# Proximity Based Low-Energy Adaptive Clustering Hierarchy Protocol for WSN

## A DISSERTATION

Submitted in Partial fulfilment of the Requirement for the Degree of

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Submitted By

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# CERTIFICATE

This is to certify that Project Report entitled "**Proximity Based Low-Energy Adaptive Clustering Hierarchy Protocol for WSN"** submitted by **Abbas Khaliq** (2K17/CSE/01) in partial fulfilment of the requirement for the award of degree Master of Technology (Computer Science and Engineering) is a record of the original work carried out by him under my supervision.

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# DECLARATION

I hereby declare that the Major Project-II work entitled **"Proximity Based Low-Energy Adaptive Clustering Hierarchy Protocol for WSN"** which is being submitted to Delhi Technological University, in partial fulfilment of requirements for the award of the degree of Master of Technology (Computer Science and Engineering) is a bona fide report of Major Project-II carried out by me. I have not submitted the matter embodied in this dissertation for the award of any other degree or diploma.

**ABBAS KHALIQ**
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# ABSTRACT

Wireless sensor networks (WSN) are utilized for measuring various parameters such as pressure, temperature or humidity monitoring, in buildings to monitor smoke and fire, surveillance monitoring and also for environmental monitoring etc. These sensors are comprised of numerous small electronic devices known as sensors, which are operated on battery. The wireless sensors are deployed in the chosen region according to the area of interest so that it can continue sensing for a long duration. But to keep these sensors active for a desired duration, the network's lifetime should be necessarily prolonged with less power consumption because unbalanced battery usage becomes a major challenge in WSNs. LEACH, focus on prolonging the stable region - the period before the death of the first node. During the lifetime of the network, nodes which are far from sink, start dying first. Somehow we delay there death, network lifespan and stability will increase. In our work, we come up with three solutions, first we create a circular boundary that fits within the sensor field and node outside the circular boundary cannot be a CH in their entire life, secondly we create a circle within the network. All the nodes are eligible to be a cluster head but there is a little difference in the working of cluster head which are outside the circle than those inside the circle and in third solution we are merging first and second solution and then comparing them with LEACH protocol. We found that our approach improves on LEACH by prolonging the stable region of the network.

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| 2. | CH: | Cluster Head |
| 3. | LEACH: | Low-Energy Adaptive Clustering Hierarchy |
| 4. | PEGASIS: | Power-Efficient Gathering in Sensor Information Systems |
| 5. | SEP: | Stable Election Protocol |
| 6. | GAEEP: | Genetic Algorithm-based Energy-Efficient Protocol |
| 7. | C-LEACH: | Centralised LEACH |
| 8. | F-LEACH: | Frequency based LEACH |
| 9. | EAMMH: | Energy Aware Multi-Hop Multi-Path Hierarchy |
| 10. | TL-LEACH: | Two Level LEACH |
| 11. | TEEN: | Threshold sensitive Energy Efficient sensor Network |
| 12. | K-LEACH: | K-medoids based LEACH |
| 13. | I-LEACH: | Improved LEACH |
| 14. | V-LEACH: | Vice-CH LEACH |
| 15. | TDMA: | Time Division Multiple Access |
| 16. | DD: | Direct Diffusion |

# CHAPTER 1: INTRODUCTION

## 1.1 WIRELESS SENSOR NETWORK

Wireless sensor network is a networkment of little battery powered sensors positioned to watch natural or physical conditions or different parameters. A traditional sensors network involves an expansive number of sensor gadgets which are connected to each other wirelessly. The sensors can communicate among themselves through radio transceivers. The sensor gadget is equipped with radio transmitters, computing and sensing extras and power source. The resources in a solitary WSN node are few and limited: they have controlled power supply, constrained radio capacities and restricted onboard computational power. Thus, a WSN framework comprises of an interface that joins wireless network back to the wired system. This gateway is called a base station or sink node that additionally performs a large portion of the computational tasks in the system. The base station is expected to have a limitless power supply. The sensor nodes need to exchange their detected information to the sink. They can trade data with the base station directly or through some intermediate sensors.

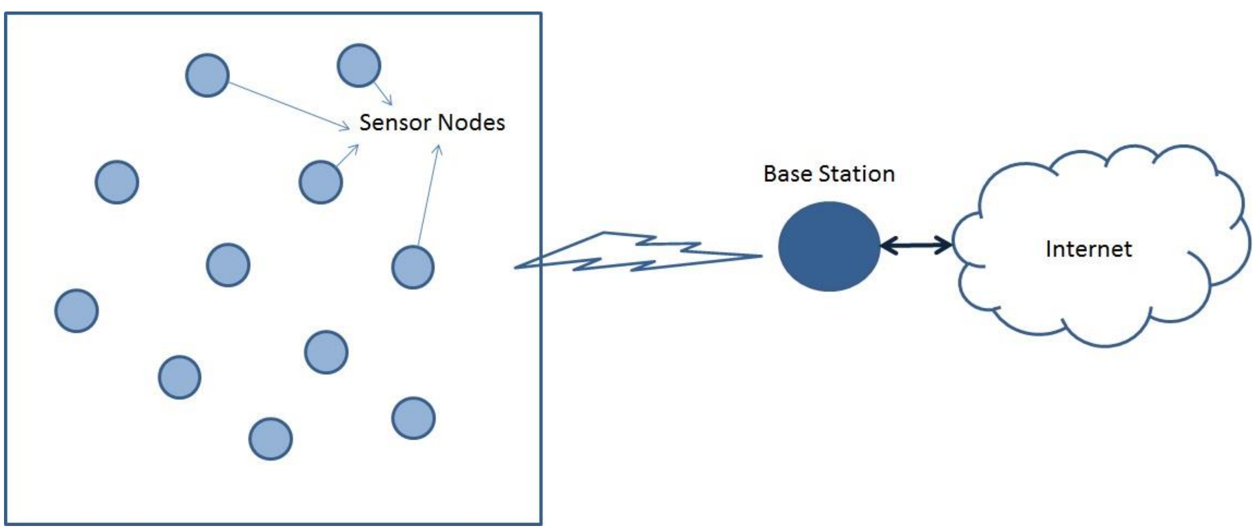


**Fig. 1.1: Wireless Sensor Network**

The most of the energy of the SNs is spent in communicating with other nodes or with the sink. Thus, the protocols designed for WSNs for communication has to be energy aware so as to increase the network lifetime of the system. Different techniques are now available for different applications and implementations of the WSNs. Needless to say, WSNs have a long list of applications now a days as everything eventually is becoming a part of IoT. Most of the time the application of WSN dictates the selection of the wireless model used. Some of the important applications of WSNs are mentioned below.

## 1.2 ARCHITECTURE OF WSN

The most well-known WSN architecture takes after the OSI engineering Model. It incorporates five layers and three cross layers. For the most part in sensor n/w we require five layers, to be specific application, transport, n/w, data link and physical layer. These layers of the WSN are utilized to achieve the n/w and influence the sensors to cooperate so as to raise the total effectiveness of the system.

The sensor nodes are commonly dispersed in the field as appeared in the Figure 1. Every one of these nodes dispersed in the sensor field have the abilities to aggregatel information and course this information to the sink.The traditional stack used by the WSN nodes and the base stations . This tradition stack joins steering and power care, consolidates data with frameworks organization traditions, passes on control adequately through the remote medium and advances supportive undertakings of the sensor nodes. The tradition stack includes physical layer, data link layer, network layer, transport layer, application layer and three administration planes in particular power management, mobility management and task management.

**Application layer**

The application layer is responsible for traffic management and offers software for various applications that change over the information in an unmistakable frame to discover positive data. Sensor systems orchestrated in various applications in various fields, for example, agrarian, military, condition, medicinal, and so on.

**Transport layer**

The role of the transport layer is to provide congestion shirking and unwavering quality where a great deal of conventions proposed to offer this capacity are either pragmatic on the upstream. These conventions utilize divergent instruments for misfortune acknowledgment and misfortune recuperation. The vehicle layer is precisely required when a framework is wanted to contact different systems.

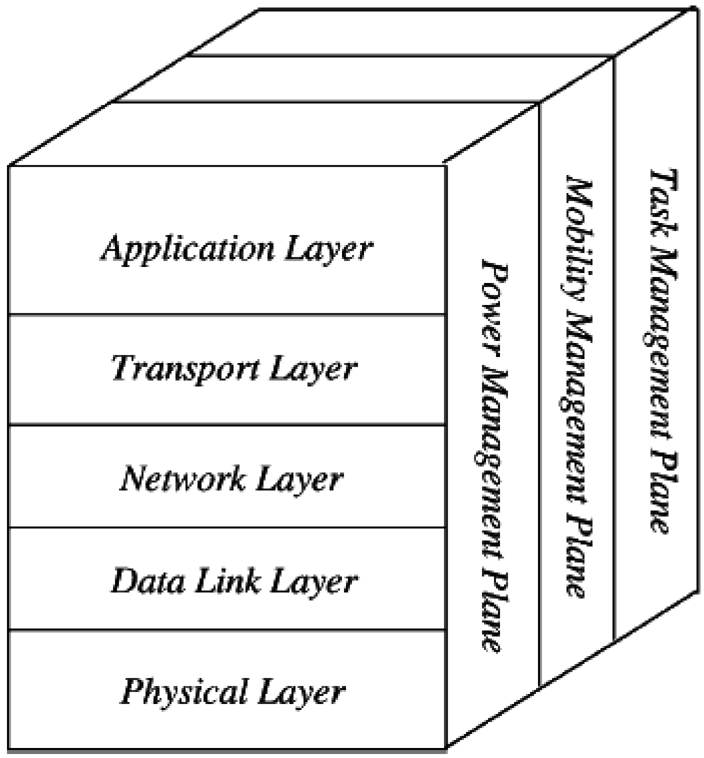


**Fig.1.2: Architecture of WSN**

Giving a solid loss recovery is more energy aware and that is one of the fundamental reasons why TCP isn't fit for WSN. All in all, Transport layers can be isolated into Packet driven and Event driven. There are some prominent conventions in the vehicle layer specifically STCP (Sensor Transmission Control Protocol), PORT (Price-Oriented Reliable Transport Protocol) and PSFQ (pump slow fetch quick).

**Network layer**

Routing is fundamental role of the network layer and it has considerable measure of errands in light of the application, in any case, the principle undertakings are in the power rationing, partial memory, buffering, and sensor don't have an all inclusive ID and must act self composed.

The basic thought of the routing protocol is to clarify which is a dependable path and redundant paths, as per a persuaded scale called metric, which fluctuates from protocol to protocol. There are a great deal of protocols that already exist for this layer, they are generally separated into; flat routing protocols and hierarchal routing or can be isolated into time driven, inquiry driven and event driven.

**Data link layer**

The data link layer is obligated for multiplexing information, frame detection, information streams, MAC and error control, affirm the unwavering quality of point– point (or) point– multipoint.

**Physical layer**

The physical layer gives an edge to exchanging a current of bits over physical channel. This layer is in charge of the choice of frequency, bearer frequency, signal recognition, modulation and encryption. IEEE 802.15.4 is proposed as common for low rate specific zones and Wireless sensors connect easily, control utilization, density, the scope of communication to increase life of the battery. CSMA/CA is used to help star and shared topology. There are a few adaptations of IEEE 802.15.4.V.

Generally, the wireless subsystem needs to work in measuring the energy. Along these lines, information is conveyed via the radio system whenever required. A calculation has to be piled in the node so as to decide when information has to be send in view of the detected occasion. Besides, it is essential to limit the power consumed by the sensor. Consequently, the equipment need to be predetermined to enable the microchip to carefully control energy to the radio, sensor, and sensor flag conditioner.

## 1.3 CHARACTERISTICS AND ADVANTAGES OF A WSN

The major characteristics of WSNs incorporate the accompanying,

- The utilization of Power limits for nodes with batteries.
- Ability of dealing with node disappointments.
- Some portability and heterogeneity of nodes.
- Adaptability to substantial size of dispersion (scalability).
- Ability to guarantee strict ecological conditions.
- Ease of use.
- Cross-layer model.

Implementation of WSN comes with a great deal of advantages to the user. Some of the advantages of WSNs are,

- System courses of action can be carried out without immobile infrastructure.
- Suitable for remote places like mountains, oceans, dense forests and remote areas.
- Adaptable if there is a circumstance when an extra workstation is required.
- Execution costs are reasonable and flexible.
- It makes do without the use of a lot of wiring.
- Can provide housing for new devices whenever required.
- Can be accessed using a centralized interface.

## 1.4 APPLICATIONS OF WSN

Sensor systems have gathered wide recognition due to their flexibility in the handling of concerns in different fields and can improve our livelihood in a number of ways. WSNs have historically been successfully associated with diverse application domains, for example:

- Area Monitoring: For examining an area, the nodes are distributed over a field where some phenomenon is to be observed. The moment of time when the sensors recognise some activity (thermal, environmental, chemical, etc.), it is communicated to the base stations, which then undertakes appropriate action.

- Healthcare/Medical applications: Some of the usages for health monitoring using sensors networks incorporate graphic interfaces for the coordinated patient examining, analysis, and managing medication in medical institutions, assessment of an individual's physiological report and inquiring about physicians or patients within a healthcare facility.
- Military usage: WSNs have a wide range of military applications like war zone tracking, force protection, navigation, communications, figuring insight, war-time reconnaissance and surveillance of the hot zones..
- Nature and natural phenomenon sensing:
    - Observing air contamination
    - Wildfire instrumentation and identification
    - Habitat monitoring
    - Observation of greenhouse effect
    - identification of landslide prone zones
- Architectural Monitoring: WSNs are now also employed to monitor the activities inside structures and foundations, which empowers engineering systems and tools to control and manage resources from a remote base; without physically being present at the site.
- Industrial checking:  WS networks provide notable cost saving services for machine control remotely, and there is no need for wired connections during installation of sensor and hence saving the wiring expenditure.
- Highway/Traffic observation: Real-time activity data is assembled by WSNs and then encourage transportation models and prepare drivers of clog and traffic issues. The sensors collect traffic flow statistics, like the volume of traffic, highway densities, vehicle speeds, and then send this information through a wireless network to the base station for advance processing.

## 1.5 CHALLENGES OF WIRELESS SENSOR NETWORKS

The WSNs face a considerable number of difficulties owing to the sensor nodes and the wireless setting. There are no reliable lines or foundation for communicating. Sensor node application may suffer from the model used. Sensor nodes convey over remote, unreliable lines with no foundation. With the end goal to prolong the lifespan of the WSN, the conventions must accordingly be planned with the goal of proficient administration of the vital resources.

The challenges faced by a WSN are primarily of two types: *challenges due to design and topology* and *challenges in real time like power management, node management, etc.* Below we describe some of these challenges.

***Adaptation to internal failure:*** Sensor nodes are vulnerable to physical damage as a significant part of the time is passed on in dangerous conditions. Sensors can fall as a result of hardware issues or natural causes or by draining their battery capacity. It is foreseen that the node accidents will be impressively more prominent than what is routinely seen in customary remote frameworks or the wired systems as the sensors are deployed in an uncontrolled environment.

***Versatility:*** Sensor systems may change in scale from a few nodes to conceivably a few hundred thousand. What's more, the sending thickness is likewise a factor. For gathering high determination information, the density of nodes may increase up to a certain height when there are many nodes close to each other in the communication zone. Conventions that are being used in the sensor systems must be adaptable to certain standards and have the capacity for keeping up satisfactory execution.

***Production Costs:*** Because numerous networkment models view the sensor nodes as dispensable gadgets, sensor systems can rival with conventional data collection procedures and hence the nodes could be manufactured efficiently.

***Equipment Limitations:*** At the very least, every WSN node needs a transmission, processing and sensing system, and an energy source. Alternatively, the nodes can have implicit sensing equipment or smart gadgets. Notwithstanding, every extra usefulness accompanies extra cost also, builds the power utilisation and physical size of the node. There should be a proper adjustment between the expense and low-energy specifications as per the changing functionalities.

***Communication Medium:*** The correspondence among the sensors is ordinarily actualized utilising wireless medium in the famous industrial, scientific band. Be that as it may, some sensor systems utilise infrared or optical correspondence and former providing the obstruction free robust path.

***WSN Topology:*** Even though WSN have developed in numerous viewpoints, these systems keep on being with restrained assets as far as energy, processing force, memory, and interchanges capacities are concerned Problems like routing holes, an area where there are no nodes or the nodes can't participate in routing, are caused due to the topology of the network. Topology Route control is a standout amongst various critical concerns investigated for diminishing power utilisation of WSN systems.

***Energy Dissipation:*** As we have observed, large portions of the challenges of WSN systems or sensor nodes revolve around the low power resources as nodes are battery enabled. The product and equipment configuration requires the consideration of the concerns of effective power utilisation. Just as an example, information pressure may diminish the measure of energy utilised for radio transmission, however, utilises the extra energy for evaluation as well as separate. The energy network ment likewise relies on upon the application. Sometimes, it is desired to power off a few nodes with a specific end goal to ration energy while different applications require all nodes working at the same time. Most of the research in this field revolves around minimizing the power expend of the senor networks.

## 1.6 ENERGY DISSIPATION PROBLEMS IN A NODE

Power dissipation is visibly the essential part to decide or increase the lifespan of a sensors organize since sensor nodes are run by the battery. A portion of the time control streamlining is more convoluted in sensor frameworks since it included not simply diminishing of intensity dispersal moreover drawing out the life of the framework much as could be normal. The network consists of multiple small, battery powered, mobile/static, sensor nodes having limited onboard computing and storage. This restricts the performance of a network as network can only work until the batteries of the sensor node die out. Thus, battery drain of the sensor nodes has to be minimized so as to increase the network lifetime of the system. Network lifetime is the total period of time for which network is up and running. When all of the nodes die, the network stops or dies.

A sensor node fundamentally comprises of four subsystems:

A computing system: It incorporates a micro-chip which has to deal for the sensors and execution of communication traditions. Microcontroller units generally work under various modes for energy management purposes. As these working styles incorporate dissemination of power, the energy dissipation of the distinctive modes should be taken care while considering the nodes battery remaining limit.

Communication system: In this, the short range radio can converse with outside world through neighbouring nodes positioned in the area. Additionally, such radios gadgets can work under the many modes. Accordingly, there is need to close down the radio gadget when it isn't transmitting the information to some other radio set remotely to preserve the power.

Identifying system: The mix of sensors and actuators for the most part associates the few nodes to the outside world. Power expend ought to be decreased after using low power portions and accordingly sparing the power.

Power source system: This subsystem includes a small battery which gives power source for the node. It ought to be comprehended that the proportion of power drawn from the node’s battery should to be viewed over. Since if more energy is expended from a similar power hotspot for a long duration of time, the battery will fail horrendously snappier despite the way that it could have proceeded for a more drawn out time. Regularly the evaluated current breaking point of a battery limit used by sensor node isn't as much as the base Power expenditure. In this way, there are networkments for expanding life expectancy of battery by diminishing the current persistently or by closing down routinely.

For lessening the power dispersal of WSN systems, unmistakable sorts of traditions and counts are present wherever all through the entire domain. The life expectancy of WSN systems must be extended by and large with working structure identified with the application layer. Moreover, the framework traditions are expected to be control careful. These conventions and computations must think about the gear and prepared to use remarkable components of the little scale processors beside handsets to constrain the sensor nodes' energy dissemination. This method may forward the client characterized respond in due order regarding different sorts of sensor nodes designs. Particular sorts of sensor nodes sent also incite unmistakable sorts of sensor frameworks. This may in like manner provoke the particular sorts of network counts in remote sensor frameworks field.

## 1.7 ROUTING OF DATA IN WSN AND ITS EFFECT ON NETWORK LIFETIME

Remote sensor frameworks have augmented striking acknowledgment in view of their versatility in dealing with issues in different fields and can change our vocation in an across the board scope of ways. Remote sensors systems have been effectively connected with various application spaces. Attributable to a colossal number of nodes in the framework and the complexities of the earth, it is intense and even hard to trade or energize batteries for the sensor nodes. Remembering the true objective to suitably utilize remote sensor network we need to decrease the energy expend while cluster generation and amid the trading of data between the WSN nodes and the sink node.

***Direct communication***

In this, every SN directly sends its data straight to the base station. In the case that the base station is far away from the nodes, the data transfer will require a huge measure of transmission energy from each node which will rapidly deplete the battery of the nodes and lifetime of the system. The role of receiving data happens only at the sink, hence if either the base station is near the nodes or the energy needed for receiving data is huge, this might be a worthy technique for communication.

***Multi-hop communication***

Another approach to convey is through multi-hop communication. In this, it includes transmission of the information to the sink node by means of at least one delegate nodes. The nodes that are more noteworthy separation far from the base station transmit their information to some other node which thusly advances it to another node or the base station. Along these lines of correspondence may jump out at have defeated the constraint of the direct communication, however, it likewise has its own restriction. In this strategy, the nodes that go about as mediator nodes deplete out of energy quicker than other nodes. Consequently the nodes closer to the sink node are more plausible to deplete out of intensity than that are at significantly more noteworthy separation from the base station. So there came a requirement for some other technique for data trade between sensor nodes and the sink nodes. Another issue that ascends during trade of data between sensor nodes and the sink node is the exchange of a considerable measure of repetitive information from SNs towards the sink. The greater part of the information detected by sensors that are close to each other are excess, and this information is sent to the sink node. In the event that some way or another this excess can be expelled, network lifetime can be upgraded numerous folds.

**Clustering in WSNs**

Multi-hop routing solves a lot of problems that were there in Direct communication, but the problem of redundant data being sent over to the sink node still persists. Due to this redundant data transmission, more energy is wasted in the transfer than expected. Eliminating this problem will extend the network lifespan of our WSN quite a lot.

The answer for these issues is to cluster the sensors into little gatherings. These gatherings are called clusters. This apportioning of the remote sensors network into the clusters is called clustering. Every one of the clusters has their head called cluster head. Each and every other individual node from the cluster sends its information towards their cluster head. Cluster heads may straightforwardly forward every one of the information got towards the sink. Else, it can expel the excess from information gathered and afterward forward it to the sink node. Along these lines clustering takes care of the issue of exchange of excess of information from the sensor to sink node. If static clustering is utilized, then issue of the lopsided system remains. Static clustering implies that once the clusters are shaped are not changed. Cluster head stays same for the lifetime of the system. Presently since the cluster head disseminates significantly more power than the other sensor nodes, it will deplete out of energy substantially quicker than other nodes. Consequently dynamic clustering is utilized as a part of this postulation. In dynamic clustering, the clusters and the cluster heads continue evolving. The cluster head ought to be picked with care. The execution of the calculation basically relies upon the networking of clusters and choosing the cluster heads.

## 1.8 MOTIVATION

A WSN consists of tiny inexpensive power obliged SNs that senses the sensing region and collects information and transmit data to the SN in a synergetic way. Basic goal of WSN is to enhance the node lifespan, stability period and throughput of network. The wireless sensor network nodes have limited energy, storage capacity, and computing power. Clustering is used to improve stability and lifetime. The many protocols were proposed to efficiently use battery power to extend the lifespan of the WSN. Many WSN protocols are derived from hierarchical based LEACH protocol [8]. It is energy efficient protocol for sensor environment. In this, in every round, new CH is elected. In each cluster all the member nodes collect data and send the infomation to CH which then further sends the info to sink. The sensors are deployed to capture some change in physical attributes so that the change can be detected from remote location.

During the lifetime of the network, nodes which are far from sink, start dying first. Somehow we delay there there death, network lifespan and stability will increase. In our work, we come up with three solutions, first we create a circular boundary that fits the sensor field and node outside the circular boundary cannot be a CH in their entire life, secondly we create a circle within the network. All the nodes are eligible to be a CH but there is a little difference in the working of CH which are outside the circle than those inside the circle and in third solution we are merging first and second solution and then comparing them all.

## 1.9 MAJOR CLUSTERING ALGORITHMS AS BASE FOR ANALYSIS

**LEACH (Low Energy Adaptive Clustering Hierarchy)**

LEACH [1] is a self-arranging, versatile clustering protocol. It utilizes randomization for disseminating the power stack among the sensors in the system. The accompanying are the suppositions made in the LEACH convention:

a. All nodes can transmit with enough capacity to achieve the base station.

b. Every node has enough computational capacity to help diverse MAC conventions.

c. Nodes found near each other have associated information.

As per this convention, the base station is settled and situated a long way from the sensor nodes and the nodes are homogeneous and energy compelled. Here, one node called cluster head (CH) goes about as the nearby base station. Drain arbitrarily turns the high-energy CH with the aim that the exercises are similarly shared among the sensors and the sensors devour battery control similarly. LEACH moreover performs data aggregation, i.e. compression of information when information is sent from the clusters to the base station hence lessening energy scattering and upgrading framework lifetime. LEACH isolates the aggregate procedure into rounds—each round comprising of 2-stages: set-up stage and stable stage.

In the set-up stage, clusters are framed and a CH is chosen for each cluster. The CH is chosen from the sensor nodes at once with a specific likelihood. Every node creates an arbitrary number from 0 to 1. In the event that this number is lower than the edge node [T(n)] then this specific node turns into a CH.
T(n) is given as takes after:

$$T(n) = \frac{p}{1-p*\left(r mod\left(\frac{1}{p}\right)\right)}, if\ n \in G \quad (1)$$

$$T(n) = 0, otherwise \quad (2)$$

Where, p => fraction of nodes that are CHs, r => current round and G => set of nodes that have not filled in as cluster head in the previous 1/p rounds.

At that point the CH distributes schedule vacancies to nodes inside its cluster. In stable state stage, nodes send information to their CH amid their distributed schedule vacancy utilizing TDMA. At the point when the cluster head gets information from its cluster, it totals the information and sends the packed information to the BS. Since the BS is far from the CH, it needs high energy for transmitting the information. This affects just the nodes which are CHs and that is the reason the choice of a CH relies upon the rest of the energy of that node.

**SEP (Stable Election Protocol)**

In SEP [2], the effect of heterogeneity of nodes is examined in remote sensors networks that are dynamically gathered. In these frameworks, a part of the nodes advance toward getting to be cluster heads, add up to the data of their cluster people, likewise, transmit it to the BS. We expect that the rate of the masses of sensor nodes is equipped with some additional essentialness resources—which is a wellspring of heterogeneity which may happen from hidden setting or as the task of the framework creates. We in like manner expect that the sensor nodes are aimlessly (reliably) scattered and they are not mobile, the bearings of the sink and the estimations of the sensor field are known and also we exhibit that the direct of such sensor frameworks ends up being to a great degree problematic once the principle node kicks the basin, especially inside sight of node heterogeneity. Set up gathering traditions expect that every one of the nodes is outfitted with a comparative measure of imperativeness, and therefore, they can't take the full favoured point of view of the closeness of node heterogeneity. SEP is a heterogeneous-careful tradition to drag out time break before the principle node’s death (which we imply as stability region), and which is vital for a few applications where the feedback from the sensor network out must be reliable. SEP relies upon weighted choice probabilities of each node to twist up cluster go to whatever is left of the energy in each node. We show up by diversion that the SEP constantly drags out the stable time frame appeared differently in relation to (and that the typical throughput is more conspicuous than) those which got using current clustering traditions. We complete up by concentrating affectability of our SEP tradition to the heterogeneity parameters getting imperativeness abnormality in the system. SEP always yields longer stable regions for the higher estimations of the additional energy consist by more extraordinary advanced nodes.

# CHAPTER 3: LITERATURE REVIEW

Improvement of network lifetime in WSNs has been researched with different approaches. Routing based on Multipath, Query based routing, QoS based routing and Clustering based hierarchical routing are some examples. The early research on improving the lifetime were LEACH [1], Directed Diffusion [3] and PEGASIS [4].

In [3], the author proposed a data-centric approach. The nodes in DD are application aware enabling them select energy efficient paths by caching and aggregation with the help of diffusion. In [4], the author, motivated by [1], proposed an optimal chain based approach where each and every node is communicating only with a node nearer to them and then they take turn one by one transmitting the data to the BS, reducing net energy spent in a round.

This dissertation is focussed on [1], [2] and their developments. In [1], W. Heinzelman proposed LEACH, a low energy clustering based algorithm where the idea was to share the energy spent to all the nodes in order to increase the lifetime of the system. To achieve this, every the SNs were divided into clusters with each cluster having a CH. The CH is to communicate with the sink. The role of being a CH was rotated to every node. The LEACH clustering framework is upheld by two key assumptions: (1) All the SNs transmit their data to a single BS; and (2) All nodes have the ability to talk particularly with the sink node. Remembering the true objective to adjust the framework power usage, the LEACH tradition realizes a store altering framework that allows the individual nodes to wind up CH at different rounds. For each round, sort out nodes select an random number in the region of zero and one. The node picks itself as a CH set out toward the current round if the number is not as much as the threshold. The formula for the threshold is given in equation (1) and (2).

LEACH beats static clustering counts by obliging nodes to embrace to be high energy cluster heads and changing the relating clusters in perspective of the nodes that are cluster heads at a given time. At different circumstances, each node has the heaviness of anchoring data from the nodes in the gathering, joining the data to get an aggregate banner, and transmitting this aggregate banner to the sink node. LEACH is totally distributed, i.e., it doesn't require any control data from the sink node and the nodes require no data about the worldwide system by and large for LEACH to work. Distributing the energy among the node in the framework is practical in diminishing energy dispersal from an overall perspective and extending network lifetime.

The main problem with LEACH was that it was developed only for homogeneous systems without any consideration for heterogeneity. This made it impractical for a majority of applications. Also the CH selection does not take into account the remaining energy in the nodes making the whole process a little unreasonable.

Then came SEP which took heterogeneity into account as to churn out the more practical solution [2]. It assumed that a small set of nodes has higher energy the rest. It also made a change in the election probability formula to make it heterogeneity aware. This resulted in the widening of the stable period making the network more stable and practical as most of the WSNs employed are heterogeneous and even homogeneous networks show heterogeneity after running for a period of time.

In SEP, every sensor node in a heterogeneous two-level orchestrate independently picks itself as a cluster head in perspective of its energy in regard to that of other nodes. SEP is dynamic in that we don't acknowledge any prior spread of the assorted levels of energies in the sensor nodes. Additionally, our examination of SEP is definitely not simply asymptotic, i.e. the examination applies correspondingly well to smaller systems. SEP does not need any overall data of power at every choice round. Finally SEP is flexible as it doesn't require any data of the right position of each node in the field. The makers have proposed to extend SEP to oversee clustered sensor frameworks with in excess of two levels of the chain of significance and in excess of two sorts of nodes.

Further research on LEACH yielded many variants. In [5], author proposed C-LEACH a centralized approach that required the coordinates of each node.. The BS, with the knowledge of the coordinates, had the role of create better clusters. It would then choose the nodes with enough energy as the cluster heads and broadcast this info. The drawback being that it needed the coordinates of all the nodes to operate. F-LEACH proposed an approach in which clusters are formed only once and only the CHs are rotated in each round [6]. This approach flaws if nodes start dying or there are nodes to be added or removed as the clusters need to be flexible for that.

In [7], the author proposed a Multi-hop multi-path approach. EAMMH organizes the nodes into clusters and establishes multiple routes from each node to the CH and then chooses the optimal path using an energy aware heuristic function. TEEN is based on threshold sensitivity [7]. TEEN was developed for reactive networks. The CHs in TEEN broadcasts a hard threshold, absolute value of the sensed attribute beyond which node starts transmitting, and a soft threshold, a small change in the value of the attribute that activates the node to transmit, to all the nodes.

Apart from that, there is I-LEACH which proposes the theory of twin nodes, geographically very close nodes [8]. It stated that in the cases of twin nodes, which are frequent in random deployment, one of the nodes should remain off until the energy of the twin goes down. This helps the target area remain under sensing for a extended duration of time. On the other hand, TL-LEACH, employs a two-level hierarchy in that there is an extra cluster head with a sole purpose of collecting the aggregated info from all the CHs and then sending it to the BS [9].

A new research on LEACH followed the path of data fusion [10]. It employed their own data fusion algorithm during the data aggregation in addition with two cluster heads for each cluster. First, the network was divided into cluster by the use of k-medoids technique, then the first cluster head was selected following a procedure similar to that of [1]. The second cluster head was selected as the one nearest to the centroid of the cluster. This approach required the coordinates of the node to be known beforehand making it less suitable for a number of applications. The work depicted in [11] proposed V-LEACH (Vice-CH LEACH) tradition. In this protocol, other than having a CH in the gathering, the sensor network also comprises of a vice-CH that fills the job of the CH and makes the clusters reliably connected with Base station when the cluster head terminates. LEACH tradition requires customer to show the liked probability of Cluster heads for use with the edge work in choosing if a node transforms into a CH or not.

The homogeneity of LEACH algorithm is a very major drawback now-a-days. That's why we were motivated for SEP which is heterogeneous aware.

In [12], the K-medoids LEACH (KLEACH) protocol for WSN was depicted to upgrade the gathering and cluster heads assurance procedure. In the first round of communication, in the first phase, i,e,.setup stage, the K-medoids estimation was applied for cluster improvement, which make sures that gathering is consistent. In [13], a GAEEP protocol for WSN has been displayed to capably intensify the lifespan of the network and the consistent quality time of remote WSN. GAEEP uses genetic estimation to gain ground the framework lifespan and stable region of the remote WSN by determing the perfect no. of gathering CHs and their zones in light of restricting the power usage of the sensor nodes.

TSEP (Threshold SEP) is a protocol that utilizes three levels of heterogeneity [14]. TSEP is a reactive protocol, meaning it responds when changes to relevant attributes occur. The election of the CHs is based on a threshold. This protocol increases the stability region of the WSN.

# CHAPTER 3: PROPOSED WORK

Research on WSN has been carried out many times to refine the network lifetspan and stability period of the network so that the network may sense the target region for longer. However, there are applications that require the sensing feed to be on and reliable all the time, i.e., they require that all the nodes should sense the field for a longer time. This would require the batteries of the nodes to be updated. LEACH also worked to improve the stable region, period before the death of the firstrnode, in order to expand the network lifetime.

The proposed work has been detailed in this section with simulation and experimental results being provided in the next. The results have been compared with other algorithms and indicate the better performance of as compared to other algorithms.

## 3.1 PROBLEM STATEMENT

A WSN is designed to gather the information through the area and the sensed information must be transmitted to a central node that is a BS or sink. The technique through which data is gathered and transmitted to sink node through a network is crucial for the duration of the network and energy consumption. SN deploy in the area of interest may send sensed data directly or indirectly to sink node. In both direct mode sensor has to upload information to base station or sink using one hop wireless communication, while in indirect mode information transmitted by sensors using multi-hop wireless communication but due to short communication range of SNs, sink nodes communicate with limited no. of SNs. In WSN, each sensor node has limited storage capacity so some nodes may fail to receive or transmit information further to base station or sink node.

After a comprehensive survey of available clustering algorithms, it has been found that there is need work on extending the stable region and lifetime of the network. There are a lot of application like surveillance that require all the nodes be up and running for a long period of time. They require avoiding any blind spots. Therefore extending the stable region and lifetime of a network is the way to go also because in hierarchical clustering like in [1] and [2], the network is seen to die out rapidly when first node die. LEACH because of its energy efficient approach is one of the finest clustering protocols for WSN. But we can point our some of the drawback in LEACH protocol. Also, the cluster head selection algorithm can be further enhanced

## 3.2 LEACH PROTOCOL

LEACH [1] is a hierarchical clustering algorithm for WSN. It was introduced by W. Heinzelman. LEACH protocol for WSN arranges all the sensor nodes present into many small clusters [19] and elects one node as the cluster-head from the cluster [20]. Firstly nodes sense target sensor network and then sensed information is sent to its CH. Then CH aggregates received data from all the member nodes and compresses it and sends it to the SN. Because of data computational overhead and high transmission cost to send data to BS, CH consumes more energy because of more workload on them as compared to normal nodes. So, we can’t use a single node for cluster head for long time, as it may become dead. LEACH randomly cluster head nodes so that overhead is evenly distributed. LEACH protocol is used when sensor nodes constantly need to monitor sensor area. The info collection is centralized at the BS and the data sent by sensor nodes periodically.

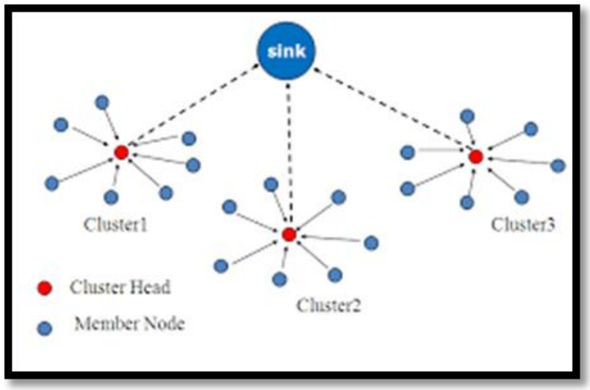


**Fig. 3.1: Clustering in LEACH protocol**

## LEACH Operation

LEACH operations are divided into two phases:

1. Setup Phase
2. Steady Phase

In the first phase, clustering is done, first CHs are choosen and then for each CH clusters are formed. In this phase, nodes sense information, do some computation and send the information towards the SN. Setup phase is smaller than steady phase. This is done because of minimizing the overhead cost.

In the second phase, a fraction p of the total nodes would become cluster head in a round. It guaranteesjthat each node becomes cluster head every 1/p rounds. LEACH refers to this period as epoch. Nodes that are selected cluster heads cannot take the role again in the same epoch. Nodes that haven't become cluster heads in an epoch belong to set G. In each round, every node belonging to G is given a random number in [0,1] and then is compared with a threshold, T(s). If a random number is less than this threshold, then node is elected a CH. As each round passes, election probabilities of nodes in G increase.

:

$T(n) = p / 1 - p \times (r \times \text{mod } p)$, if $\forall n \in G$

Or 0, otherwise

where G is set of nodes that aren't become CH in last 1/p rounds.

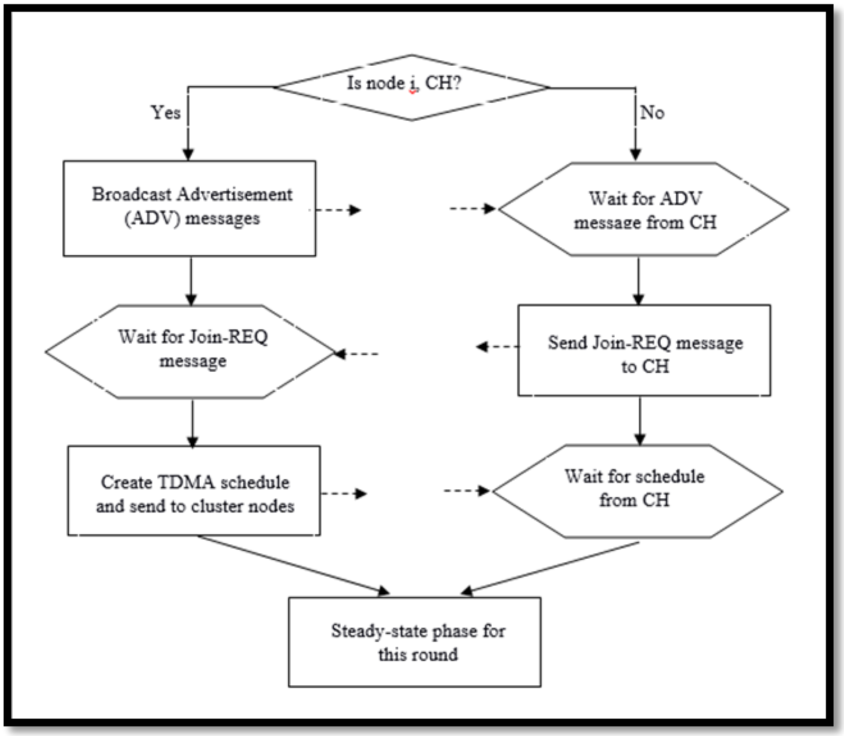


**Fig 3.2: Flowchart of Setup phase in LEACH protocol**

All the nodes who want to be the CH select a value between 0 and 1 randomly and becomes CH for the current round if randomly chosen value is less than threshold value. Each CH broadcasts an advertisement message which is an invitation from the CH to other nodes to join their cluster. The normal nodes decide to join a cluster based on the strength of advertisement signal. Acknowledgement message is sent by the non- cluster node to the head of the cluster. All the non-cluster nodes, sending acknowledgement message to a particular CH become part of that cluster. The cluster nodes sense the data and sends to the CH as per time slot allotted to them by cluster head. Cluster head allocate time slots using TDMA scheduling [9]. The CH of current round can become CH again only after all the other nodes become CH.

Steady Phase: All cluster nodes are already allocated time slots to send their data in that time slot to CH in setup phase. So, in this phase cluster nodes senses the data from the target region and transmit it to the cluster head as per their allocated timeslot. The role of the CH is to receive and aggregate the data from all the member cluster nodes and send it towards sink node. After a certain predefined time, setup phase is repeated again and new cluster heads are chosen in similar way so that the load of CH is distributed equally among all the nodes.

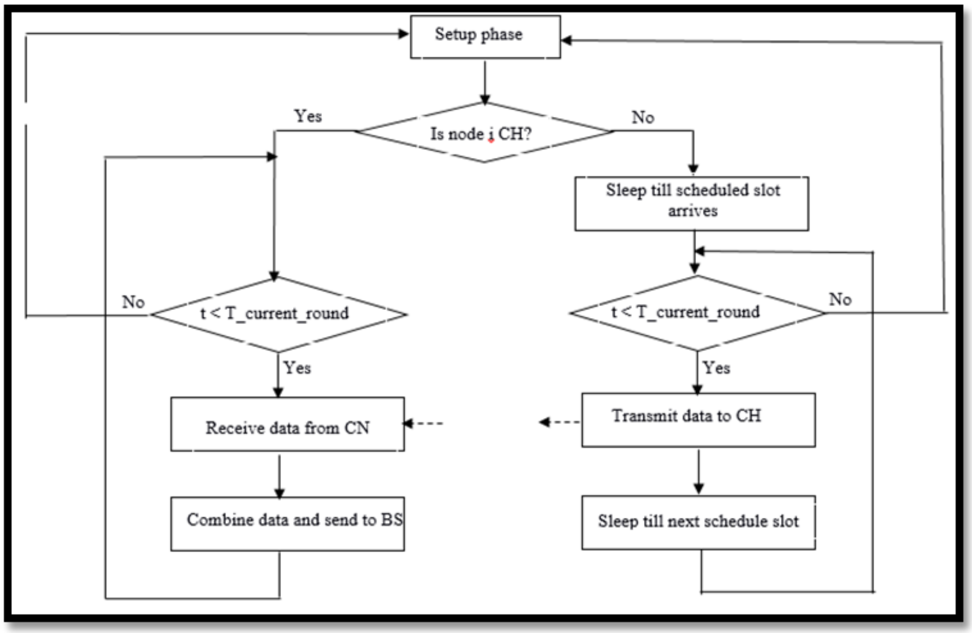


**Fig 3.3: Flowchart of Steady phase in LEACH protocol**

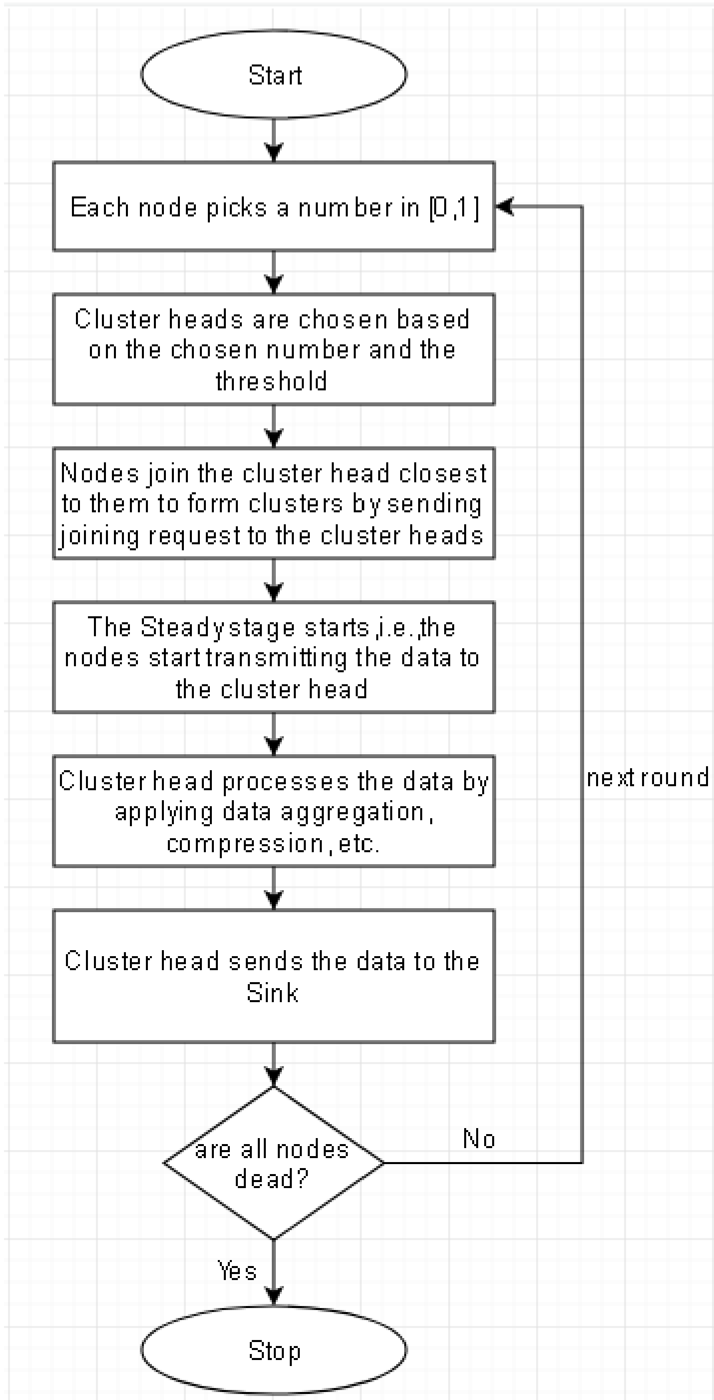


**Fig 3.4: Flowchart for LEACH Protocol**

## 3.3 PROPOSED SCHEME

The proposed work is closely based on LEACH. All the stages are similar to LEACH and include changes inside those stages. In our work, we come up with three solution, in the first solution we create a circular boundary that fits the sensor field and node outside the circular boundary cannot be a CH in their entire life, in second solution we create a circle within the network. All the nodes are eligible to be a cluster head but there is a little difference in the working of cluster head which are outside the circle than those inside the circle and in third solution we are merging first and second solution and then comparing them all. The idea is to make algorithm more efficient by reducing the overall transmission cost of cluster nodes so that overall energy consumption in WSN will be reduced and the lifetime of network will increase. The main focus is in reducing the energy dissipation of nodes which are far from sink because nodes which are far from sink die first that means their energy dissipation rate is high. Like [1] and [2], the operation of proposed work is also broken down in rounds. Each round begins with the setup phase followed by the steady phase, also called stable region.

The assumptions made in LEACH are also carried forward.

### 3.3.1 WORKING FOR FIRST SOLUTION

Each round consists of two phases like that in [1], set-up phase where the clusters are formed but there is a circular boundary that fits within the network. Those nodes which are within the circular boundary are eligible to be a cluster head, i.e., nodes outside the circular boundary cannot be a cluster head.

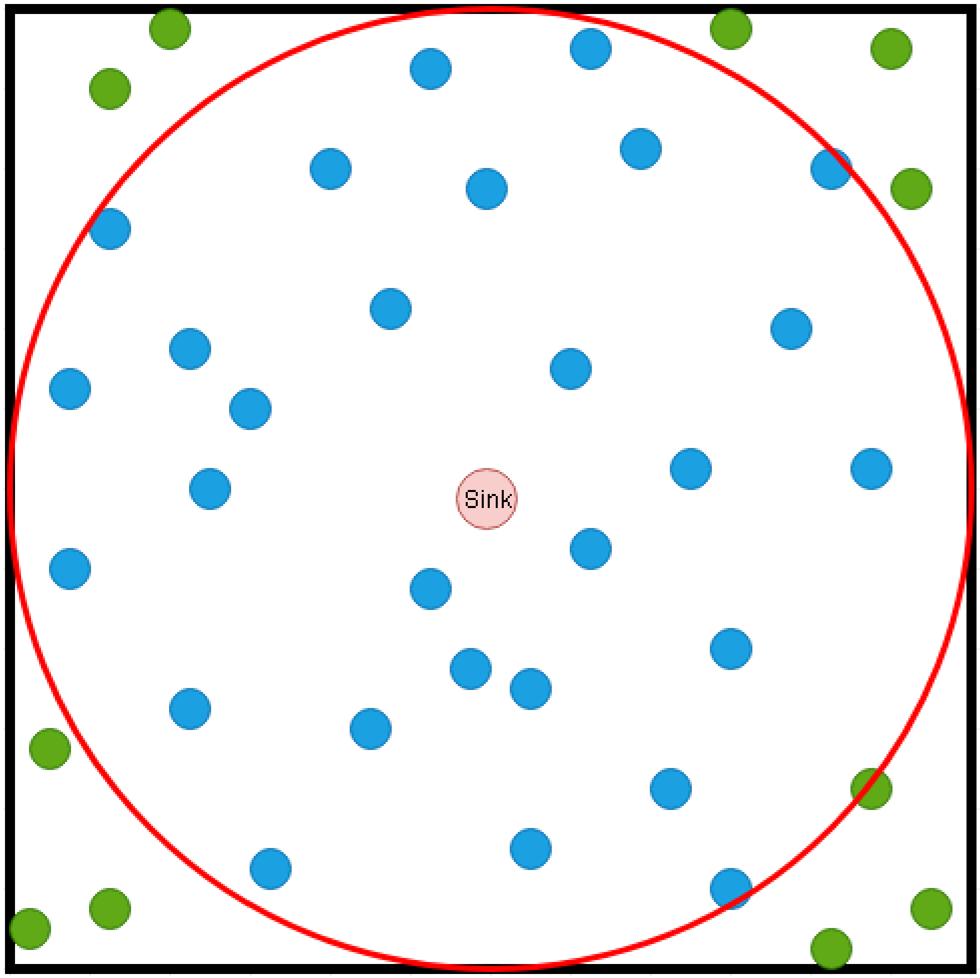


**Fig 3.5: Sensor field in proposed work-1**

***Setup phase***

Initially, create a circular boundary that fits within the sensor field and if a node is outside the circular boundary, set a flag that tells the node that it cannot be a Cluster head in its entire life.

Each node which is within the circular boundary is assigned a random number from the range [0, 1]. This random number is then comparedcto the threshold in (1). If a random number assigned is lesscthan the threshold, the node is made a CH for the round.

After thecselection of cluster heads, the clusters are created based on the Euclidian distance of the nodes from the cluster heads. Each node including which is outside the circular boundary joins the cluster if distance between the cluster head and the node is minimum in comparison to all other cluster heads. The nodes inform the cluster head about the inclusion in the cluster which then creates a TDMA schedule for each node to transmit their data based on the count of nodes in the cluster. This schedule is then broadcasted back tojthe nodes.

***Steady phase***

After the setup phase is over, the operation of transmitting of data by the sensor nodes can begin. If a node has data to send, it will only transmit during its TDMA schedule. The transmitter of the nodes is off at times other than allotted. This minimizes energy expend of the nodes.

The CH, however, has to keep its receiver on at all times. All the data is compressed into a single signal once collected which is to be processed upon and finally sent to the sink.

After a certain amount of pre-determined time, the next rounds begins and it done all over. This pre-determined time, in which the data transmission occurs, is called the steady phase. This is determined to be longer than the setup phase to reduce the overhead of clustering and head selection and to improve efficiency. If there are very few alive nodes left within the circle, standard LEACH will be perform on all the alive nodes in the field irrespective of the circular boundary.

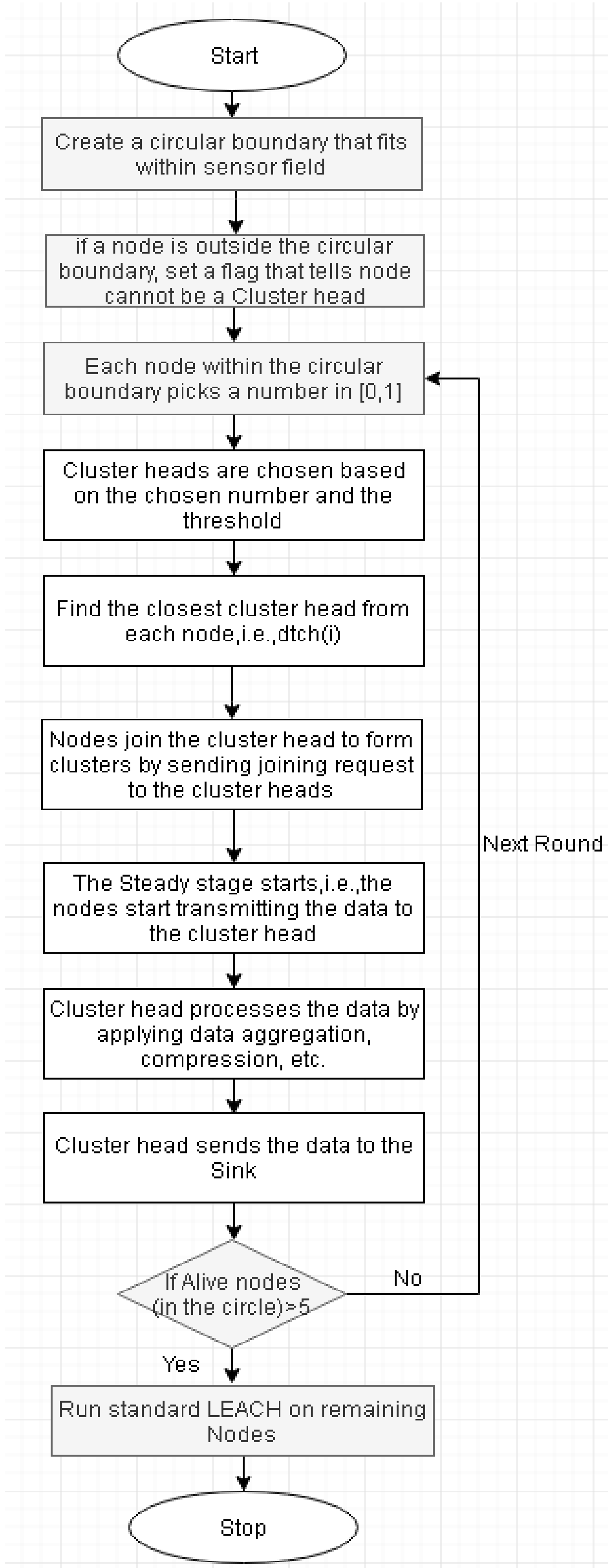


**Fig 3.6: Flowchart for First proposed solution**

## 3.3.2 WORKING FOR SECOND SOLUTION

Each round consists of two phases like that in [1], set-up phase where the clusters are formed but there is a circle within the network. All the nodes are eligible to be a cluster head but there is a little difference in cluster head which are outside the circle than those inside the circle.

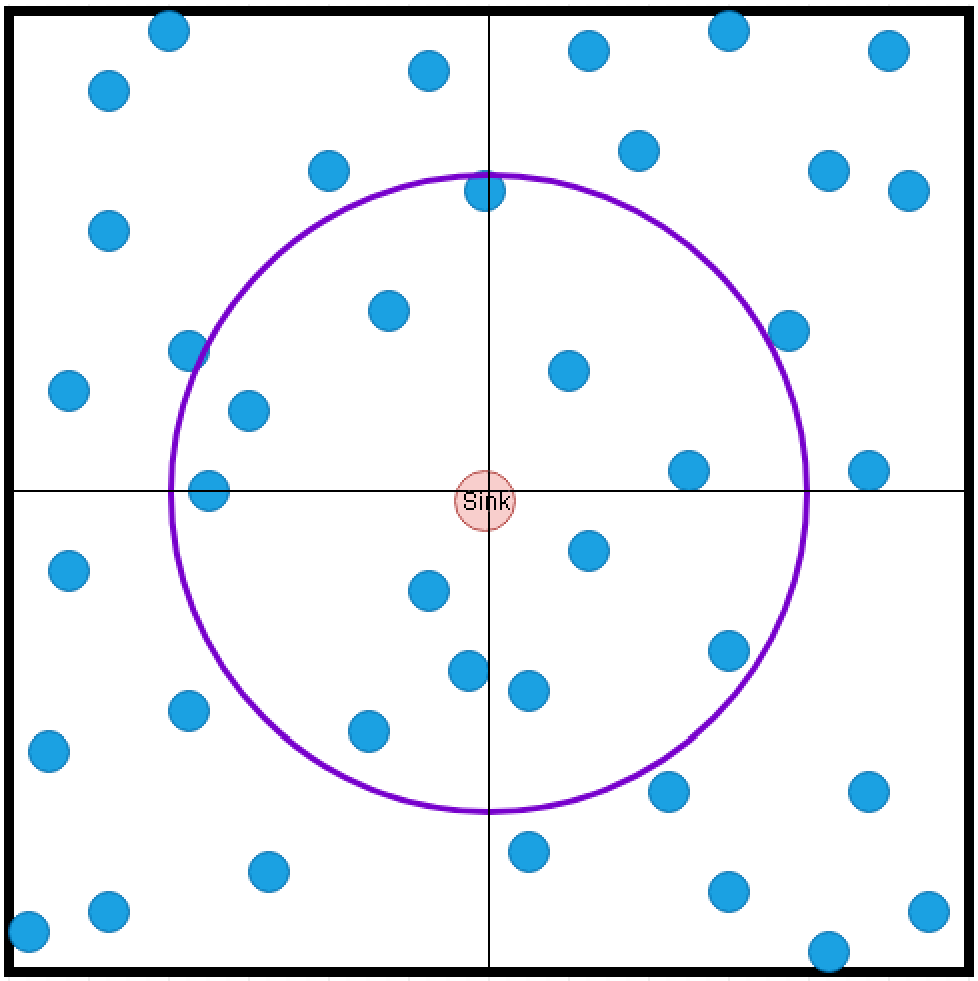


**Fig 3.7(a): Sensor field in proposed work-2**

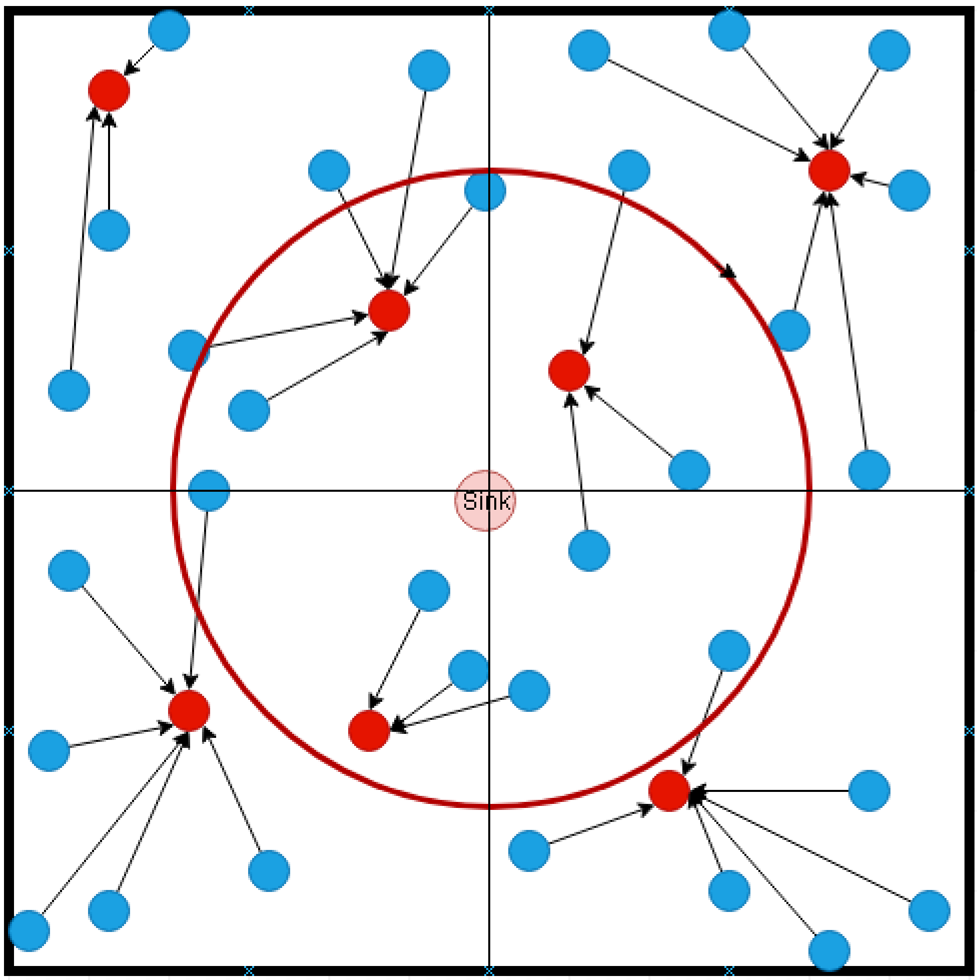


**Fig 3.7(b): Cluster formation in proposed work-2**

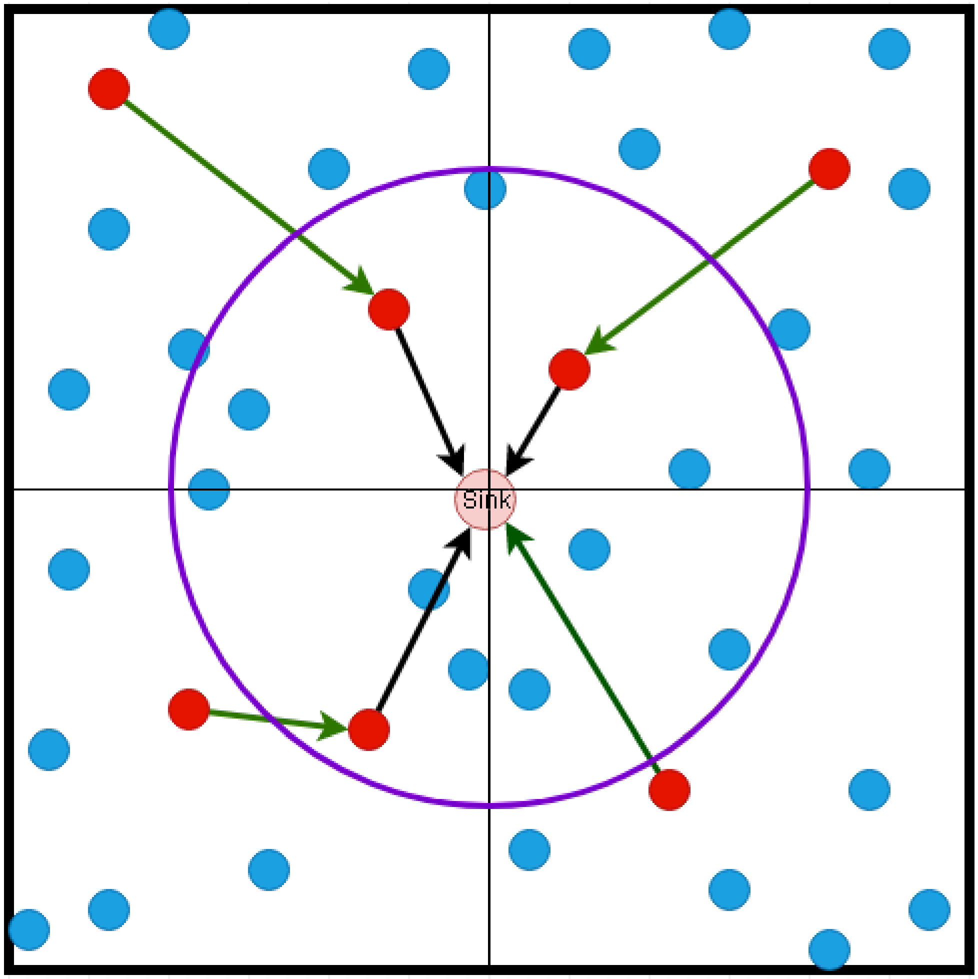


**Fig 3.7(c): Cluster heads sending data in proposed work-2**

***Setup phase***

Initially, create a circle within the sensor field and imagine that the field is divided in quadrants and then assign a quadrant number to each node to which they belong. Then, each node is assigned a random number from the range [0 ,1]. This random number is then compared to the threshold in (1). If the random number assigned is less than the threshold, the node is made a CH for the round.

After the selection of cluster heads, the clusters are created based on the *Euclidian distance* of the nodes from the cluster heads. Each node joins the cluster if the distance between the CH and the node is minimum in comparison to all other CHs. The nodes inform the *CH* about the inclusion in the cluster which then creates a TDMA schedule for each node to transmit their data based on the count of nodes in the cluster. This schedule is then broadcasted back to the nodes.

***Steady phase***

After the *setup phase* is over, the operation of transmitting of data by the sensor nodes can begin i.e., steady state starts, this is where energy dissipates. If a node has data to send, it will only transmit during its TDMA schedule. The transmitter of the nodes is off at times other than allotted. This minimizes energy expend of the nodes.

The *CH,* however, has to keep its receiver on at all times. All the data is compressed into a single signal once collected which is to be processed upon. If a CH is outside the circle and there is a CH inside the circle and within the same quadrant then this CH which is outside circles sends the data to the CH which is inside the circle and within same quadrant. But if there is a CH inside the circle and but node within the same quadrant then this CH sends the data directly to the sink. All the CHs inside the circle sends data directly to the sink.

After a certain amount of pre-determined time, the next rounds begins and it done all over. This pre-determined time, in which the data transmission occurs, is called the *steady phase*. This is determined to be longer than the *setup phase* to reduce the overhead of clustering and head selection and to improve efficiency.

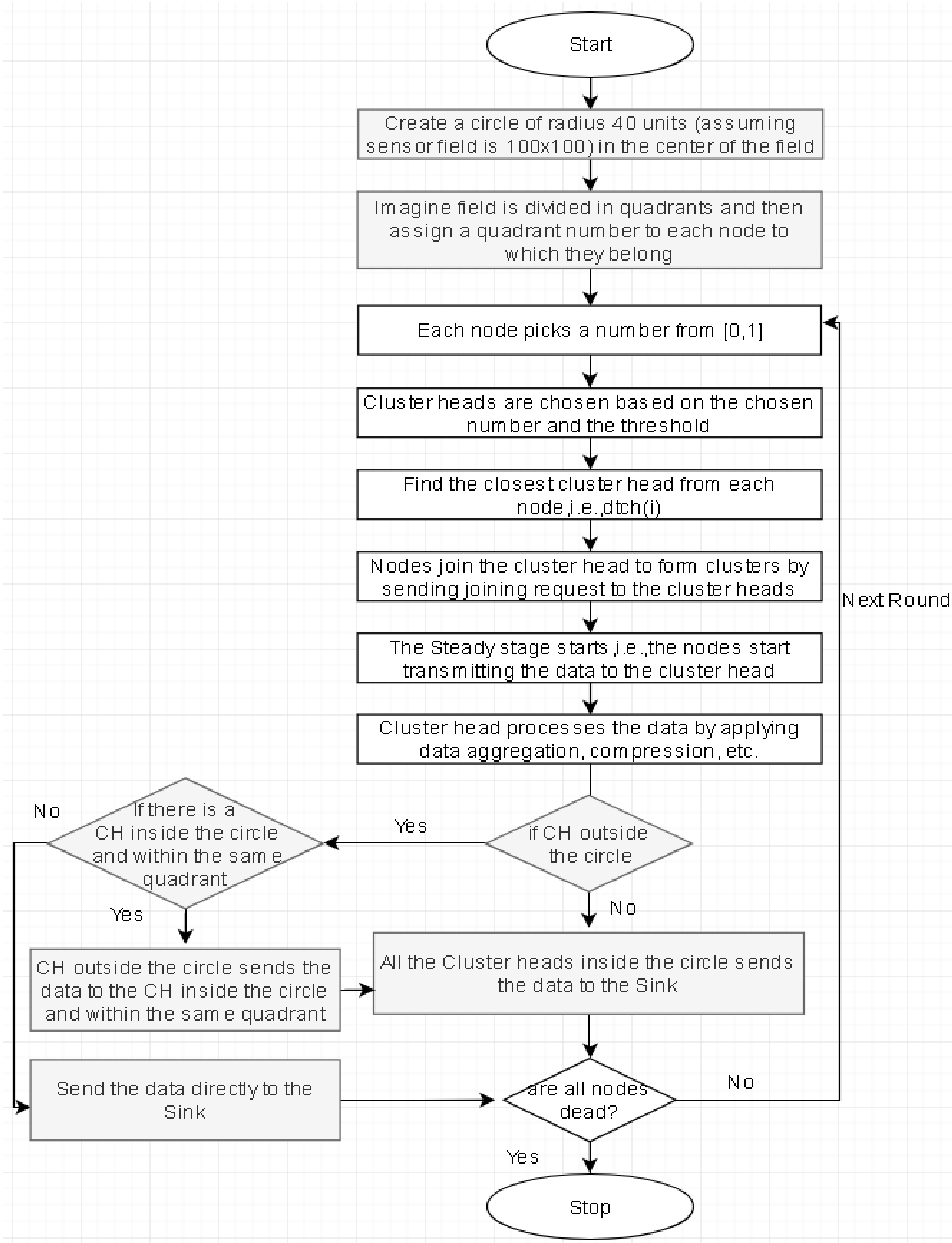


**Fig 3.8: Flowchart for proposed solution-2**

## 3.3.3 WORKING FOR THE THIRD SOLUTION

Third solution is the combination of first and the second solution. Each round consists of two phases like that in [1], set-up phase and steady phase. In this, there are two circles, one circle fits within sensor field and other of radius 40 units (assuming sensor field is 100x100) in the center of the field. Those nodes which are within the circular boundary are eligible to be a cluster head, i.e., nodes outside the outer circular boundary cannot be a cluster head. But there is a little difference in cluster head which are present between the two circle than those inside the inner circle.

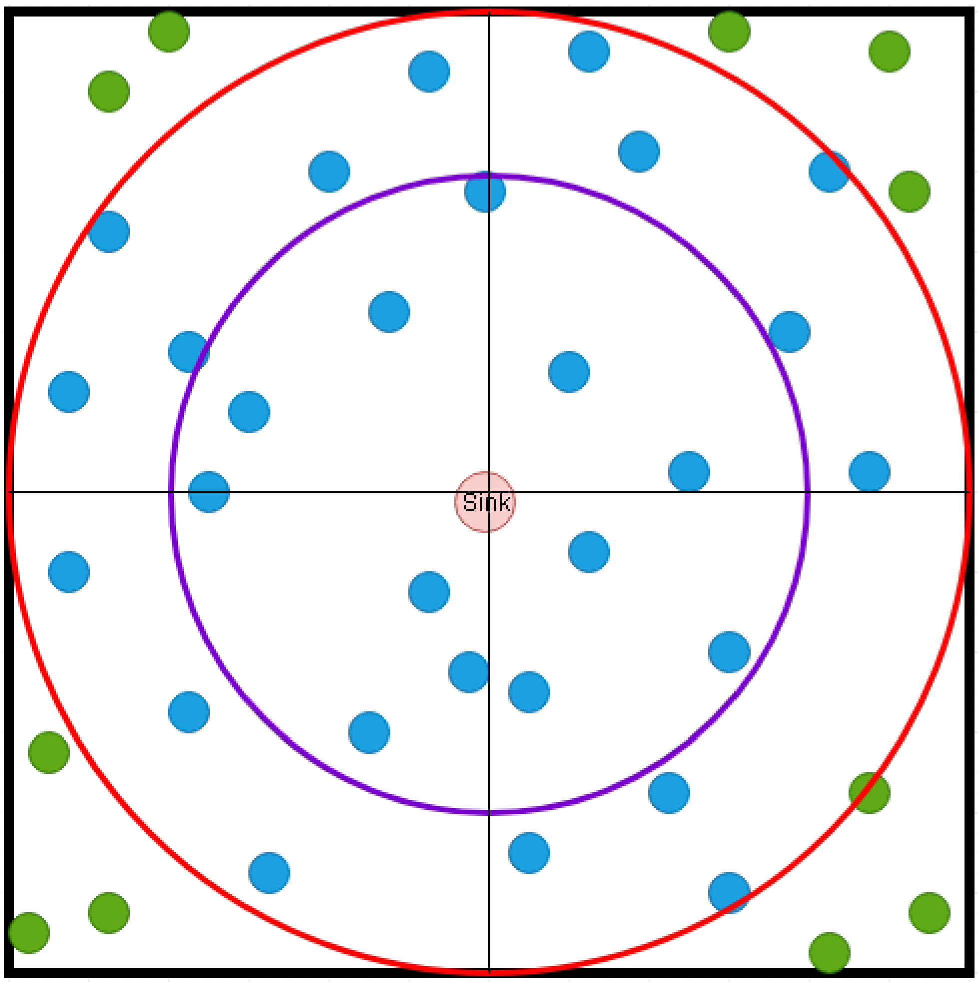


**Fig 3.9(a): Sensor field in proposed solution-3**

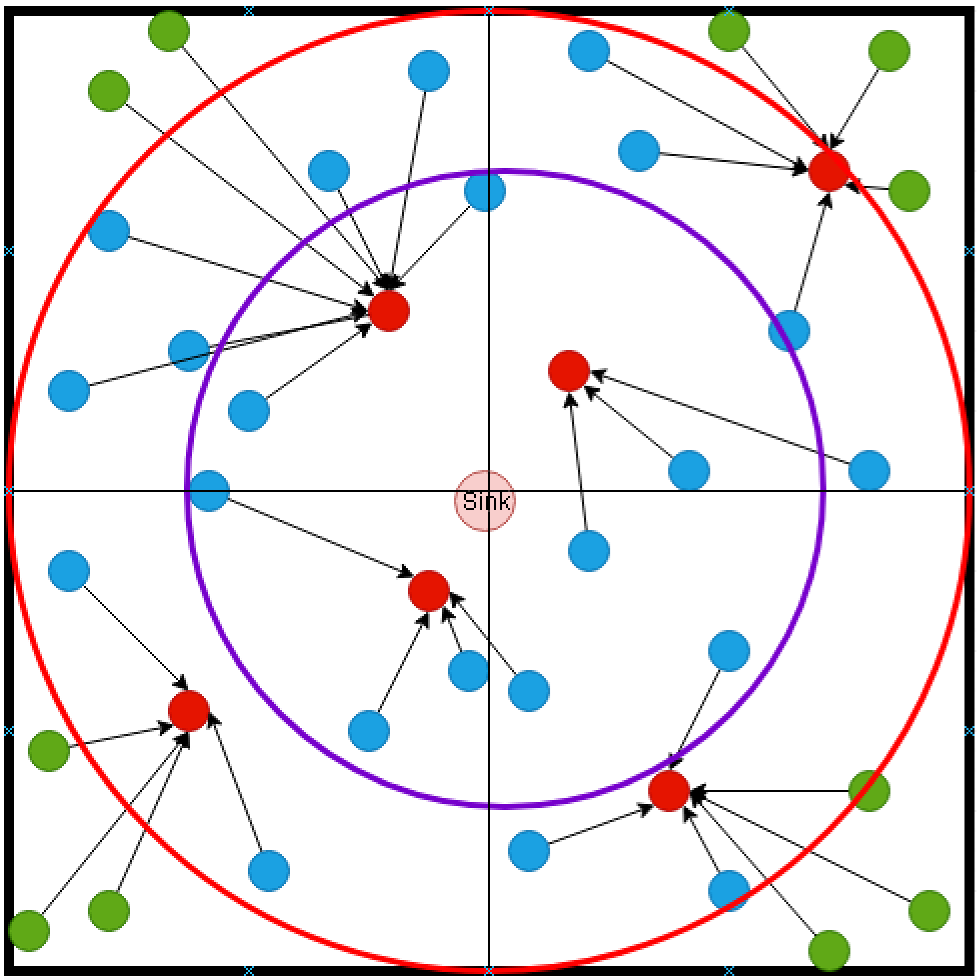


**Fig 3.9(b): Cluster formation in proposed solution-3**

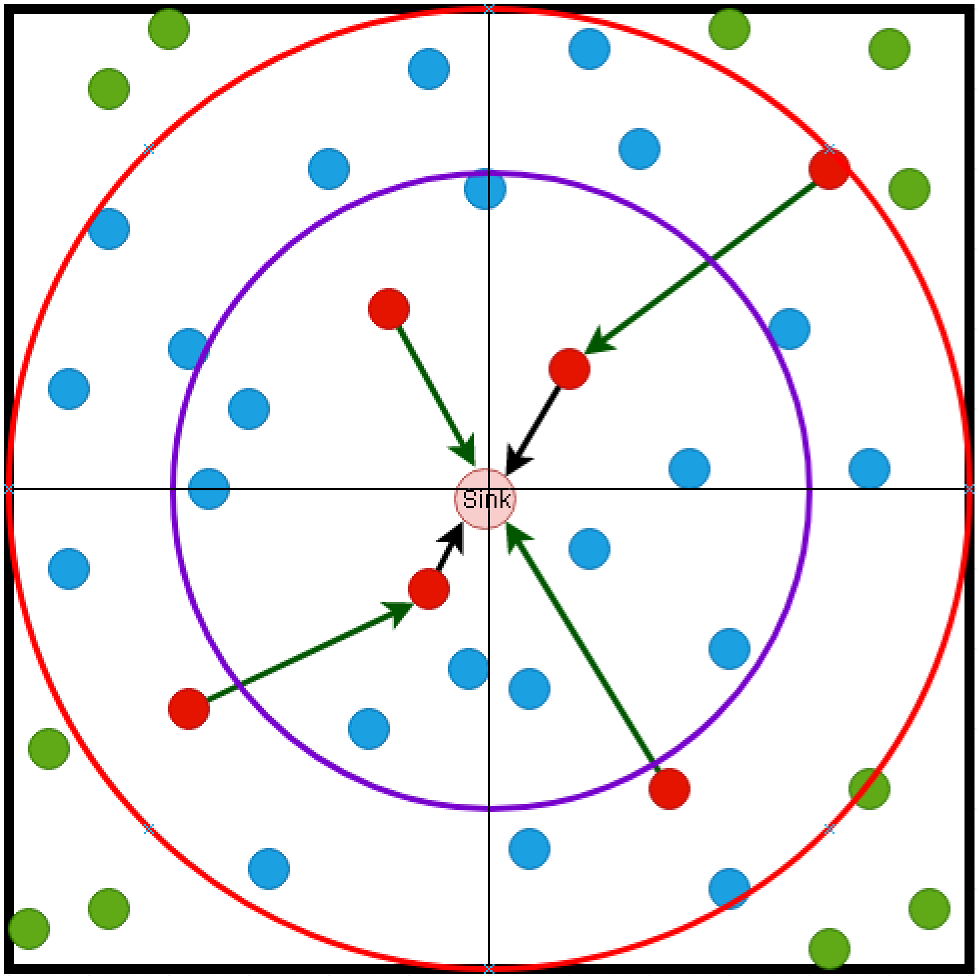


**Fig 3.9(c): Cluster heads sending data in proposed solution-3**

***Setup phase***

Initially, create two circles, one circle fits within sensor field and other of radius 40 units (assuming sensor field is 100x100) in the center of the field and if a node is outside the outer circle boundary, set a flag that tells node that it cannot be a Cluster head in its entire life. Imagine field is divided in quadrants and then assign a quadrant number to each node to which they belong. Each node which is inside circles is assigned a random number from the range [0, 1]. This random number is then compared to the threshold in (1). If a random number assigned is less than the threshold, the node is made a CH for the round.

After the selection of cluster heads, the clusters are created based on the Euclidian distance of the nodes from the cluster heads. Each node including which are outside both the circles joins the cluster if distance between the cluster head and the node is minimum in comparison to all other cluster heads.The nodes inform the cluster head about the inclusion in the cluster which then creates a TDMA schedule for each node to transmit their data based on the count of nodes in the cluster. This schedule is then broadcasted back to the nodes.

***Steady phase***

After the setup phase is over, the operation of transmitting of data by the sensor nodes can begin i.e., steady state starts, this is where energy dissipates. If a node has data to send, it will only transmit during its TDMA schedule. The transmitter of the nodes is off at times other than allotted. This minimizes energy expend of the nodes.

The *CH*, however, has to keep its receiver on at all times. All the data is compressed into a single signal once collected which is to be processed upon. If a CH is between the two circles and there is a CH inside the inner circle and within the same quadrant then this CH which is between the two circles sends the data to the CH which is inside the inner circle and within same quadrant. But if there is a CH inside the circle and but node within the same quadrant then this CH sends the data directly to the sink. All the CHs inside the inner circle sends data directly to the sink.

After a certain amount of pre-determined time, the next rounds begins and it done all over. This pre-determined time, in which the data transmission occurs, is called the *steady phase*. This is determined to be longer than the *setup phase* to reduce the overhead of clustering and head selection and to improve efficiency. If there are very few alive nodes left within the inner circle, standard LEACH will be perform on all the alive nodes in the field irrespective of the circular boundaries.

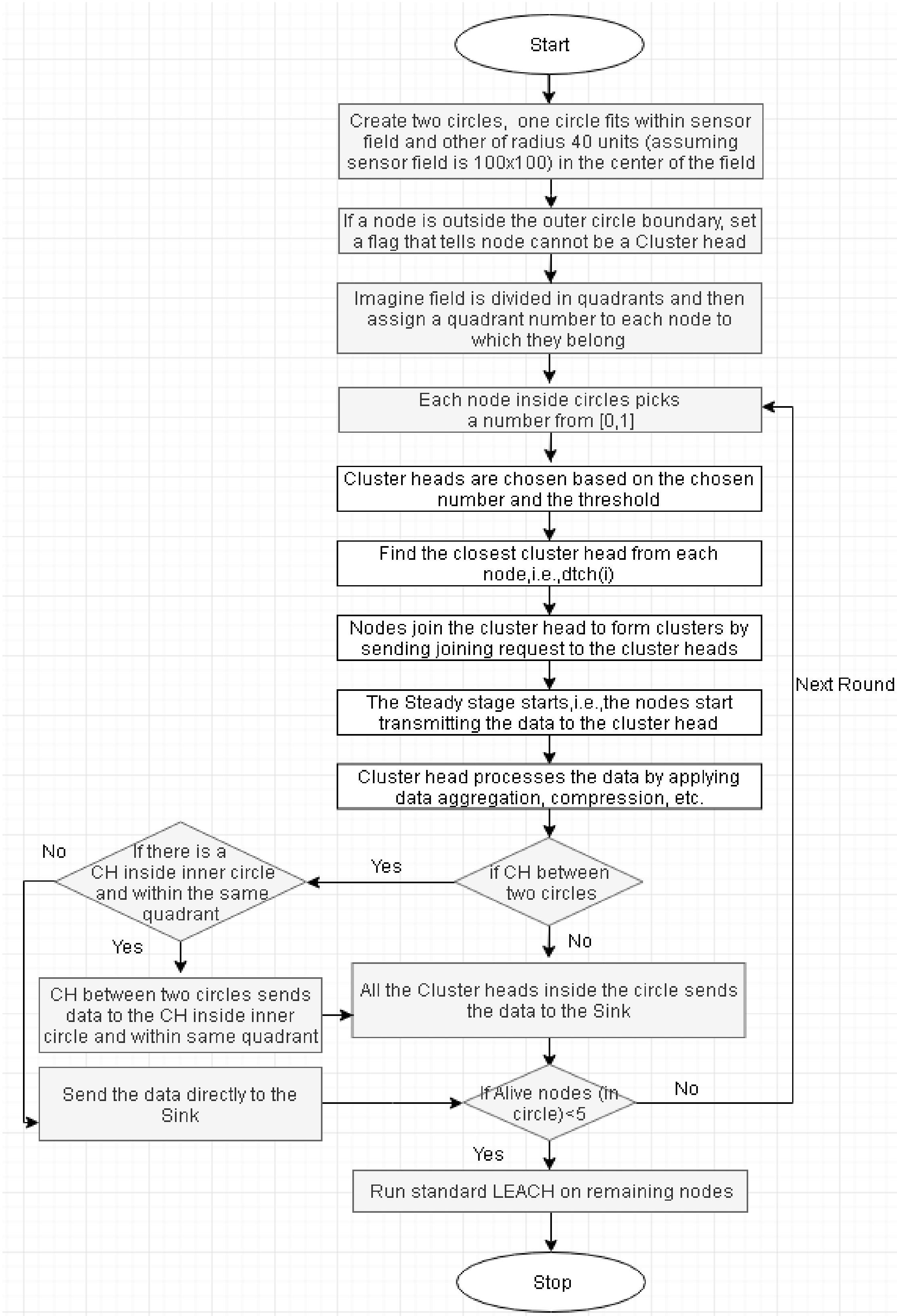


**Fig 3.10: Flowchart for proposed solution-3**

# CHAPTER 4: SIMULATION AND RESULT

For the purpose of the performance analysis, we use MATLAB. For the sake of simplicity, the following assumptions are made in the model,

- The nodes are randomly distributed across the field.
- The sink, *base station,* is not power limited.
- The base station is reachable from every node
- Cluster nodes always have data to transmit.
- The nodes are not mobile.

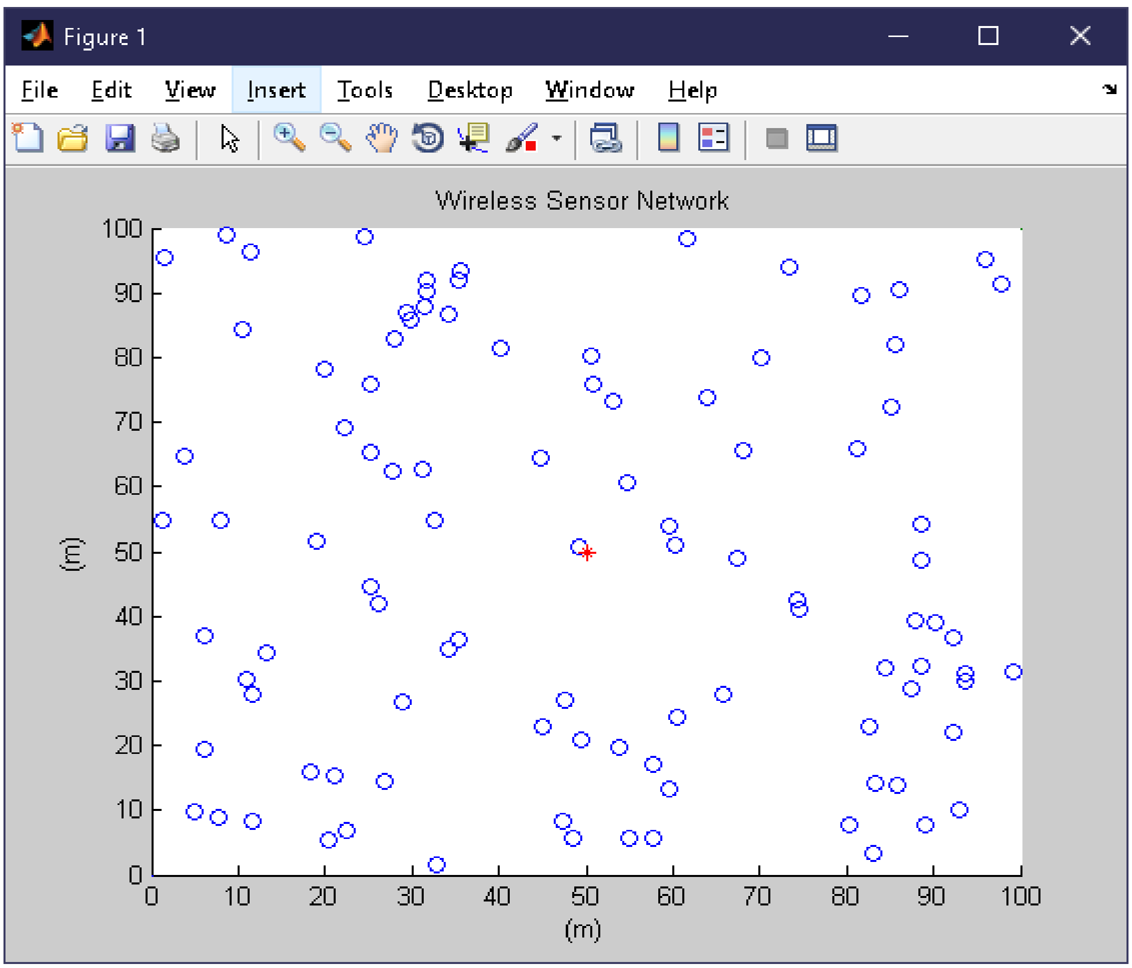


**Fig 4.1: Wireless Sensor network**

The following values were set as the simulation parameters,

- Percentage of header nodes per round, p=0.1

- Percentage of advanced nodes, m =0
- α=1.
- Number of nodes, n=100.
- Dimensions of field, 100m*100m.

The energy levels considered for the simulation are described in table 1.

| **Parameter** | **Value** |
|---|---|
| Node initial energy, Eo | 0.2 J |
| $E_{amp}$ | 100 Pj.(bit.m$^{4}$)$^{-1}$ |
| $E_{da}$ | 50 nj.bit$^{-1}$ |
| $E_{rx}$, $E_{tx}$ | 50 nj.bit$^{-1}$ |
| Packet size | 4000 bits |

**TABLE I. Energy Level Parameters**

With these parameters set, we analyzed our work. The random node distribution is shown in Fig. 4.1.We then compares the performance of the algorithm with that of LEACH [1].

## 4.1 PROPOSED SOLUTION-1

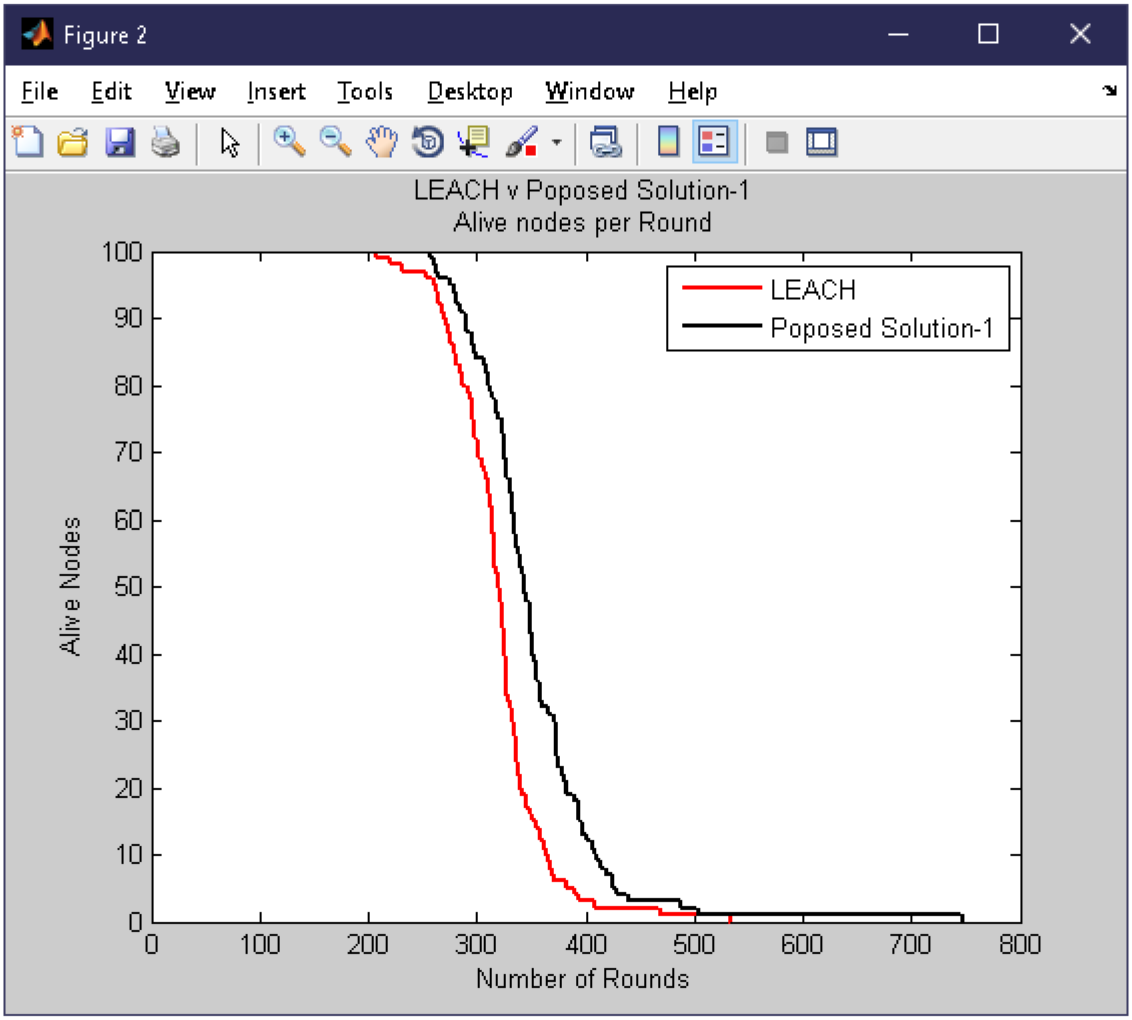


**Fig 4.2: Result for Proposed Solution-1**

| Comparison Factor | LEACH | Proposed Work-1 |
|---|---|---|
| First Node Die | 209 | 257 |
| 10% Node Die | 277 | 289 |
| 90% Node Die | 370 | 408 |
| Last Node Die | 533 | 747 |

**TABLE II. Comparison of LEACH and Proposed Work-1**

We can see from the graphs that our proposed solution-1 performs very well compared to LEACH and prolongs the stable region for the longer time with the first node dying at round 257, 10% nodes dying at 289. 90% nodes dying at 408 and last node dying at 747 whereas for LEACH the first node dying at round 218, 10% nodes dying at 277, 90% nodes dying at 370 and last node dying at 533. This simulation solidifies the position of the work that it does indeed prolong the stable region of the network as well as lifetime of the network. We do not focus on the death of the last node aspect of network lifetime as after the death of 90% node, the network is considered dead.

## 4.2 PROPOSED SOLUTION-2

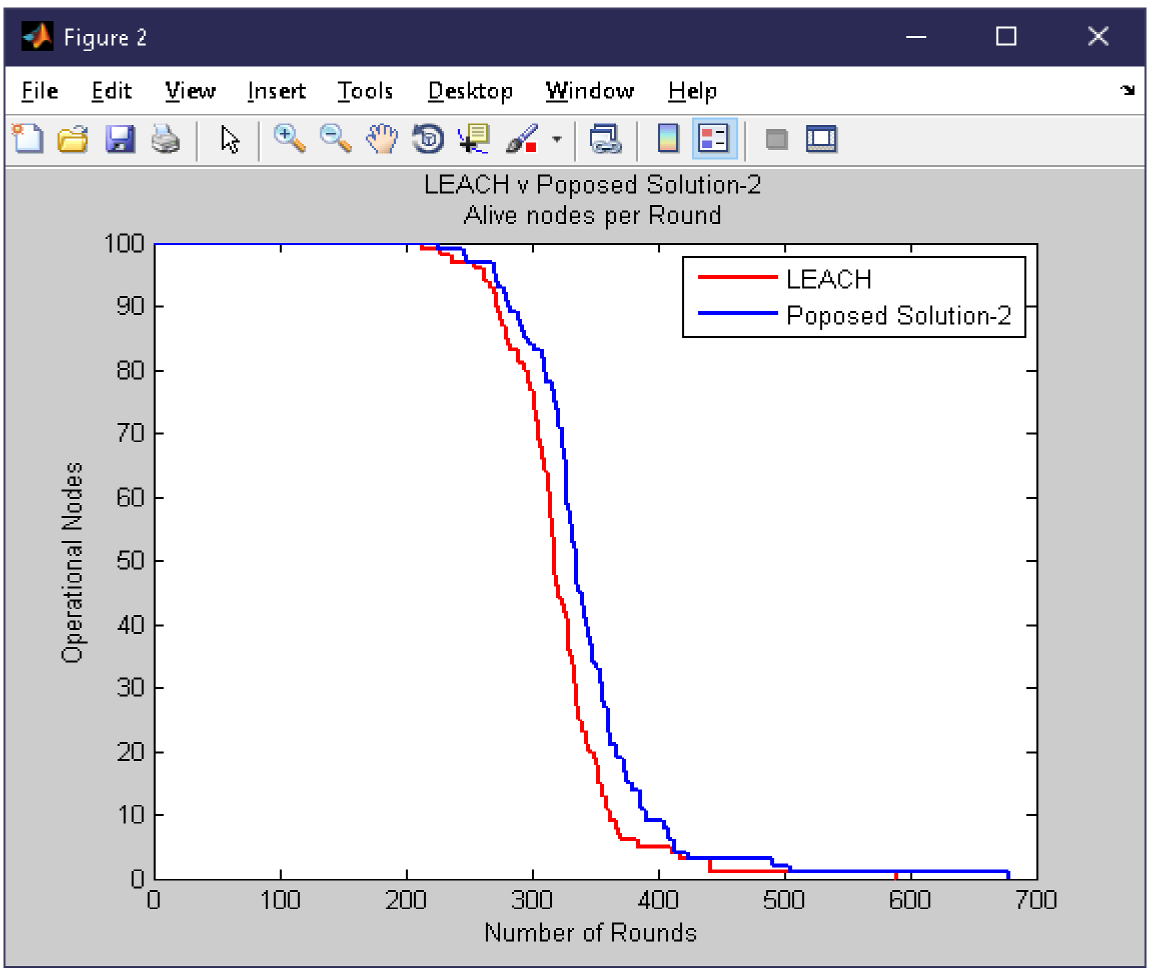


**Fig 4.3: Result for Proposed Solution-2**

| **Comparison Factor** | **LEACH** | **Proposed Work-2** |
| --- | --- | --- |
| First Node Die | 213 | 226 |
| 10% Node Die | 273 | 291 |
| 90% Node Die | 370 | 390 |
| Last Node Die | 728 | 600 |

**TABLE III. Comparison of LEACH and Proposed Work-2**

We can see from the graphs that our proposed solution-2 performs well compared to LEACH and prolongs the stable region for the longer time with the first node dying at round 226, 10% nodes dying at 291. 90% nodes dying at 390 and last node dying at 600 whereas for LEACH the first node dying at round 213, 10% nodes dying at 273, 90% nodes dying at 370 and last node dying at 728. This simulation solidifies the position of the work that it does indeed prolong the stable region of the network as well as lifetime of the network. We do not focus on the death of the last node aspect of network lifetime as after the death of 90% node, the network is considered dead.

## 4.3 PROPOSED SOLUTION-3

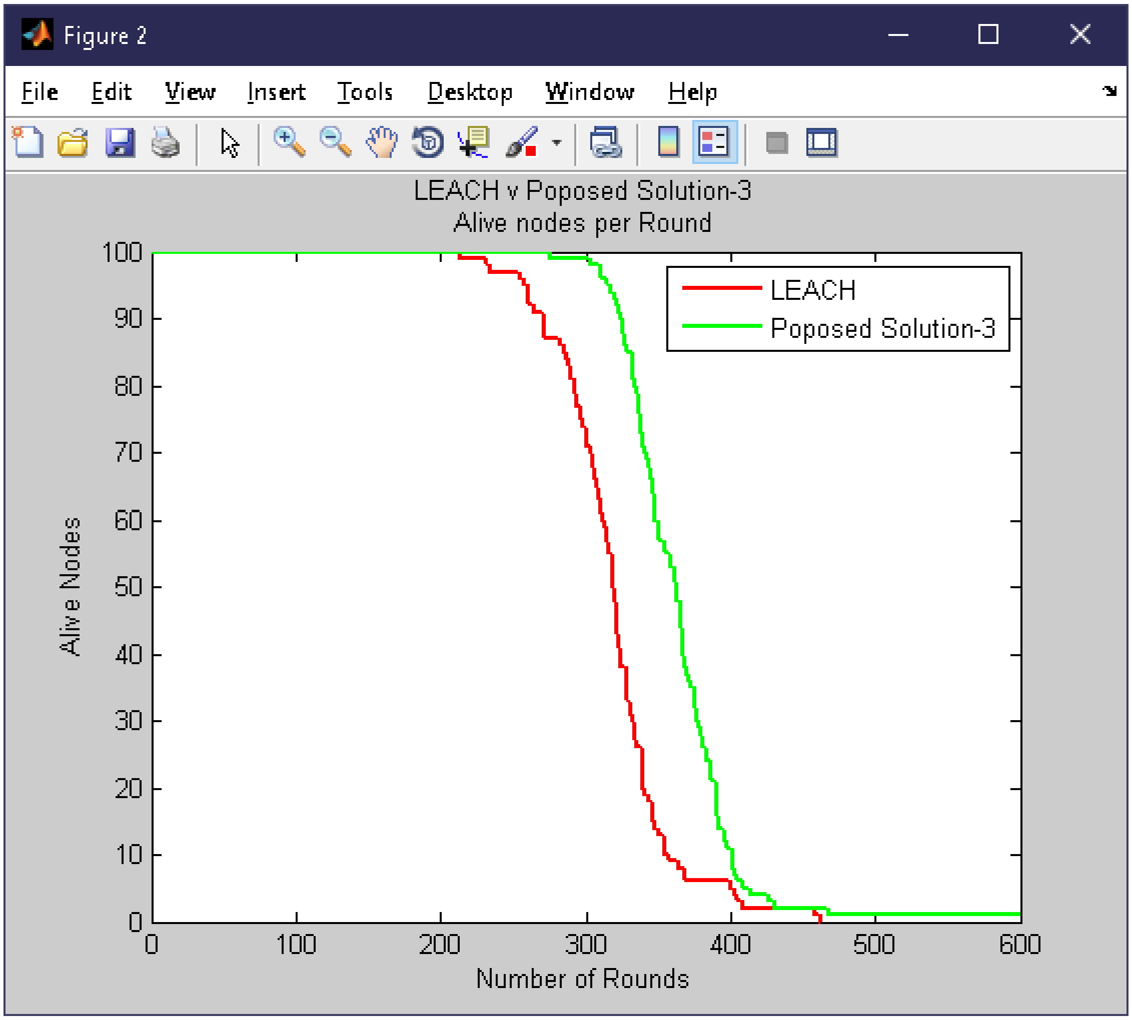


**Fig 4.4: Result for Proposed Solution-3**

| Comparison Factor | LEACH | Proposed Work-3 |
|---|---|---|
| First Node Die | 211 | 271 |
| 10% Node Die | 276 | 323 |
| 90% Node Die | 367 | 400 |
| Last Node Die | 462 | 1207 |

**TABLE IV. Comparison of LEACH and Proposed Work-3**

We can see from the graphs that our proposed solution-3 performs very well compared to LEACH and prolongs the stable region for the longer time with the first node dying at round 271, 10% nodes dying at 323. 90% nodes dying at 400 and last node dying at 1207 whereas for LEACH the first node dying at round 211, 10% nodes dying at 276, 90% nodes dying at 367 and last node dying at 462. This simulation solidifies the position of the work that it does indeed prolong the stable region of the network as well as lifetime of the network. We do not focus on the death of the last node aspect of network lifetime as after the death of 90% node, the network is considered dead.

| **Comparison Factor** | **LEACH** | **Proposed Work-1** | **Proposed Work-2** | **Proposed Work-3** |
|---|---|---|---|---|
| First Node Die | 211 | 257 | 226 | 271 |
| 10% Node Die | 276 | 289 | 291 | 323 |
| 90% Node Die | 367 | 408 | 390 | 400 |
| Last Node Die | 462 | 747 | 600 | 1207 |

**TABLE V. Comparison of LEACH and Proposed Work-1,2,3**

# CHAPTER 5: CONCLUSION AND FUTURE DIRECTIONS

Improving the network lifetime of a Wireless Sensor Network (WSN) is a frequently researched topic as the advantages are numerous. LEACH proved that hierarchical routing can save energy and extend the lifetime of a network. During the lifetime of the network, nodes which are far from sink, start dying first. In our work we focused on to somehow delay there death by reducing there energy consumption, so that network lifespan and stability will increase. This paper describes an Energy-efficient Proximity based LEACH to address the problem of improving the stable region for greater stability and reliability. First we create a circular boundary that fits within the sensor field and the nodes outside that circular boundary cannot be a CH in their entire life to safe their energy as CH head energy dissipates at faster rate, secondly we create a circle within the network. If a CH is outside the circle and there is a CH inside the circle and within the same quadrant then this CH which is outside circles sends the data to the CH which is inside the circle and within same quadrant. Otherwise sends the data directly to the sink. In third solution we are merging first and second solution and then comparing them with LEACH protocol Simulation results show that our work effectively improves the stability region when compared to LEACH.

Future directions include better selection criteria of inner cluster head by outer cluster head to send its data to inner cluster head to ensure less energy consumption. In this project, we have considered the sensor nodes to be static. We can study the behavior if sensor nodes have mobility.Also, Election thresholds can also be researched upon for better results.

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