes. The equations will be presented next.:

$$T(n) = \frac{p}{1} - p\left[r \ mod \ \left(\frac{1}{p}\right)\right], if \ n \ E \ G, \quad (3.1)$$

$$T(n) = 0 \ otherwise$$

Each hub needing to be the group head picks a worth, somewhere in the range of 0 and 1. On the off chance that this irregular number is not exactly the limit esteem, T(n), the hub turns into the bunch head for the current round. Then, at that point, each picked CH sends an advancement message to different centers in the association, welcoming them to join their packs. The non-pack head focus focuses choose to join the social events because of the strength of the business sign. The non-pack head [21] focuses then send an attestation message to their particular social occasion heads illuminating them that they will under them assemble. Following receipt of the accreditation message, the pack heads make a TDMA game plan and chooses a schedule opening for each middle point wherein it can send the recognized information, in light of the quantity of focuses under their get-together and the sort of data expected by the construction (where the WSN is in real life). The TDMA [25] plan is conveyed to all the gathering people. Expecting the size of any gathering ends up being too huge, the bundle head could pick another pack head for its bundle. The bundle head picked for the current round can't again transform into the gathering head until the wide scope of different canters in the association haven't transformed into the pack head.

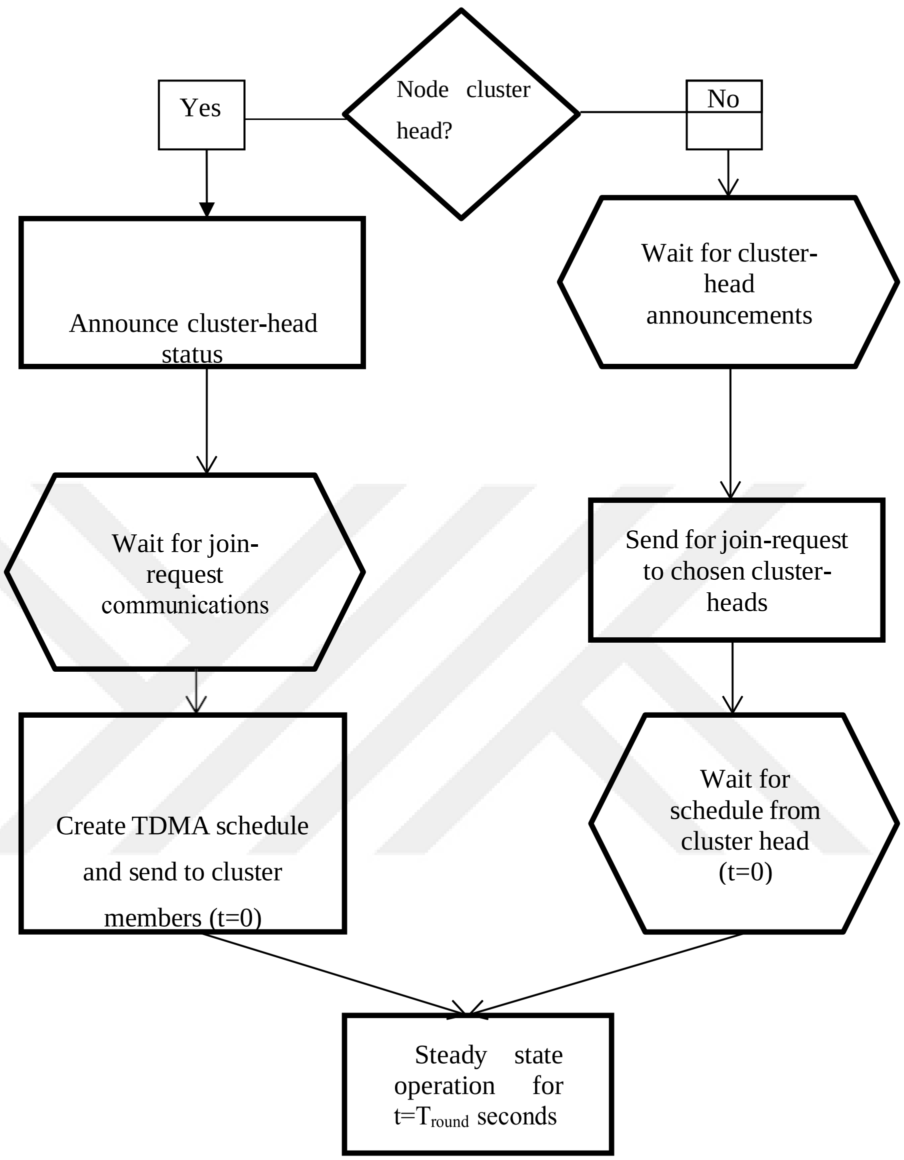

Figure 3.2: Flow chart for setup phase of Leach

Steady phase: During the predictable stage [16], the sensor centers for instance the non-bunch head center points starts recognizing data and sends it to their bundle head according to the TDMA plan. The gathering head center, resulting to getting data from all the part centres, sums it and a while later sends it to the base-station. After a predetermined amount of time, the organization returns to the planning stage and selects new bundle heads. Each bundle grants the use of various CDMA codes to reduce check from centers with a location with various gatherings.

3.2 PROPOSED OCCN OVERVIEW

The OCCN routing protocol is developed in this study by incorporating features of energy aware routing and multi-hop intra cluster routing. The OCRSN convention is partitioned into adjusts, with each gather starting with a set-together stage in which the bunches are coordinated, trailed by a consistent state work in which information moves to the base station happen. The stream diagram beneath gives an outline of the convention. At first, the client should give input as the quantity of hubs. The places of the produced hubs are allocated and shown indiscriminately. After the hubs are sent, every hub utilizes the neighbor revelation calculation to find its neighbors. Group heads are browsed among the hubs utilizing the bunch head choice calculation. These group heads broadcast the notice message to their adjoining hubs as a whole, bringing about bunches with a decent bound size. Every hub in the bunch keeps a steering table in which the hubs' it is refreshed to defeat data. The DRAND strategy (disseminated randomized schedule opening task calculation) is utilized, which permits numerous hubs to have a similar recurrence channel by separating the sign into various time allotments. The information from everything hubs in the bunch is amassed by the group head and communicated to the base station.

3.2.1 Network Model

The organization is considered as a roundabout region where, the sink is put in the middle and hubs are equitably dispersed around it. The correspondence convention begins with arrangement stage. In this stage, every hub takes part in a self-putting together interaction to distinguish its job (either CH or non-CH) in the following stage and accepts its time plan.

Next stage is information gathering stage, in information gathering stage, network activity is partitioned into many time allotments and each schedule opening incorporates time periods. In each time allotment, non-group head hubs act just in their planned time span and are inert in the remainder of it to save energy. As managed beforehand, grouping, information collection and, multi-jump correspondence are three significant strategies to lessen network energy utilization. Then again, load adjusting among all hubs assists with staying away from unexpected passing of hubs. Subsequently an ideal versatile bunching technique which gives fair traffic sending utilizing ideal measured groups and ideal multi jump parcel transferring is proposed called Optimal

Clustering in Circular Networks (OCCN). OCCN is a distributed sub-optimal clustering algorithm which benefits from the optimal parameters

3.2.2 OCCN

Calculation activity OCCN could be separated into a few rounds. Each round begins with an arrangement stage and wraps up with consistent state stage. In the arrangement stage bunches are coordinated and in consistent state data is communicated to base station. Arrangement stage First off, every sensor decides if it needs to be group head or not considering its lingering energy and number of times it is chosen as bunch head. The choice is made in light of an arbitrary number somewhere in the range of nothing and one. A short time later, assuming chosen number is not as much as edge that hub will be bunch head in a new round. This trust limit is gotten from following condition:

$$T(n) = \frac{p}{1-p} \times \left(r\ mod\ (p-1)\right) \tag{3.2}$$

Where p is probability for bunch heads (picked by pack), r is current round and 1/p is a lot of centers which were picked as gathering heads in past round. At the chief stage all that centers might be bundle heads with p probability. Whenever a center point is picked as pack head it can't be a gathering head for next 1/p changes. As the probability of being bundle head is lower for specific centers, with this system all that center points could be picked as gathering head. Whenever the gathering head is settled it announces what is happening by broadcasting [25] notice message (ADV). This message incorporates a little message comprising of hub ID and a header as declaration message. All hubs store got messages for next adjusts. Every hub chooses its comparing group head concerning force of gotten signal. In the event that toward the finish of system one hub doesn't choose its bunch head, one group head is arbitrarily chosen as its bunch head. Every hub sends a participation demand message to its bunch head. In all phases of this stage, radio equipment of bunch heads should be on. Bunch head [16] gets messages of its individuals. In LEACH calculation, bunch heads work as nearby control places for coordination of information move in their group. In light of number of hubs, a bunch head plans a timetable utilizing TDMA technique and sends it to part hubs.

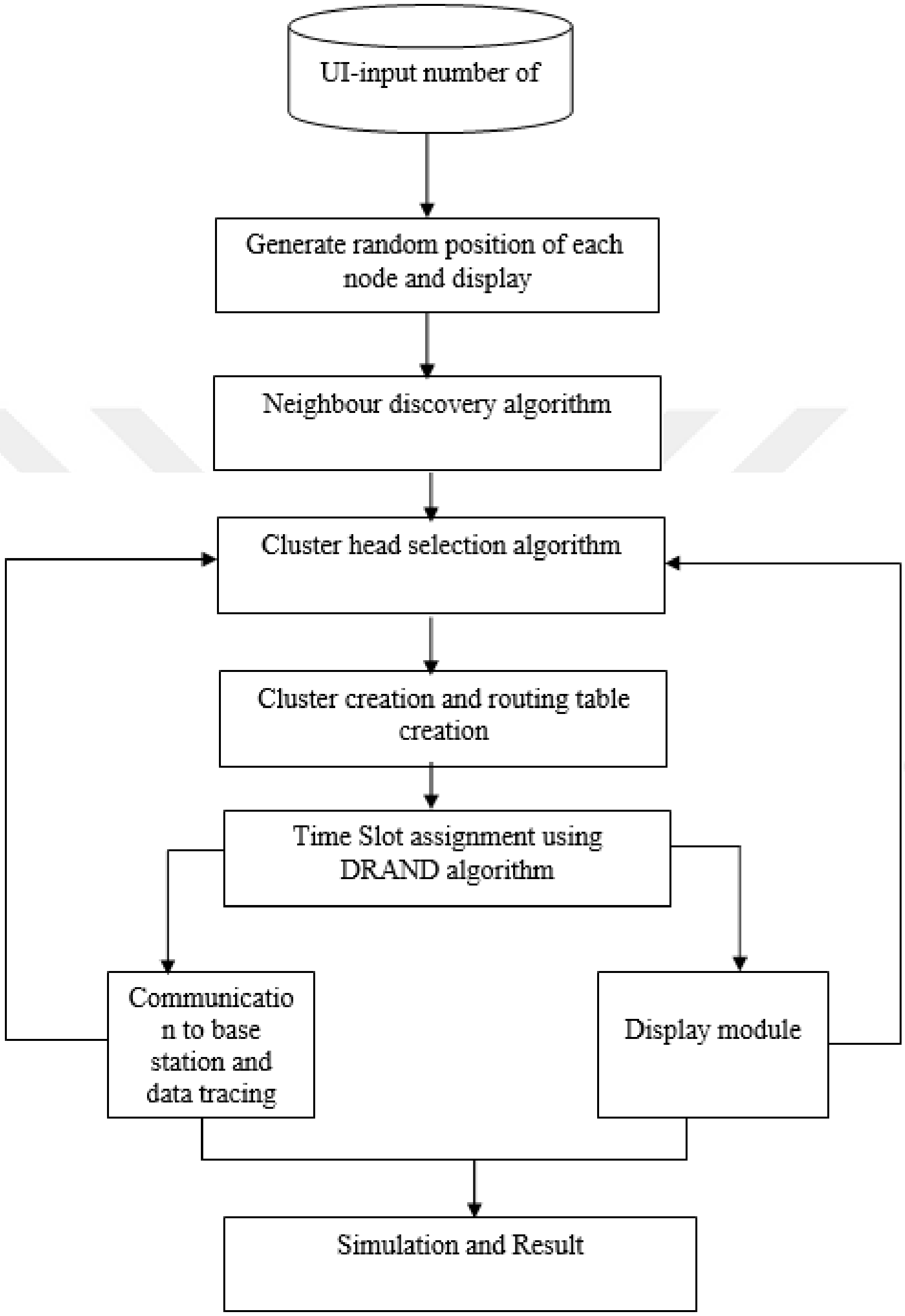

Figure 3.3: OCCN Flow chart

3.2.3 Setup Phase

From the get go, after the center point association the neighbor disclosure occurs. This ought to be conceivable using various methods like: k-of-n approach, ping, guide illuminating. When gathering begins after neighbor exposure, For the current round, each middle point chooses whether or not to change into a pack head. This system is practically identical to that utilized in LEACH. The accompanying gatherings utilize the course of action stage:

i- CH (Cluster Head) Selection [16]

ii- Cluster Formation

In LEACH, hubs take independent choices to shape bunches by utilizing a dispersed calculation with practically no incorporated control. Here no significant distance correspondence with the base station is required and disseminated bunch arrangement should be possible without knowing the specific area of any of the hubs in the organization. Moreover, no worldwide correspondence is expected to set up the bunches. The group arrangement calculation ought to be planned to such an extent that hubs are bunch heads around similar number of times, accepting every one of the hubs start with a similar measure of energy. At long last, the bunch head hubs ought to be spread all through the organization, as this will limit the distance the non-group head hubs need to send their information. A sensor hub picks an arbitrary number, r, somewhere in the range of 0 and 1.
Let a threshold value be:

$$T(n) = \frac{p}{1-P} \times \left(r\ mod\ (p-1)\right) \tag{3.3}$$

Accepting that this erratic number is under a breaking point esteem, T(n), the center turns into the gathering chief for the current round. The breaking point not entirely set in stone by the former condition, which joins the best rate to transform into a bundle head, the current round, and the plan of centers that poor person been picked as a pack head in the past (1/P) changes, where p is the pack head likelihood. It sends a business message after the centers have chosen themselves to be pack leaders (ADV). This message is a small message that contains the ID of the center as well as a header that identifies this message as a revelation message. Each non-pack head center point determines which bunch it belongs to by selecting the gathering head that requires the most correspondence energy while taking into account the received signal strength from each gathering head. After each middle point has chosen to which bundle it has a spot, it should illuminate the pack head focus that it will be an individual from the get-together. Each middle point responds with a join-demand message to the selected group head. The LEACH group leaders are most likely to go as adjoining control conditions to coordinate the information transmissions [15] in their social affair. The group head hub creates a TDMA plan and distributes it to the bunch's hubs. This ensures that no information messages collide, and it also allows the radio parts of each non-bundle head hub to be turned off consistently other than during their send time, thereby limiting the energy dispersed by the person.

3.2.4 Data Transmission Phase

Whenever the bundles are framed, the sensor centers are doled out timeslots to send the information. Tolerating centers normally have data to send and convey it during their allocated stretch of time. It utilizes a heuristic ability to pursue this choice, and the heuristic limit is given by,

$$h = K\left(\frac{Eavg}{hmin} * t\right) \tag{3.4}$$

where K is a steady, Eavg is the typical energy of the ongoing way, hmin is the most limited skip recall for the ongoing way, and t = traffic on the ongoing way. The way with the most elevated heuristic worth is picked. Tolerating that this is Emin's> limit, it is picked. In any case, the way with the most elevated heuristic worth is picked, where:

$$Emin = Eavg/Const \tag{3.5}$$

Any whole number worth, like 10, can be utilized as the consistent. Assuming that no hub in the steering table has Emin more noteworthy than the edge energy, the hub with the most elevated least energy is picked.

3.2.5 Periodic Updates

The data about the ways and steering table [20] sections at every hub becomes old after a short time. The heuristic qualities determined in light of the flat data regularly prompts wrong choices. Consequently, the hubs are to be provided with new data occasionally. This will expand the exactness and idealness of the heuristic capacity. During the activity of each round, the essential data is traded at standard spans. The time frame refreshes are picked carefully with the end goal that the hub doesn't put together its choices with respect to the old data and simultaneously, the occasional update doesn't over-burden the organization activity.

4. RESULTS AND DISCUSSION

Today, the greater part of the exploration is done to create super low fuelled WSN which is just conceivable provided that the general organization lifetime increments, energy utilization [16] diminishes and the organization run with high security and unwavering quality. To accomplish this, numerous calculations have been executed. They are called energy-productive calculations. These calculations in their fundamental structure have previously been carried out on different organization conventions including LEACH, AODV, TEEN and so on. Be that as it may, these calculations need further examination for expansion in network lifetime, energy productivity and so forth. So OCCN is one of the energy productive conventions intended to build the organization lifetime.

4.1 MATLAB ENVIRONMENT

The amusement [13] is finished, and it remembers a Custom Built Iterative Based Simulator for MATLAB 8.2.0.701 (R2017a) that re-enacts sending, getting, dropping, and information sending, in addition to other things. MATLAB is a gigantic level express enrolling language and natural climate for estimation development., information insight, information evaluation, and numeric assessment. Utilizing the MATLAB thing, specific enrolling issues can be settled quicker than with customary programming vernaculars, like C, C++, and Fortran. It is utilized for an assortment of purposes, including sign and picture managing, exchanges, control configuration, test and appraisal, monetary displaying, and assessment. Reserve of additional hardware (assortments of express clarification MATLAB limits, open unreservedly) To manage unequivocal classes of issues in these application regions, relax the MATLAB climate. MATLAB gives different elements to story work. MATLAB code can be joined with an assortment of vernaculars and applications to deliver an assortment of new calculations and applications. Its parts meet:

- i- Undeniable level language for specialized registering
- ii- Improvement climate for overseeing code, documents, and information
- iii- Intuitive apparatuses for iterative investigation, plan, and critical thinking
- iv- Numerical capacities for direct variable based math, measurements, Fourier investigation, separating, enhancement, and mathematical joining
- v- 2-D and three dimensional designs capacities for picturing information.

vi- Tools for building custom graphical user interface.

4.1.1 Implementation of OCCN Algorithm

The work, sensor nodes randomly deployed in an area of 100 meter × 100 meter as shown in Figure 4.5. This section describes the results of OCCN algorithm. To validate the algorithm, network lifetime and packets sent to BS are chosen as performance parameters. Table 4.1 illustrates the parameters settings of the OCCN algorithm whereas; Figure 4.5 shows the sensor field used for experimentation. All sensor centers are reliably dispersed in recently referenced sensor field and it is accepted that the BS is arranged inside the sensor field. The show is executed in MATLAB Software environment. The association lifetime limit is portrayed with respect to number of live and dead centers. The result of the computation is differentiated and LEACH estimation. From this table, it is construed that in LEACH computation, first center become dead following 561 seconds as the total of its energy consumed during the data combination and transmission, a major piece of sensor centers fails horrendously up to 645 seconds and following 746 seconds, no live center point is accessible in the sensor field. In OCCN estimation, first center become dead following 590 seconds as the total of its energy consumed during the data arrangement and transmission, a major piece of sensor center points kick the pail up to 690 seconds and following 785 seconds, ten center points remaining as live center point is accessible in the sensor field. Consequently, it is seen that consolidation of the OCCN calculation in Standard LEACH expands the lifetime of the organization and decreased the power utilization of hubs.

4.2 NETWORK PARAMETERS AND ASSUMPTION

Both LEACH [22] and OCCN are re-enacted utilizing MATLAB. The boundaries thought about while assessing OCCN and LEACH are as per the following.

i- Round Number vs Number of Dead Nodes (with variation of probability)

ii- Round Number vs Average Energy of Each node (with variation of probability)

iii- Round Number vs Number of Dead Nodes (with variation of number of nodes)

iv- Round Number vs Average Energy of Each node (With variation of number of nodes)

To simplify the simulation of these protocols few assumptions are made. They are as follows:

i- Initial energy of nodes is same.

ii- Nodes are static

iii- Nodes are assumed to have a limited transmission range after which another equation for energy dissipation is used

iv- Homogeneous distribution of nodes.

v- Nodes always have to send the data.

Table 4.1: Network Parameters

Parameter	Value
Simulation Area	100×100
Channel type	Wireless channel
Base station Location	(150,50)
Energy Model	Battery
Transmission amplifier E_{fs}	10*0.000000000001
Transmission amplifier E_{mp}	0.0013*0.000000000001
Data aggregation Energy	5*0.000000001
Transmission Energy E_{Tx}	50*0.000000001
Receiving Energy E_{Rx}	50*0.000000001

4.3 RESULT

4.3.1 Simulation of protocols at 0.2 probability

The under set of results address the multiplication of both LEACH and OCCN shows at 0.2 probability that is the level of hard and fast center points which can become bundle head is 2% of without a doubt the quantity of centers.

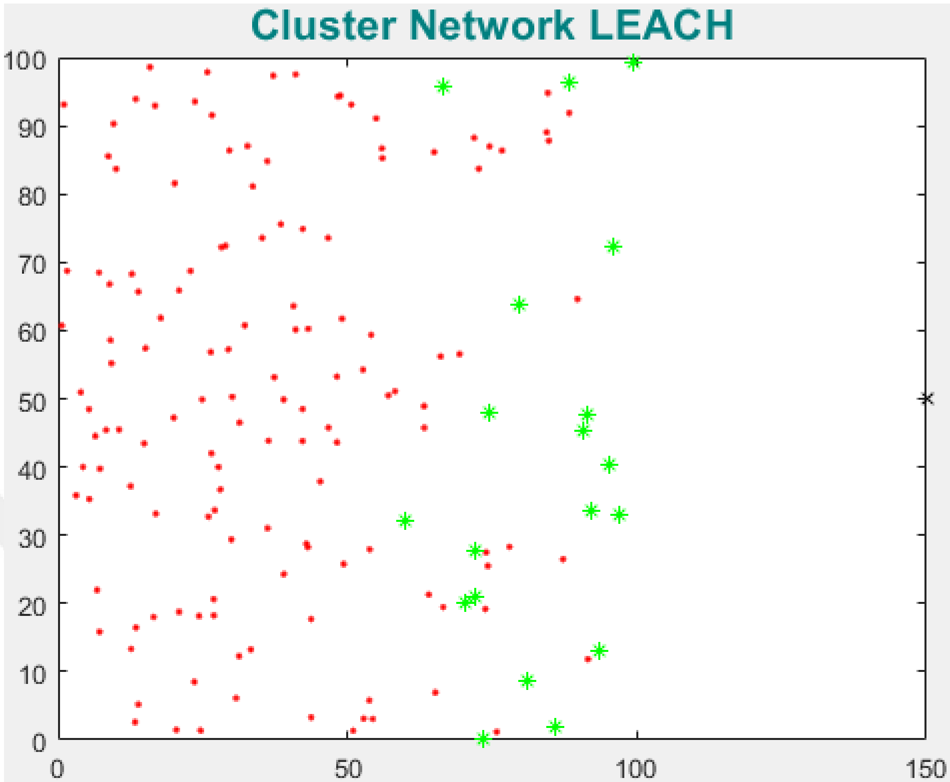

Figure 4.1: Cluster network of LEACH for 200 nodes

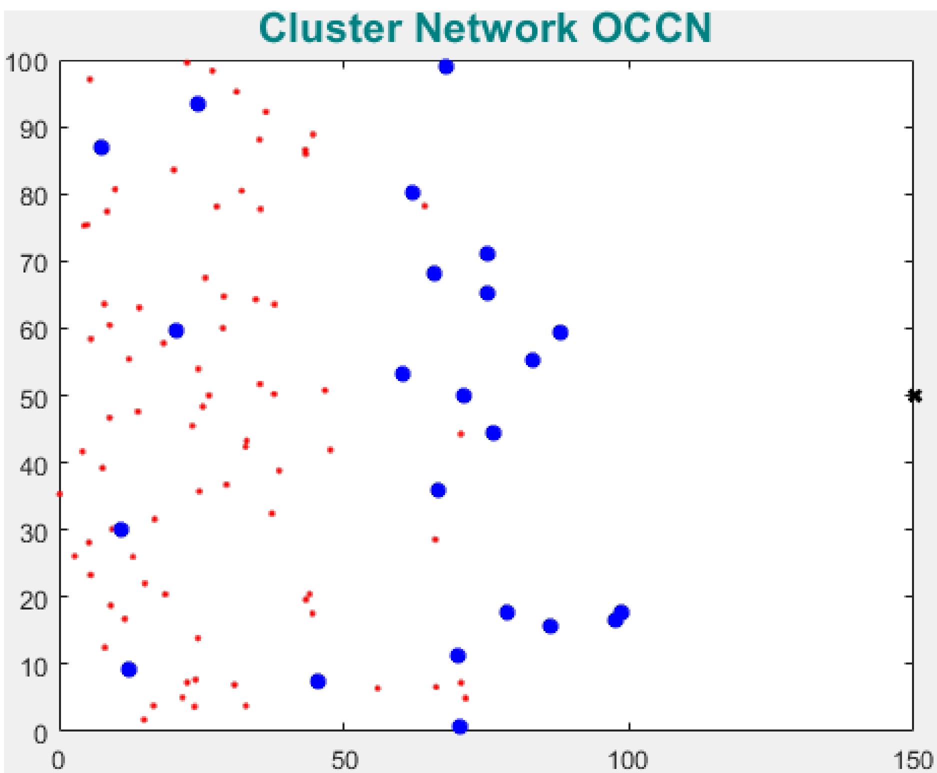

Figure 4.2: Cluster network of OCCN for 200 nodes

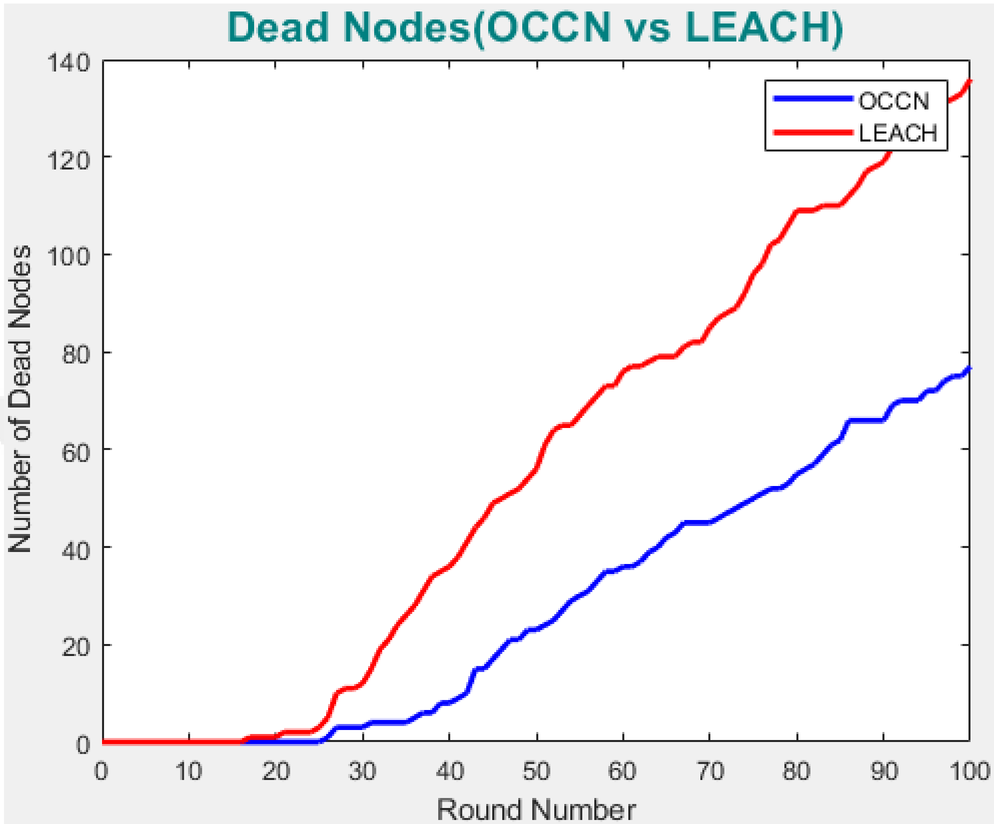

Figure 4.3: Comparison of dead nodes for 100 rounds for 200 nodes in LEACH and OCRSN

Figure 4.4 compares the number of live and dead nodes in each round of the LEACH and OOCN algorithms. It is clear from these results that there is a significant difference in the performance of the LEACH and OCCN algorithms. All nodes in the LEACH and OCCN algorithms die after 746 and 785 seconds, respectively, but there is a significant difference in the node death rate.

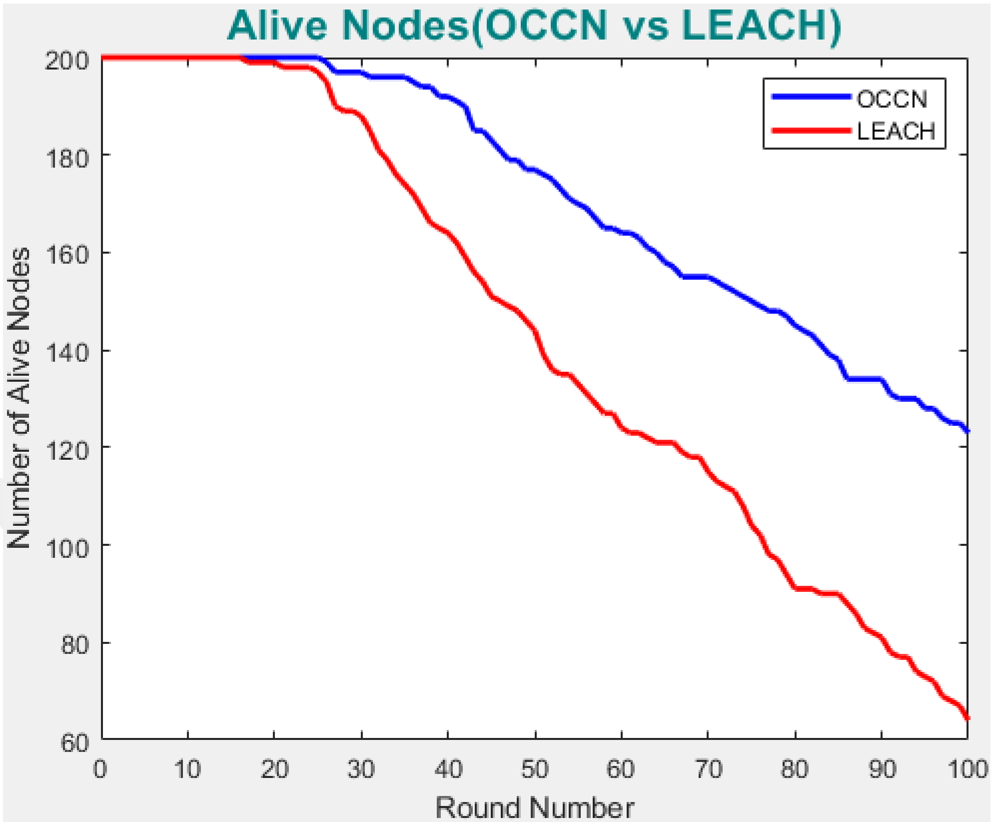

Figure 4.4: Comparison of Alive nodes for 100 rounds for 200 nodes in LEACH and OCRSN

Figure 4.5 and 4.6 shows the correlation of bundles shipped off CHs for LEACH and OOCN conventions for each round and it's demonstrate that the exhibition of the LEACH conventions is successfully moved along.

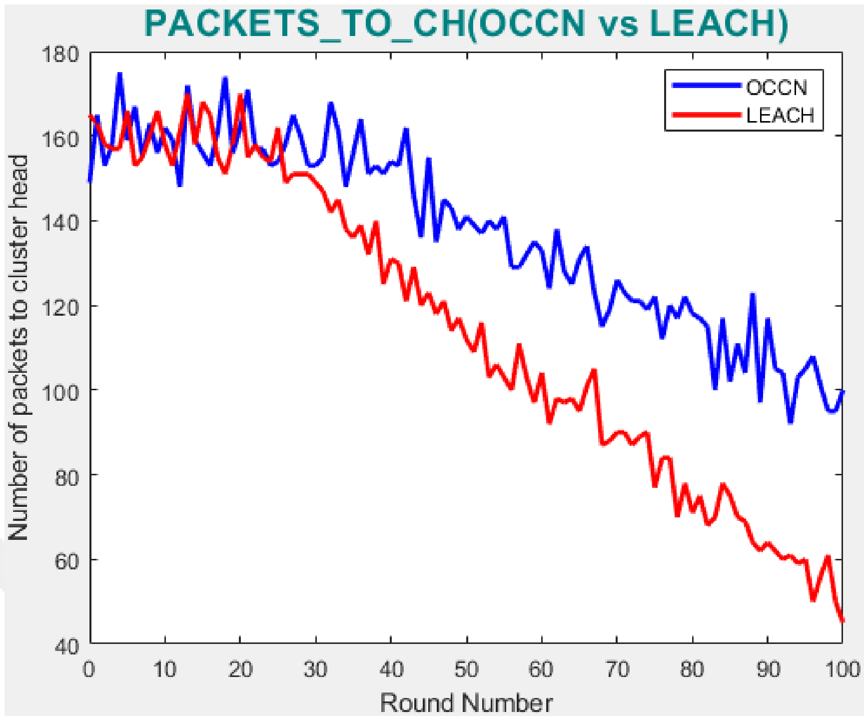

Figure 4.5: Comparison of Number of packets sent to Cluster Head for 100 rounds for 200 nodes between LEACH and OCRSN

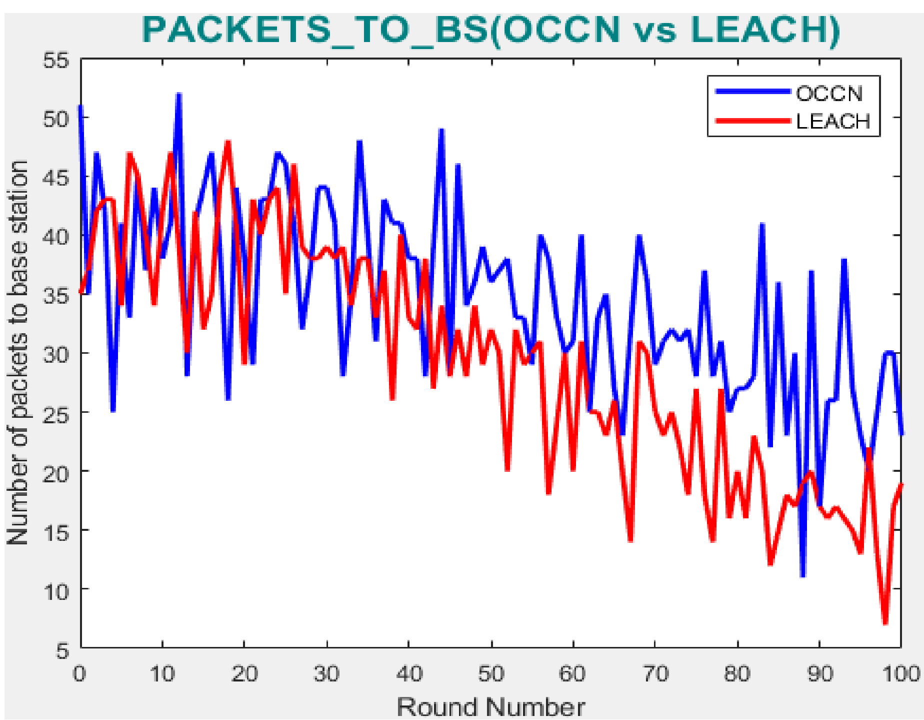

Figure 4.6: Comparison of number of packets sent to base station for 100 rounds for 200 nodes between LEACH and OCRSN

Reenactment result shows that the typical start to finish postponement of the convention without security system is a lot higher and the pattern of normal defer increments when the quantity of hub is expanded.

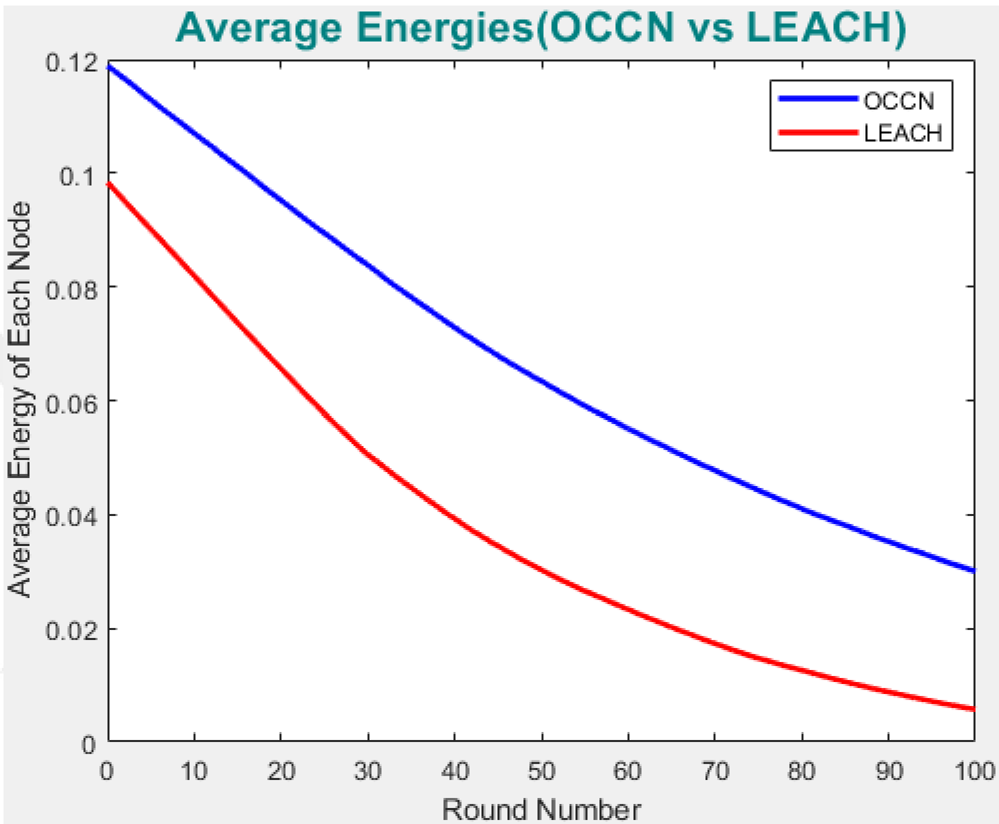

Figure 4.7: Average Energy of each node

4.3.2 Discussion

Remote Sensor Networks are typically spread over huge regions are Lately, I've been tracking down applications in a variety of fields. As a result, there is a requirement for strategies that can deal with WSNs more effectively. The limited capacity of batteries governs Remote Sensor Networks. Because of the limited amount of energy in the sensor hubs, the primary test in the Wireless Sensor Network design is energy proficiency. A definitive thought process behind any steering convention is to be as energy proficient as conceivable to keep the organization running for a more extended timeframe. In this paper we have introduced grouping as a way to conquer this trouble of energy effectiveness. Nitty gritty depiction about the working of two conventions, specifically LEACH and OCCN are introduced. We have likewise introduced the insights concerning the reproduction and its consequences. Based on the brief examinations of the re-enactment, we have concluded that LEACH can be preferred in cases of smaller organizations with fewer than fifty hubs, where it performs slightly better than OCCN, and OCCN can be preferred in larger organizations with a higher heuristic likelihood of Cluster Head selection.

Advantages:

i- It increases the network life time.

ii- It is used to outrage the battery replacement problem in nodes.

iii- Average energy of the nodes get preserved.

iv- Number of alive nodes is comparatively larger.

v- Data transmission rate is higher.

Besides these advantages LEACH suffers from many drawbacks such as:

i- Extra overhead to do dynamic clustering.

ii- Cluster head selection is randomly that doesn't take into account energy consumption

iii- LEACH is not able to cover large area.

iv- Cluster heads are not uniformly distributed

4.4 CONCLUSION

Little remote sensor hubs experience the ill effects of various limitations like little battery limit. Henceforth a multi-jump correspondence convention is proposed which benefits from ideal boundaries. Also, an appropriated reservation based pack head affirmation is proposed to diminish the energy utilization because of inestimable message passing during iterative get-together head choice. Stood out from the ongoing methodology, the proposed OCCN further fosters the association lifetime altogether. Beside network lifetime, the energy decline design is cheerful, essentially until half of the centers are alive. Moreover, OCCN faultlessly concedes the time that the central center is dead when the association is segregated into the best number of packs.

5. CONCLUSIONS AND FUTURE WORKS

5.1 CONCLUSIONS

WSNs can be utilized for an assortment of military, regular citizen and business applications. This proposal was motived by the expansion of WSNs for military applications. The current examination zeroed in on energy protection without worry for WSN security or WSN protection without worry for the restricted assets of a WSN. The exploration in the two regions neglected to address practical geographies for certifiable applications. We reviewed the current examination in both the protection and energy preservation fields to search for commitments from the two fields which could be united to foster a directing calculation that comprehensively resolves the particularly imperative issue of sink hub security/namelessness in an asset proficient way. From the energy protection point of view, we took on a bunching calculation which gives energy productive execution [3, 13, 19]. According to the protection viewpoint, we tracked down ideas on spurious traffic age and strategies to characterize and assess the obscurity [5, 9, 10]. We set off to execute the calculation, run recreations and determine results with the goal that the calculation could be assessed for security heartiness and energy conservation. Our model and directing calculation were carried out and recreated in MATLAB. From our re-enactments we had the option to gather huge outcomes. The obscurity factor is free of traffic volume for the steering calculation. We observed that the secrecy factor fluctuated from one geography to another and across the different mimicked traffic volumes yet that the outcomes were eventually autonomous of the traffic volume. The normal number of hubs that were communicated to by the transmission CHs went from 21 on the low finish to 32 on the very good quality and was reliably from 25 to 30. The normal secrecy across the four geographies was 0.036566. To make sense of this in easier terms, an enemy leading traffic investigation of the sent WSN has an under 4% possibility tracking down the sink hub on his/her first think about while truly looking for the sensor. This is fundamentally better compared to the protection plans talked about in Chapter III where all of the traffic meets on the sink hub.

5.2 FUTURE WORKS

Because some round sensor nodes are dead, designing an efficient energy routing protocol is a fundamental requirement for WSNs. The number of rounds is determined by the power of each individual sensor, which is measured in joules per node. So we can change the rounds by varying the transmission energy of the nodes. As a result, we now need to develop an energy-efficient routing protocol that will allow us to keep sensors alive for extended periods of time or for long rounds. In this project we have studied various energy efficient routing protocols and we can compare the efficiency of OCRSN with other protocols like SEP and HEED

REFERENCES

[1] Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. Future generation computer systems, 29(7), 1645-1660.

[2] Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of things: A survey on enabling technologies, protocols, and applications. IEEE communications surveys & tutorials, 17(4), 2347-2376.

[3] Silva, B. N., Khan, M., & Han, K. (2018). Internet of things: A comprehensive review of enabling technologies, architecture, and challenges. IETE Technical review, 35(2), 205-220.

[4] Ray, P. P. (2018). A survey on Internet of Things architectures. Journal of King Saud University-Computer and Information Sciences, 30(3), 291-319.

[5] Tahir, Y., Yang, S. and McCann, J. (2018), 'Brpl: Backpressure rpl for high-throughput and mobile iots', IEEE Transactions on Mobile Computing 17(1), 29–43.

[6] Khan, R., Khan, S. U., Zaheer, R., & Khan, S. (2012, December). Future internet: the internet of things architecture, possible applications and key challenges. In 2012 10th international conference on frontiers of information technology (pp. 257-260). IEEE.

[7] Karagiannis, V., Chatzimisios, P., Vazquez-Gallego, F., & Alonso-Zarate, J. (2015). A survey on application layer protocols for the internet of things. Transaction on IoT and Cloud computing, 3(1), 11-17.

[8] Lin, J., Yu, W., Zhang, N., Yang, X., Zhang, H., & Zhao, W. (2017). A survey on internet of things: Architecture, enabling technologies, security and privacy, and applications. IEEE internet of things journal, 4(5), 1125-1142.

[9] Poluru, R. K., & Naseera, S. (2017). A Literature Review on Routing Strategy in the Internet of Things. Journal of Engineering Science & Technology Review, 10(5).

[10] Alvi, S. A., ul Hassan, F., & Mian, A. N. (2017, June). On the energy efficiency and stability of RPL routing protocol. In 2017 13th International Wireless Communications and Mobile Computing Conference (IWCMC) (pp. 1927-1932). IEEE.

[11] Izquierdo, S., & Izquierdo, L. R. (2017). Mamdani fuzzy systems for modelling and simulation: A critical assessment. Available at SSRN 2900827.

[12] Qasem, M., Al-Dubai, A., Romdhani, I., Ghaleb, B., & Gharibi, W. (2016, October). A new efficient objective function for routing in Internet of Things paradigm. In 2016 IEEE conference on standards for communications and networking (CSCN) (pp. 1-6). IEEE.

[13] Sanmartin, P., Rojas, A., Fernandez, L., Avila, K., Jabba, D., & Valle, S. (2018). Sigma routing metric for RPL protocol. Sensors, 18(4), 1277.

[14] Ghaleb, B., Al-Dubai, A. Y., Ekonomou, E., Romdhani, I., Nasser, Y., & Boukerche, A. (2018). A novel adaptive and efficient routing update scheme for low-power lossy networks in IoT. IEEE Internet of Things Journal, 5(6), 5177-5189.

[15] Davoli, L., Antonini, M., & Ferrari, G. (2018). DIRPL: A RPL-based resource and service discovery algorithm for 6LoWPANS. Applied Sciences, 9(1), 33.

[16] Dong, Q., & Dargie, W. (2012). A survey on mobility and mobility-aware MAC protocols in wireless sensor networks. IEEE communications surveys & tutorials, 15(1), 88-100.

[17] Migabo, M. E., Djouani, K., Kurien, A. M., & Olwal, T. O. (2015). Gradient-based routing for energy consumption balance in multiple sinks-based Wireless Sensor Networks. Procedia Computer Science, 63, 488-493.

[18] Mazinani, S. M., & Safari, M. (2015). Secure localization approach in wireless sensor network. International Journal of Machine Learning and Computing, 5(6), 458.

[19] Migabo, M. E., Djouani, K., Kurien, A. M., & Olwal, T. O. (2015). Gradient-based routing for energy consumption balance in multiple sinks-based Wireless Sensor Networks. Procedia Computer Science, 63, 488-493.

[20] Yadav, L., & Sunitha, C. (2014). Low energy adaptive clustering hierarchy in wireless sensor network (LEACH). International journal of computer science and information technologies, 5(3), 4661-4664.

[21] Zhong, C., Eliasson, J., Mäkitaavola, H., & Zhang, F. (2010, September). A cluster-based localization method using RSSI for heterogeneous wireless sensor networks. In 2010 6th International conference on wireless communications networking and mobile computing (WiCOM) (pp. 1-6). IEEE.

[22] Sadananda, P., Trojet, W., & Mouzna, J. (2013). Multicast authentication framework for hierarchical networks using Chinese remainder theorem. International Journal of Computer Applications, 82(11).

[23] Arce, P., Guerri, J. C., Pajares, A., & Lázaro, O. (2008). Performance evaluation of video streaming over ad hoc networks using flat and hierarchical routing protocols. Mobile Networks and Applications, 13(3), 324-336.

[24] Abdelzaher, T., Blum, B., Cao, Q., Chen, Y., Evans, D., George, J., ... & Wood, A. (2004, March). Envirotrack: Towards an environmental computing paradigm for distributed sensor networks. In 24th International Conference on Distributed Computing Systems, 2004. Proceedings. (pp. 582-589). IEEE.

[25] Adnan, M. A., Razzaque, M. A., Ahmed, I., & Isnin, I. F. (2013). Bio-mimic optimization strategies in wireless sensor networks: A survey. Sensors, 14(1), 299-345.

[26] Salayma, M., Al-Dubai, A., Romdhani, I., & Nasser, Y. (2017). Wireless body area network (WBAN) a survey on reliability, fault tolerance, and technologies coexistence. ACM Computing Surveys (CSUR), 50(1), 1-38.

[27] Lee, J. S., & Cheng, W. L. (2012). Fuzzy-logic-based clustering approach for wireless sensor networks using energy predication. IEEE Sensors Journal, 12(9), 2891-2897.

[28] Zhang, Y., Chen, W., Liang, J., Zheng, B., & Jiang, S. (2015). A network topology control and identity authentication protocol with support for movable sensor nodes. Sensors, 15(12), 29958-29969.

[29] Wang, F., Wu, S., Wang, K., & Hu, X. (2016). Energy-efficient clustering using correlation and random update based on data change rate for wireless sensor networks. IEEE Sensors Journal, 16(13), 5471-5480.

[30] Thakkar, A., & Kotecha, K. (2014). Cluster head election for energy and delay constraint applications of wireless sensor network. IEEE sensors Journal, 14(8), 2658-2664.

[31] Sohn, I., Lee, J. H., & Lee, S. H. (2016). Low-energy adaptive clustering hierarchy using affinity propagation for wireless sensor networks. IEEE Communications Letters, 20(3), 558-561.

[32] Taheri, H., Neamatollahi, P., Younis, O. M., Naghibzadeh, S., & Yaghmaee, M. H. (2012). An energy-aware distributed clustering protocol in wireless sensor networks using fuzzy logic. Ad Hoc Networks, 10(7), 1469-1481.

[33] Nayak, P., & Vathasavai, B. (2017). Energy efficient clustering algorithm for multi-hop wireless sensor network using type-2 fuzzy logic. IEEE Sensors Journal, 17(14), 4492-4499.

[34] Nayak, P., & Devulapalli, A. (2015). A fuzzy logic-based clustering algorithm for WSN to extend the network lifetime. IEEE sensors journal, 16(1), 137-144.

[35] Kurmi, A., Lal, J. D., Charhate, S. V., & Ganvir, S. (2015). A Review: Cluster Head Selection using Fuzzy logic in Wireless Sensor Networks. International Journal of Innovations in Engineering and Technology, 5(1), 283-290.

[36] Ghate, V. V., & Vijayakumar, V. (2018). Machine learning for data aggregation in WSN: A survey. International Journal of Pure and Applied Mathematics, 118(24), 1-12.

[37] Pourahmad, S., Taghi Ayatollahi, S. M., & Taheri, S. M. (2011). Fuzzy logistic regression: a new possibilistic model and its application in clinical vague status. Iranian Journal of Fuzzy Systems, 8(1), 1-17.

[38] Alsheikh, M. A., Lin, S., Niyato, D., & Tan, H. P. (2014). Machine learning in wireless sensor networks: Algorithms, strategies, and applications. IEEE Communications Surveys & Tutorials, 16(4), 1996-2018.

[39] Ahlawat, M. (2013). Wireless sensor network-a theoretical review. International Journal of Wired and Wireless Communications, 1(2), 1-19.

[40] Singh, V. K., Kumar, M., & Verma, S. (2017). Accurate detection of important events in WSNs. IEEE Systems Journal, 13(1), 248-257.

[41] Song, Y., Zhang, C., & Fang, Y. (2010). Minimum energy scheduling in multi-hop wireless networks with retransmissions. IEEE transactions on wireless communications, 9(1), 348-355.

[42] Fateh, B., & Govindarasu, M. (2013). Joint scheduling of tasks and messages for energy minimization in interference-aware real-time sensor networks. IEEE transactions on mobile computing, 14(1), 86-98.

[43] Guo, P., Jiang, T., Zhang, Q., & Zhang, K. (2011). Sleep scheduling for critical event monitoring in wireless sensor networks. IEEE Transactions on Parallel and Distributed Systems, 23(2), 345-352.

[44] Radhika, S., & Rangarajan, P. (2021). Fuzzy based sleep scheduling algorithm with machine learning techniques to enhance energy efficiency in wireless sensor networks. Wireless Personal Communications, 118(4), 3025-3044.

[45] Gupta, S. K., Kumar, S., Tyagi, S., & Tanwar, S. (2020). Energy efficient routing protocols for wireless sensor network. In Handbook of Wireless Sensor Networks: Issues and Challenges in Current Scenario's (pp. 275-298). Springer, Cham.

[46] Akhil, K. M., & Sinha, S. (2020, February). Self-localization in large scale wireless sensor network using machine learning. In 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE) (pp. 1-5). IEEE.

[47] Akyildiz, I. F., Su, W., Sankarasubramaniam, Y., & Cayirci, E. (2002). Wireless sensor networks: a survey. Computer networks, 38(4), 393-422.

[48] Arampatzis, T., Lygeros, J., & Manesis, S. (2005, June). A survey of applications of wireless sensors and wireless sensor networks. In Proceedings of the 2005 IEEE International Symposium on, Mediterrean Conference on Control and Automation Intelligent Control, 2005. (pp. 719-724). IEEE.

[49] Majhi, S., & Kumar Soni, H. (2014). 3D Localization in wireless sensor networks. International Journal of Advanced Research in Computer Science, 5(6).

[50] Serra, A. P. (2013). World â€ TM s largest Science, Technology & Medicine Open Access book publisher. Biomass Now-Sustain. growth use.

[51] Arghavani, M., Esmaeili, M., Esmaeili, M., Mohseni, F., & Arghavani, A. (2017). Optimal energy aware clustering in circular wireless sensor networks. Ad Hoc Networks, 65, 91-98.

[52] Uma, J. S. S., & Sugua, J. (2015). Human interaction pattern mining using enhanced artificial bee colony algorithm. International Journal of Innovative Research in Computer and Communication Engineering, 3(9), 2320-9798.

[53] Kohanbash, D., Valada, A., & Kantor, G. (2012, July). Base station design and architecture for wireless sensor networks. In Proc. Intl. Conf. Agr. Eng., Valencia, Spain (Vol. 8, p. 12)."

[54] Giacomin, J. C., Correia, L. H., Heimfarth, T., Pereira, G. M., Silva, V. F., & De Santana, J. L. (2010). Radio channel model of wireless sensor networks operating in 2.4 ghz ism band. INFOCOMP Journal of Computer Science, 9(1), 98-106.

[55] Wang, X. (2004). Wide-band TD-CDMA MAC with minimum-power allocation and rate- and BER-scheduling for wireless multimedia networks. IEEE/ACM transactions on networking, 12(1), 103-116.

[56] Anasane, A. A., & Satao, R. A. (2016). A survey on various multipath routing protocols in wireless sensor networks. Procedia Computer Science, 79, 610-615.

[57] Wang, J., Li, B., Xia, F., Kim, C. S., & Kim, J. U. (2014). An energy efficient distance-aware routing algorithm with multiple mobile sinks for wireless sensor networks. Sensors, 14(8), 15163-15181.

[58] Arjun, R. V., & Naveen, H. M. (2013). Data-centric routing in a wireless sensor network. IJETTCS.

[59] Kumar, V., Dhok, S. B., Tripathi, R., & Tiwari, S. (2014). A review study of hierarchical clustering algorithms for wireless sensor networks. International Journal of Computer Science Issues (IJCSI), 11(3), 92.

[60] Kumar, V., Dhok, S. B., Tripathi, R., & Tiwari, S. (2014). A review study of hierarchical clustering algorithms for wireless sensor networks. International Journal of Computer Science Issues (IJCSI), 11(3), 92.

[61] Tandel, R. I. (2016). Leach protocol in wireless sensor network: a survey. International Journal of Computer Science and Information Technologies, 7(4), 1894-1896.

[62] Chen, Z., Xiao, Y., Li, X., & Li, R. (2013). A clustering protocol for wireless sensor networks based on energy potential field. The Scientific World Journal, 2013..

[63] Al-Karaki, J. N., Ul-Mustafa, R., & Kamal, A. E. (2004, April). Data aggregation in wireless sensor networks-exact and approximate algorithms. In 2004 Workshop on High Performance Switching and Routing, 2004. HPSR. (pp. 241-245). IEEE.

[64] Liu, X. (2012). A survey on clustering routing protocols in wireless sensor networks. sensors, 12(8), 11113-11153.

[65] Mhatre, V., & Rosenberg, C. (2004, June). Homogeneous vs heterogeneous clustered sensor networks: a comparative study. In 2004 IEEE international conference on communications (IEEE Cat. No. 04CH37577) (Vol. 6, pp. 3646-3651). IEEE.

[66] Geetha, V. A., Kallapur, P. V., & Tellajeera, S. (2012). Clustering in wireless sensor networks: Performance comparison of leach & leach-c protocols using ns2. Procedia Technology, 4, 163-170.

[67] Ramesh, K., & Somasundaram, D. K. (2012). A comparative study of clusterhead selection algorithms in wireless sensor networks. arXiv preprint arXiv:1205.1673.