DATA AGGREGATION IN WIRELESS SENSOR NETWORK

A DISSERTATION

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

Master of Technology

In

Computer Science and Engineering

Submitted By

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2K16/CSE/13

UNDER THE SUPERVISION OF

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JULY 2018

DECLARATION

I hereby declare that the Major Project-II work entitled **"Data Aggregation in Wireless Sensor Network"** 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 bonafide 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.

Place: Delhi **Sandhya Adhikari**

Date: **2K16/CSE/13**

CERTIFICATE

This is to certify that Project Report entitled **"Data Aggregation in Wireless Sensor Network"** submitted by **Sandhya Adhikari** (roll no. 2K16/CSE/13) 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 her under my supervision.

To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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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. There has been a vast research in last few decades on different types of protocols depending upon the type of network i.e. homogenous or heterogeneous. It is seen that energy efficiency can be obtained by clustering methods. Various meta-heuristic optimization techniques also have been proposed earlier to resolve the optimization problems. In this paper, we aim to achieve energy efficiency by using Grey Wolf Optimizer (GWO) for clustering problem.

ACKNOWLEDGEMENT

First of all, I would like to express my deep sense of respect and gratitude to my project supervisor Dr. Daya Gupta for providing the opportunity of carrying out this project and being the guiding force behind this work. I am deeply indebted to her for the support, advice and encouragement he provided without which the project could not have been a success.

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List of Abbreviations

1. GWO: Grey Wolf Optimisation
2. WSN: Wireless Sensors Network
3. CH: Cluster Head
4. GA: Genetic Algorithm
5. LEACH: Low-Energy Adaptive Clustering Hierarchy
6. PEGASIS: Power-Efficient Gathering in Sensor Information Systems
7. SEP: Stable Election Protocol
8. GAEEP: Genetic Algorithm-based Energy-Efficient Protocol
9. GEACH: Genetic Algorithm Based Energy Efficient Clustering Hierarchy
10. TL-LEACH: Two Level LEACH
11. A-LEACH: Amend LEACH
12. GA-LEACH: Genetic Algorithm based LEACH
13. E-LEACH: Energy LEACH
14. TDMA: Time Division Multiple Access
15. DD: Direct Diffusion

CHAPTER 1: INTRODUCTION

1.1 Wireless Sensor Network

Wireless sensors network is a wireless system of several little 'battery operated sensing devices' commonly known as sensor nodes, stationed to watch environmental or physical conditions or other parameters. A conventional sensors network comprises of a large number of sensor devices. They are linked to each other wirelessly. The sensor devices can convey amongst themselves utilising radio beacons. The sensor device is outfitted with radio transceivers, computing and sensing accessories and energy source. The resources contained in a single WSN node are scarce and confined: they possess restrained power supply, limited radio capabilities and limited on-board computational power. Hence a WSN system consolidates a gateway that unites wireless connectivity back to the wired network. This gateway is known as the base station or the sink node that also performs most of the computational tasks of the network. The base station is assumed to have an infinite power supply. The sensor devices need to transfer their sensed data to the sink node for processing. They can undeviatingly exchange information with the base station or through some intermediary sensor nodes.

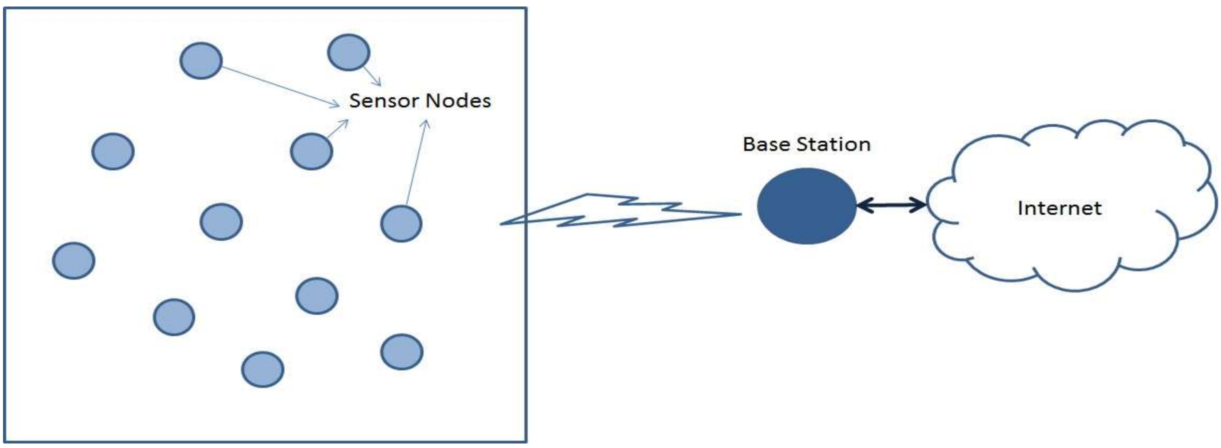


Fig. 1. Wireless Sensors Network

Communication between two nodes or with base station consumes much power, and hence the protocols and algorithms designed for communication should be energy conscious to prolong the network lifetime. Once the nodes are disposed of, they are now qualified for self-ordering into a proper system framework on a regular basis with multi-hop communication within themselves. At this point, the nodes begin gathering locally available data of importance to it. The wireless convention selected relies upon the application necessities.

1.1.1 Applications of WSN

Wireless sensor systems have enlarged notable recognition due to their adaptableness in the handling of concerns in various fields and can improve our livelihood in a broad span of ways. Wireless sensors networks have been successfully associated with diverse application spaces, for example:

- Region Monitoring: For examining a region, the nodes are distributed over a district where some phenomenon is to be observed. The moment of time when the sensors recognise the phenom being actuated (heat, humidity and so on), the phenom is communicated to the base stations, which at that instant takes proper activity.
- Agrarian area: Utilising a wireless system liberates the agriculturalist from the repairs of wiring in a problematic situation. Irrigation system mechanisation empowers more effective water utilisation and decreases waste.
- Wellbeing applications: Some of the usages for health monitoring using sensors networks are supporting GUIs for the restrained, coordinated patient examining, analysis, and managing medication in clinics, checking of an individual physiological report and trailing and checking physician or patients within a healthcare facility.
- Military usage: WSNs be suitably a central section of military regulation, administration, communications, figuring, insight, war zone reconnaissance and surveillance.
- Nature detecting:
  - Air contamination observing
  - Wildfire instrumentation
  - Habitat monitoring

    - Greenhouse observing
    - Landslide revealing
- Architectural Monitoring: WSNs can be employed to observe the actions inside structures and foundation, empowering engineering systems to control resources from a remote base; without physically being present at sight.
- Industrial checking: WSN networks provide notable cost saving infrastructure for machine control remotely, and there is no need of wired connections during installation of sensor and thus saving the wiring cost.
- Highway Checking: Real-time activity data is being gathered by Wireless sensors networks to later encourage transportation models and ready drivers of clog and movement issues. The sensors collect traffic flow statistics, like vehicle speeds, the volume of traffic, and highway densities, and then transmit this information through a wireless network to a base station.

1.1.2 Difficulties in a WSNs

A considerable number of difficulties ascend during the installation of sensors network. Sensor nodes convey over remote, unreliable lines with no foundation. An extra test is identified with the partial, generally non-sustainable power source supply of the sensor nodes. With a precise end goal to expand the lifetime of the system, the conventions should be planned from the earliest starting point with the goal of proficient administration of the vitality assets. The individual plan issues in more prominent detail.

Adaptation to internal failure: Sensor nodes are defenceless and much of the time conveyed in risky condition. Nodes can collapse because of equipment issues or environmental harm or by depleting their power supply. It is anticipated that the node crashes will be considerably greater than what is regularly viewed in traditional wireless systems or the wired networks. The conventions for such system ought to have the capacity to distinguish these disappointments as quickly as time permits and be sufficiently powerful to deal with a vast number of disappointments while keeping up the general usefulness of the system. This is particularly pertinent to the steering convention outline, which needs to guarantee that the substitute ways are accessible for rerouting of the parcels. Diverse organisation conditions posture distinctive adaptation to non-critical failure prerequisites.

Versatility: Sensor systems change in scale from a few nodes to conceivably a few hundred thousand. What's more, the sending thickness is likewise 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 heights and have the capacity for keeping up satisfactory execution.

Creation Costs: Because numerous arrangement 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, for example, a limitation framework to empower area mindful directing. 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 to be with restrained assets as far as energy, processing force, memory, and interchanges capacities. Of these requirements, energy utilisation is of vital significance, which is exhibited by the expansive number of calculations, methods, and conventions that have been produced to spare energy, and along these lines expand the network life. Topology Route control is a standout amongst various critical concerns investigated for diminishing power utilisation of WSN systems.

Power Dissipation: As we have as of now observed, large portions of the difficulties of sensor systems rotate around the restricted power assets. 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 extra energy for calculation as well as separate. The vitality arrangement 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.

1.1.3 Architecture of WSN

The design of a WSN incorporates distinctive network topologies for wireless correspondences systems. The some of the network topologies which apply to distributed network systems are illustrated beneath:

Star Topology

This system employs the network topology in which an individual sink node can transmit or receive messages to/from the various sensors. Such nodes cannot transmit the messages to each other until there is establish routes among the nodes. One of the main benefits of the star network is that it can incorporate effortlessness, capacity for remote sensor systems by keeping or maintaining the remaining energy of node to the certain level so that there is an enhancement of longer period. Similarly, this topology permits less latency transmission connecting the sensor nodes and the sink node.

The limitations of star topology is that there is only single sink node at the center to which all the nodes in the network can communicate the sensed data to this node and thus leads to congestion at this node. Also, a single node cannot manage the network whenever node failures occur. For WSN, the sink node must be reachable for all the sensor nodes.

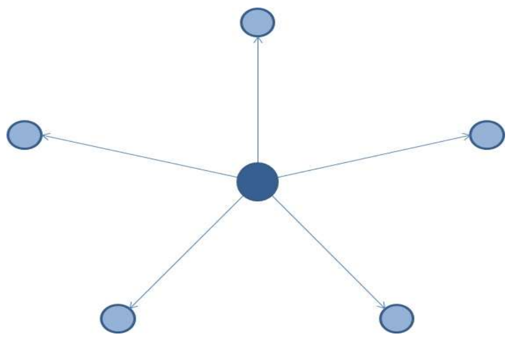


Fig. 2. Star Topology

Mesh Topology

A mesh topology supports multi-hop path communication in which multiple nodes transmit the sensed information to other nodes. In the cases where multi-hop communication is applied, if a node cannot directly transmit its sensed data to the sink node, then it is permitted to utilise in-between nodes to convey the information to the sink node. The mesh network topology supports the scalability in term of adding more number of nodes depending upon the vast usage in various applications. Of course, the transmission range is the main problem in this system. Mostly, it is noticed that multi-hop communications consume more power of the deployed nodes during data transmission and thus increases the energy depletion of nodes due to more number of hops between them. One of the main benefits is that it avoids the data redundancy while sending the data to the sink node.

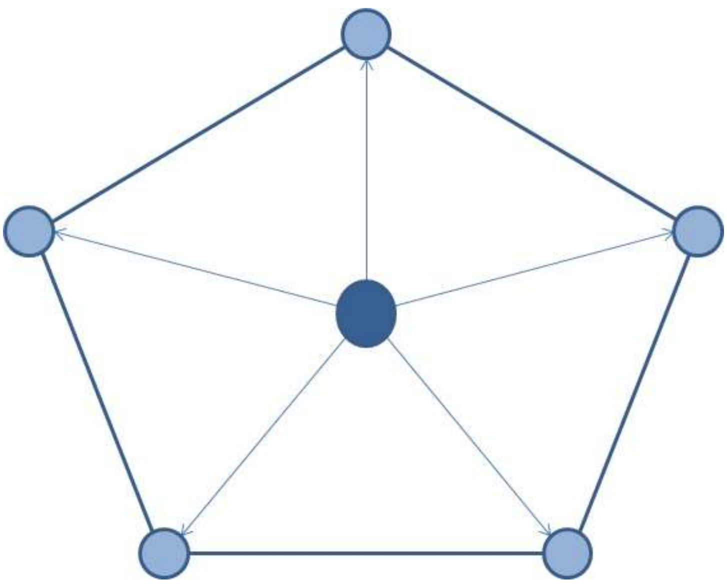


Fig. 3. Mesh Topology

1.1.4 Components of Wireless Sensor Node

In WSN node, there are four essential parts, for example, detecting unit, handling unit, power and handset unit as shown in figure 4. This additionally has application subordinate extra parts, for example, an area discovering framework, a power generator and a mobilizer. Detecting units are normally made out of two subunits: sensors and ADCs. The analogue signal created by the sensors are changed over to digital signal by the ADC, and after that forwarded to the processing unit. The processing unit is for the most part connected with a little stockpiling unit, and it can oversee the methods that make the sensor node work together with alternate nodes to do the doled out detecting errands. A furthermore handset unit interfaces the node to the system. One of the most critical parts of a sensor node is the power unit. Control units can be upheld by a power rummaging unit, for example, sun based cells. Alternate subunits, of the node, are application subordinate. Particular plan approach gives an adaptable and flexible stage to include the requirements of varied utilizations. Just for instance, contingent upon the conveyed sensors, the flag moulding square should be re-customized and supplanted. All sensor nodes have the capability of remote sensing about varied utilizations with the remote detecting node. Essentially, the wireless connection may be interchanged as per the requirements of the given applications' remote range prerequisite and the bi-directional requirement for efficient power enhancement. A key part of any remote detecting node is its ability to limit the power devoured by the framework.

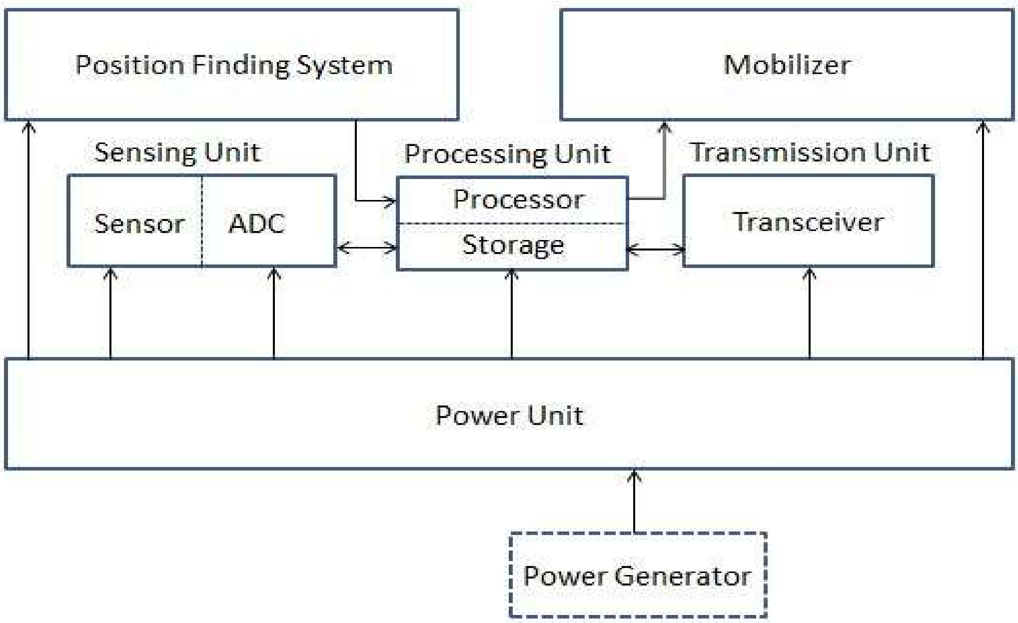


Fig. 4. Components of a Sensor Node

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

1.1.5 Communication Model

The sensor nodes are commonly dispersed in the sensor arena as presented in Fig. 1. All these scattered sensor nodes have the abilities to collect information and course this information to the base station. The convention stack utilised by the WSN nodes and the base station as shown in Fig. 5. This convention stack joins routing and energy mindfulness, incorporates information with systems administration conventions, conveys power effectively through the remote medium and advances helpful endeavours of sensor nodes. The convention stack comprises of the physical layer, data link layer, network layer, transport layer, application layer and three administration plane namely task administration plan, mobility administration plane, and power administration plane. Distinctive sorts of application programming can be constructed and utilised on the application layer contingent upon the detecting assignments.

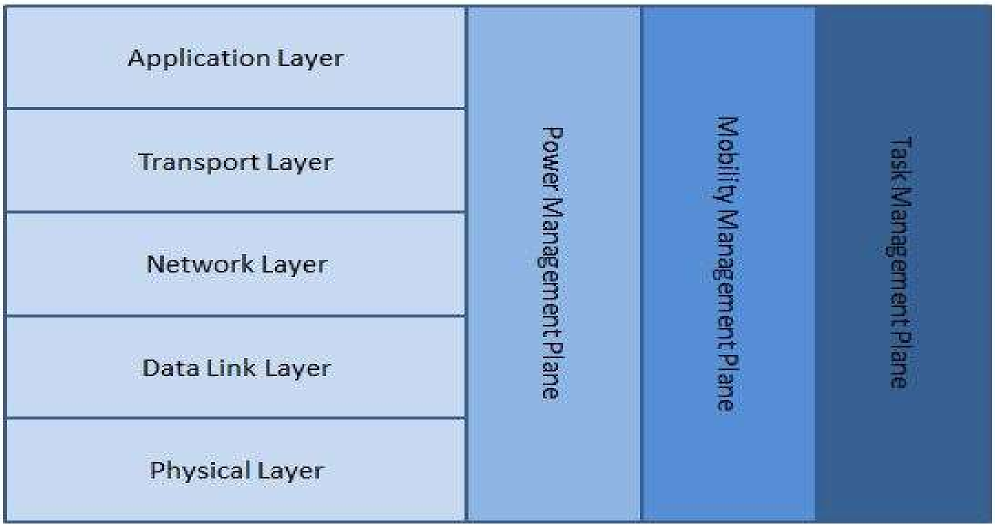


Fig. 5. Communication Model

This model focuses on making equipment and programming of the minimal layer straightforward to the end-client. The vehicle layer keeps up the information stream continuous if the sensor systems require it. The system layer deals with steering the information provided by the transport layer, particular multi-bounce remote steering conventions connecting sensor nodes and sink. The information connects the various layers such as in charge of multiplexed data streams, Media Access Control (MAC), outline location and error control. As we know that the earth is round and sensor nodes are versatile in nature. The MAC convention should be able to handle power failure and ready to limit crash with neighbors communication. Apart from this, even the physical layer includes the necessities of a basic however strong tweak, recurrence choice, information encryption, transmission and getting procedures. Moreover, the power, portability, and undertaking administration planes screen the power, development, and undertaking circulation of the sensor nodes. All the discussed plans aid the sensor nodes to organise the detecting assignment and lessen the general power utilisation.

1.1.6 Power Dissipation problems

Power dissipation is the most vital component to decide the life of a sensor arrange since as a rule sensor nodes are driven by the battery. Some of the time power streamlining is more convoluted in sensor systems since it included not just lessening of power dissipation additionally drawing out the life of the system much as could be expected. A sensor node mainly consists of four subsystems:

A processing subsystem: It includes a microprocessor which is in charge of the sensors and execution of communication conventions. Microcontroller units for the most part work under different modes for power administration purposes. As these working styles include dissipation of energy, the power dissipation of the different modes needs to be taken care while considering the nodes battery remaining capacity.

Correspondence Subsystem: In this, the short range radio can talk with outside world via neighbouring nodes stationed in the region. Moreover, such radios device can work under the several modes. Thus, there is need to shut down the radio device when it is not transmitting the data to any other radio placed remotely for preserving the energy of the subsystem.

Detecting subsystem: The combination of sensors and actuators mainly connects the several nodes to the outside world. Power dissipation should be lessened upon utilising low energy segments and thus saving the energy.

Energy source subsystem: This subsystem comprises a battery which provides energy to the node. It ought to be understood that the measure of energy drawn from the battery should be watched over. Because if more current is consumed from the same power source for quite a while, the battery will bite the dust quicker even in spite of the fact that it could have continued for a more drawn out time. Typically the appraised current limit of a battery capacity utilised by sensor node is not as much as the base Power dissipation. So, there are provisions for increasing life span of battery by decreasing the current continuously or by shutting down regularly.

For diminishing the power dissipation of WSN networks, distinctive sorts of conventions and calculations are concentrated everywhere throughout the whole domain. The life span of WSN networks must be expanded altogether with working framework related to the application layer. Furthermore, the system conventions are intended to be power mindful. These conventions and calculations must know about the equipment and ready to utilise exceptional elements of the small scale processors. Furthermore, handsets to limit the sensor nodes' power dissipation. This technique may forward the user defined answer for various sorts of sensor nodes plans. Distinctive sorts of sensor nodes sent additionally prompt distinctive sorts of sensor systems. This may likewise prompt the distinctive sorts of community calculations in remote sensor systems field.

1.2 Motivation

Based on the analysis of the existing state-of-art algorithms for cluster based data aggregation and fusion in wireless sensor networks,

- In network, selecting an optimal set of nodes as CHs is **N-P hard problem, which makes it suitable candidate for the application of enhanced evolutionary algorithms to optimize energy conservation and redundancy elimination**.

- A crucial issue faced in sensor resource management is that of **determining the optimal positions of the sensors to maximize area coverage.**
- Many Genetic and metaheuristic techniques have been applied for better solution than conventional algorithm. GWO has shown good results in many N-P hard problems such as travelling tournament problem, face recognition, test suite optimization etc.
- As In recent past most of work done on WSNs focuses on mobile adhoc sensor networks due to their wide range of potential applications **but power consumption still remains one of the critical issue for routing in mobile adhoc sensor networks ,which needs to be enhanced.**

This motivated us to address the problem of optimal clustering and cluster head selection so that the stability period and lifetime of the network could be increased.

1.3 Problem Statement

A wireless sensor network is designed to gather the information through the area and the sensed information must be transmitted to a central node that is a base station or sink. The technique through which data is gathered and transmitted to sink node through a network is important for the lifetime of the network and energy consumption. Sensor nodes 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 sensor nodes base station nodes communicate with limited number of sensor nodes.

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. Positioning of sensor nodes also affects the overall performance of the sensor network, so this addresses the following problem:
To optimize clustering and cluster head selection to increase the overall performance of the sensor network.

1.4 Scope of the work

This work introduces a cluster head selection optimization model in wireless sensor networks (WSN). It applies the grey wolf optimization. The optimization of WSN cluster heads and clustering greatly influences the network lifetime. Grey wolf optimization (GWO) is a recently proposed optimizer that has a variety of successful applications. Therefore, adapted and applied in here to solve the clustering and CH selection problem. Suitable fitness function is applied to ensure coverage of the WSN and is fed to the GWO to find its optimum.

This work had implemented a metaheuristic technique, grey wolf optimization (GWO), in wireless sensor network. It had provided improvement gains in stability period and network lifetime of wireless sensor network. Very recently GWO has been applied in [46] and has shown some positive results.

Results of this work is compared with the results of [46]. The introduced work outperforms their work in different scenarios with different parameters.

1.5 Thesis Organisation

The remainder of thesis is organised as follows: Chapter 2 contains study of WSN on the basis of data aggregation and routing. Chapter 3 contains detailed literature review. Chapter 4 contains discussion on genetic algorithm and metaheuristic techniques applied to WSN. Chapter 5 elaborates, our proposed wok, GWO in WSN. Chapter 6 shows simulation work and comparision results and Chapter 7 concludes the thesis work.

CHAPTER 2: STUDY OF WIRELESS SENSOR NETWORK

Two important parts in wireless sensor network working are:

- Routing in WSN
- Data aggregation in WSN

2.1 Routing in wireless sensors networks

Wireless sensor systems have enlarged notable recognition because of their adaptableness in handling of issues in various fields and can change our livelihood in a widespread range of ways. Wireless sensors networks have been successfully associated with diverse application spaces. Owing to a huge number of nodes in the system and the complications of the environment, it is tough and even difficult to replace or recharge batteries for the sensor nodes. Keeping in mind the end goal to viably use wireless sensors network we have to reduce the energy dissipation while cluster formation and during the exchange of information between the WSN nodes and the sink node.

2.1.1 Direct Communication

It is the simplest way of communication between a sensor node and the sink node. In this communication protocol, the sensor node sends its data to the sink node directly. The direct communication between the sensor node and the base station makes for a simple communication protocol implementation, but it has a limitation. As the energy consumed during communication depends on the distance between two parties, the nodes that are greater distance away from the sink node will be drained out of power much earlier than the nodes that are at much closer distance from the sink node. This faster draining of power will cause an unbalanced network which is not desirable in WSNs.

2.1.2 Multi-Hop Communication

Another way to communicate is through multi-hop communication. Multi-hop communication involves transmission of data to the sink node via one or more intermediary nodes. The nodes that are greater distance away from the base station transmit their data to some other node which in turn forwards it to another node or the base station. This way of communication may occur to have overcome the limitation of the direct communication method, but it also has its own limitation. In this method, the nodes that act as intermediary nodes drain out of power faster than other nodes. Hence the nodes nearer to the sink node are more probable to drain out of power than that are at much greater distance from the base station. So there came a need for some other method for information exchange between sensor nodes and the sink node. Another problem that ascends during exchange of information between sensor nodes and the sink node is the transfer of a lot of redundant data from sensor nodes to the sink node. Most of the data sensed by sensors that are near to each other are redundant, and this data is forwarded to the sink node. Unwanted energy is wasted to transmit this data to sink node. If somehow this redundancy can be removed, network lifetime can be enhanced multiple folds.

2.1.3 Need of Clustering

To process the data sensed by the sensor nodes, the sensor nodes have to send this data to the base station. Two major problems come into picture while the communication between the sensor node and the base station takes place. The first problem is the unbalanced network due to uneven consumption of energy in the sensor nodes. This problem can be explained as follows. The communication between the sensor node and the base station can take place in two ways. The first way is direct communication method. It is the simplest way of communication between a sensor node and the sink node. In this communication protocol, the sensor node sends its data to the sink node directly. The direct communication between the sensor node and the base station makes for a simple communication protocol implementation, but it has a limitation. As the energy consumed during communication depends on the distance between two parties, the nodes that are greater distance away from the sink node will be drained out of power much earlier than the nodes that are at much closer distance from the sink node. This faster draining of power will cause an unbalanced network which is not desirable in WSNs. Another way to communicate is through multi-hop communication. Multi-hop communication involves transmission of data to the sink node via one or more intermediary nodes. The nodes that are greater distance away from the base station transmit their data to some other node which in turn forwards it to another node or the base station. This way of communication may occur to have overcome the limitation of the direct communication method, but it also has its own limitation. In this method, the nodes that act as intermediary nodes drain out of power faster than other nodes. Hence the nodes nearer to the sink node are more probable to drain out of power than that are at much greater distance from the base station. So there came a need for some other method for information exchange between sensor nodes and the sink node.

Another problem that ascends during exchange of information between sensor nodes and the sink node is the transfer of a lot of redundant data from sensor nodes to the sink node. Most of the data sensed by sensors that are near to each other are redundant, and this data is forwarded to the sink node. Unwanted energy is wasted to transmit this data to sink node. If somehow this redundancy can be removed, network lifetime can be enhanced multiple folds. The solution to these problems is to group the sensors into small groups. These groups are known as clusters. This partitioning of the wireless sensors network into clusters is called as clustering. All the clusters have their leader called cluster head. Every other member of the cluster sends its data to its cluster head. The cluster heads may directly forward all the data received to the sink node. Else, it can remove the redundancy from data collected and then forward it to the sink node. This way clustering solves the problem of transfer of redundant data from the sensor node to base station. The problem of the unbalanced network remains if static clustering is used. Static clustering means the clusters once formed are not changed. The cluster head remains same for the lifetime of the network. Now since the cluster head dissipates much more energy than the other sensor nodes, it will drain out of power much faster than other nodes.

Hence dynamic clustering is used in this thesis. In dynamic clustering, the clusters and the cluster heads keep changing. The cluster head should be chosen with care. The performance of the algorithm essentially depends on the formation of clusters and selecting the cluster heads.

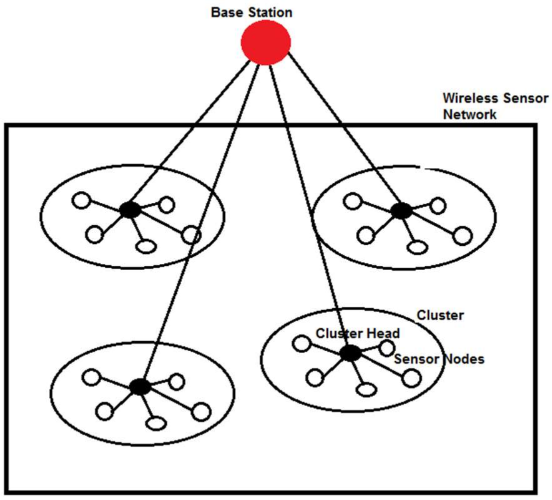


Fig.6. Clustering in Wireless Sensor network

2.1.4 Major Clustering Algorithms

2.1.4.1 LEACH

Low-energy adaptive clustering hierarchy or LEACH is a self-organizing, clustering protocol that uses a threshold value to decide the cluster heads. The threshold for every round is determined, and then the nodes generate a random number. If the random number generated is larger than the threshold, the node gets to be a cluster head for that round. Thus LEACH employs random distribution of energy load among the sensor nodes. LEACH is the clustering algorithm that focuses on extending the network lifetime by reducing the energy consumption per round. To accomplish these targets, LEACH receives a progressive way to deal with sort out the system into an arrangement of clusters. Each cluster is overseen by a chosen group head. The cluster head accepts the accountability to complete numerous undertakings. The essential operations of LEACH are sorted out in two particular stages. The primary stage, the setup stage, comprises of two stages, group head determination and cluster development. The second stage, the enduring state stage, concentrates on information accumulation, collection, and conveyance to the base station. Toward the start of the setup stage, a series of group head choice begins. The group head choice process guarantees that this part pivots among sensor nodes, in this manner appropriating energy utilisation equally overall system nodes. To decide whether the ball is in its court to end up noticeably a cluster head, a node, n, produces an arbitrary number, v, in the vicinity of 0 and 1 and analysed it to the cluster head determination limit. The node turns into a group head if it's produced esteem, v, is not as much as T (n). The group head determination limit is intended to guarantee with a high likelihood that a foreordained portion of nodes, P, is chosen cluster heads at each round. Further, the edge guarantees that nodes which served in the last 1/P rounds are not chosen in the current round.

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

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

Here, p is the desired percentage of cluster heads, r is the current round number and G is the set of nodes that have not been selected as CH in the last 1/ p rounds.

The variable G speaks to the arrangement of nodes that have not been chosen to turn into group heads in the last 1/P rounds, and r signifies the current round. The predefined parameter, P, speaks to the group head likelihood. Plainly if a node has filled in as a cluster head in the last 1/P rounds, it won't be chosen in this round. Toward the finishing of the cluster head choice process, each node that was chosen to wind up plainly a cluster head publicises its new part to whatever remains of the system. After accepting the group head notices, each residual node chooses a group to join. The fruition of the setup stage flags the start of the consistent state stage. Amid this stage, nodes gather data and utilise their dispensed openings to transmit to the cluster head the information gathered. This information gathering is occasionally performed. Recreation comes about demonstrate that LEACH accomplishes noteworthy energy investment funds.

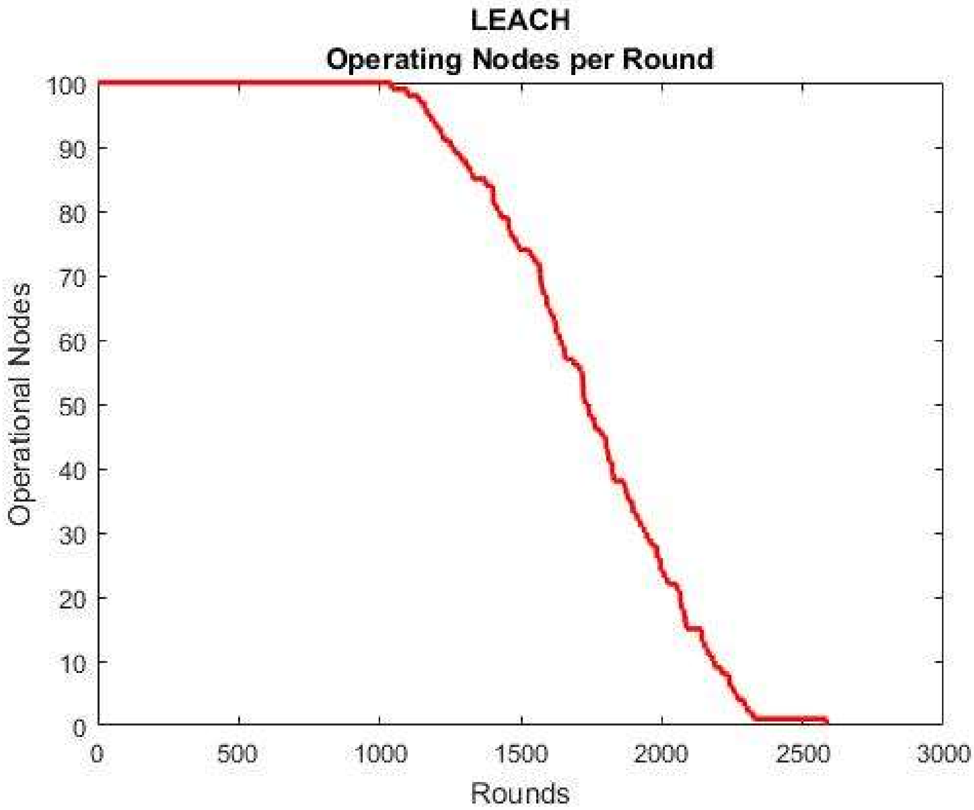


Fig.7. LEACH Result: Number of alive nodes

These investment funds depend essentially on the information collection proportion accomplished by the cluster heads. Regardless of these advantages, in any case, LEACH endures a few weaknesses. The suspicion that all nodes can achieve the base station in one jump may not be reasonable, as capacities and energy stores of the nodes may fluctuate after some time starting with one node then onto the next. LEACH is a totally circulated calculation, requiring no control data from the base station. The cluster administration is accomplished locally, which decimates the requirement for worldwide system information. Besides, information accumulation by the cluster likewise contributes extraordinarily to energy forgiving, as nodes are never again required to send their data specifically to the sink. It has been indicated utilising recreation that LEACH beats customary directing conventions, including coordinate transmission and multi hop directing, least transmission-energy steering, also, static clustering–based steering calculations.

2.1.4.2 PEGASIS

The convention goes for expanding the lifetime of a system by accomplishing an abnormal state of vitality productivity and uniform energy utilisation overall system nodes. Second, the convention endeavours to decrease the hold-up that information brings about on their way to the sink. The system demonstrates considered by PEGASIS accept a homogeneous arrangement of nodes sent over a topographical range. Nodes are accepted to have worldwide information about other sensors' positions. Moreover, they can control their energy to cover discretionary reaches. The objective is to create a steering structure and a conglomeration plan to lessen energy utilisation and convey the collected information to the base station with insignificant deferral while adjusting energy utilisation among the sensor nodes. As opposed to different conventions, which depend on a tree structure or a group based progressive association of the system for information social affair and scattering, PEGASIS utilises a chain structure. Nodes speak with their nearest neighbours. The development of the chain begins with the most distant node from the sink. Arrange nodes are added to the chain dynamically, beginning from the nearest neighbour to the end node. Nodes that are as of now outside the anchor are added to the chain in a ravenous form, the nearest neighbour to the top node in the present chain to start with until all nodes are incorporated. A node inside the affix is chosen to be the chain pioneer. Its duty is to transmit the amassed information to the base station. The chain pioneer part moves in situating the chain after each round. Rounds can be overseen by the information sink, and the move starts with one round then onto the next can be stumbled by a powerful reference point issued by the information sink. Revolution of the influential position among nodes of the chain guarantees, by and large, an adjusted utilisation of vitality among all the system nodes. The chain pioneer issues a token to the last node in the correct end of the chain. After getting the token, the end node transmits its information to its downstream neighbour in the chain at the pioneer. The neighbouring node totals the information and transmits them to its downstream neighbour. This procedure proceeds until the accumulated information come to the pioneer. After accepting the information from the correct side of the chain, the pioneer issues a token to one side end of the chain, and a similar conglomeration process is completed until the information achieve the pioneer. After accepting the information from both sides of the chain, the pioneer totals the information and transmits them to the information sink. The chain-based twofold approach prompts huge vitality diminishment, as nodes work in an exceedingly parallel way. Besides, since the various levelled, treelike structure is adjusted, the plan ensures that after log_2N steps, the collected information touch base at the pioneer. The chain-based double accumulation conspires been utilised in PEGASIS as another option to accomplishing a high level of parallelism. With CDMA-skilled sensor nodes, it has been demonstrated that the plan performs best as for the energy defer item required per round of information assembling, a metric that adjusts the energy and defers the cost.

2.1.4.3 SEP

In SEP, the effect of heterogeneity of nodes is studied in wireless sensors networks that are progressively grouped. In these systems, a portion of the nodes move toward becoming group heads, total the information of their cluster individuals, what's more, transmit it to the sink. We expect that a rate of the populace of sensor nodes is outfitted with extra vitality assets—this is a wellspring of heterogeneity which may come about from the underlying setting or as the operation of the system develops. We likewise expect that the sensors are haphazardly (consistently) dispersed and are not versatile, the directions of the sink and the measurements of the sensor field are known. We demonstrate that the conduct of such sensor systems turns out to be extremely precarious once the main node kicks the bucket, particularly within sight of node heterogeneity. Established grouping conventions expect that all the nodes are furnished with a similar measure of vitality, and as a result, they cannot take the full preferred standpoint of the nearness of node heterogeneity. SEP is a heterogeneous-mindful convention to drag out the time interim before the demise of the main node (we allude to as steadiness period), which is pivotal for some applications where the criticism from the sensor organise must be dependable. SEP depends on weighted decision probabilities of every node to wind up cluster go to the rest of the energy in every node. We appear by recreation that SEP dependably drags out the solidness period contrasted with (and that the normal throughput is more prominent than) the one got utilising current clustering conventions. We finish up by concentrating the affectability of our SEP convention to heterogeneity parameters catching vitality irregularity in the network. SEP yields longer steadiness district for higher estimations of additional energy brought by more intense nodes.

Table I. Cluster Based Data Aggregation				
Algorithms	**Network Structure**	**energy consumption balancing**	**cluster head placement**	**determining the optimal number of cluster heads**
LEACH	Hierarchical cluster	battery reduction, stable node energy consumption	Huge energy consumption	Not optimal
HEED	Hierarchical cluster	Imbalance due to network structure	node's residual energy	cluster radius
EEHC	Hierarchical cluster	energy savings increase with the number of levels in the hierarchy of cluster heads	Nearest in k hop distance	Not optimal
TEEN	Hierarchical cluster	buffer mechanism	Threshold is maintained	Based on two thresholds.
SEP	heterogeneous two-level hierarchical network	Using different type of nodes and energy	Probabilistic approach	Depends on no. of sensor nodes, network diameter, average distance between a cluster member and its cluster head

2.2 Data aggregation and fusion in wireless sensor networks

The wireless sensor networks [3] are becoming a significant enabling technology in many sectors. The sensor network is composed of lightweight network-enabled sensing devices, deployed in bulk to achieve network connectivity and reliability in results. The communication between sensors is accomplished via wireless channel.

Specialists visualize a huge arrangement of modern applications to be made conceivable with the guide of WSNs. Specifically, they guarantee that WSNs will reform the way people collaborate with their physical environment. A few cases of such applications incorporate military applications (e.g. war zone reconnaissance, well disposed/threatening powers following, checking of gear), natural observing (e.g. surge/woods fire location, space investigation, natural assault identification), wellbeing applications (e.g. incorporated patient observing, diagnostics, following and checking specialists and patients inside a doctor's facility) and numerous other business applications (e.g. home/office shrewd conditions, natural control in structures).

Data aggregation [5] largely determines the degree of optimization in the performance of sensor network. Data aggregation is a technique of collecting raw data from sensor nodes, eliminating redundant measurements, and extracting the information content for onward transmission. The process ultimately diminishes the volume of accumulated information and makes in it more relevant. Data fusion is the process of joining of data got from different sources such that either the resulting data is in some sense superior to would be possible with singular sources or the correspondence over head of sending singular sensor readings to the base station is decreased. Data aggregation mechanisms in WSNs can be classified in three category structure-based, structure-free and hybrid structure, which combines characteristics from structure-free and structure-based.

However, WSNs are typically flat and randomly deployed. Hence, by nature, they require a structure-free mechanism. At the same time, the WSN are supposed to be deployed at a large scale, which introduces a complexity in terms of data aggregation and management. Therefore, a structure-based data aggregation defines a set of algorithms, made by the system developers, to divide the network into groups and/or levels. Then, these groups manage separately their data aggregation and offer to the system developer a reduced view of the network. For sure, the structure based mechanisms require an additional charge to sort out the system and to keep up this association amid the system lifetime.

2.2.1 Types of Data Aggregation

On the basis of interactions between the sensor nodes, there are four types [6] of fusion:

Centralized Aggregation

In centralized aggregation scheme [7], the sensing nodes forward data to the sink by following the shortest path. Aggregation is not performed along the forwarding nodes. The fusion process is accomplished after the entire set of data arrives at the data processing center (sink). It is suitable for single-hop sensor networks. Consequences: Increase in data traffic, Heavy congestion in the network and frequent packet drops and huge loss of information.

Tree-based Aggregation

The implementation of tree-based aggregation [5][9] requires the formation of spanning tree over the sensor network, with sink in the root position. During the transmission of the target information, the sensors (parent nodes) wait till a period of time (aggregation time) for the data to arrive from the multiple sources. Once data reaches at the parent nodes, aggregation is performed. The aggregated data is finally forwarded to the sink through the shortest path along the spanning tree. It is suitable for Networks with shorter hop counts from sensors to sink, Sensors having smaller sensing range and Sensor networks having perfectly balanced spanning tree. Consequences: Overhead of constructing and maintaining the spanning tree, Large end-to-end delays involved in aggregation along overlapping paths, Longer aggregation time results in better fusion of data but poor response time and aggregation over shortest paths is not ideal because paths from various sources to the sink may not be converged close to the objective zone.

Static Cluster Aggregation

In static cluster aggregation [10-12], the clusters are statically formed during the initial network setup phase. Once formed, cluster structure remains unchanged (static). Each cluster thereafter appoints a cluster head and rest of the members sends data to it. The cluster head performs aggregation and reports to the sink. It is suitable for Networks with less or no mobility and Area monitoring applications (recording earthquake, temperature, humidity, etc.).

Consequences: Static cluster often fails to encapsulate the requirements of the dynamic applications and not suitable for capturing the mobility of the sensor networks.

Dynamic Cluster Aggregation

In dynamic-cluster aggregation scheme [4][24] [13] [34], clusters are formed dynamically by sensing environmental parameters or target information. Moreover, the initial cluster structure is updated periodically (adaptive clusters). Multiple sensor nodes collaborate with each other to elect a cluster head. The elected cluster head receives data from its members and transmits an aggregated data packet to the sink. It is suitable for sensors with variable sensing ranges, Large sized sensor networks with increased hop count between source and sink, Mobile wireless sensor networks and Wide range of dynamic applications: forest fire supervision, wildlife monitoring, target tracking, etc. Consequences: Better energy utilization and load balancing in the network and exhibits higher degree of collaboration among the sensor nodes.

2.2.2 Role of Data Aggregation

The aggregation process facilitates the operation of sensor networks by:

- Collaborative processing of the target information
- Sufficient compression of the sensor generated traffic
- Reducing the cost of transfer of sensor data to the sink in terms of time and power
- Reduction in network workload due to transmission of redundant information
- Optimally utilizing the network bandwidth
- Conservation of battery power and increasing the network lifetime
- Ultimately improving the system throughput to a much larger extent

There are numerous algorithms for aggregation and fusion in the literature. However, finding optimal cluster based algorithms remains a challenging task. In the data aggregation, the major challenge is to minimize the energy consumption in intra cluster communication and transmission of fused information to base station.

Table II. Study of different approaches

Protocol	Year	Aggregation approach	Design Objective	Advantages	Limitations
LEACH	2002	signal processing functions to compress the data into a single signal	To minimize Global energy usage by distributing the load to all the nodes at different points in time	Protects from Battery reduction And stability in nodes energy consumption.	wastes energy during CH selection phase & uses a huge amount of energy when CH is at large distance from the sink.
LEACHC	2000	Cluster-based, on-line, Centralised	To improve LEACH for centralised network system	It forms better balanced Clusters	it wastes energy to attain global information & not robust
HEED	2004	Hierarchical	Lifetime: number of rounds until the first node death	Multiple power levels in sensors. Cluster heads are well distributed. Achieves better performance than LEACH	network structure causes the imbalance of energy consumption about the cluster
PEGASIS	2002	nodes are organized to form a chain, so that they need to communicate only with their closest neighbors	To extend network lifetime	reduces the power required to transmit data per round	Low Scalability
PEDAP	2003	Cluster based	to minimize energy consumption in WSNs	minimum energy consuming routing for each round of communication	residual energy of the sensor node is neglected
EEBCDA	2012	Cluster head rotation in unequal sized grids	Minimize Un-balanced energy dissipation of nodes	Improved energy efficiency and prolonged network lifetime	Difficult to identify cluster sizes
TEEN	2001	By maintaining two typ of threshold	Lifetime : to reduce data stream in the networks	restrains needless data transmission by buffer mechanism	if the thresholds are not reached, the nodes will never communicate
SEP	2004	Cluster-based, on-line, distributed	Lifetime: To increase the stable period.	increase the stability period and lifetime of the network	Number of CHs is Not optimal

CHAPTER 3: RELATED WORK

Sensor networks are frequently densely conveyed to cover the region of interest. Data delivered by various neighboring nodes might be profoundly connected and excess. For occasion distinguishing applications, the same occasion might be identified and detailed by different nodes. Aggregation protocols for intermittent data gathering are usually based on arrange structure such as trees and clusters. Several works [15,16,17,18,30,31] have used the tree-based structure as a solution for productive data aggregation in WSN. The works presented in [15] and [16] are based on the change of the direct diffusion (DD) convention [18] which is one of the outstanding protocols in WSN. It is a data-driven convention, where all the correspondence is for named data, which are named using quality esteem pairs. After the data naming, the sink broadcasts a message (called interest) describing its desired data to its neighboring nodes. This broadcast passes all through the system sets up angle to demonstrate the back course of the gathered data. By sending the broadcast, the sensor node matches the properties of the measured data with the interest of the sink and after that gives its data, if there is any correspondence.

As indicated by [16], in the data aggregation process connected with DD, data got by the source nodes accumulated locally after a settled period of time, this lone reduces the data flows from the source, as opposed to precluding the immediate sending in the focal nodes. Thus, the genuine advantages of data aggregation connected in observing kind WSNs are not completely figured it out. In [16] authors proposed an enhanced data aggregation mechanism based on cascading timeouts principles, with the point of decreasing repetition caused by a lot of sending. The exactness and Real-time properties of the data are ensured by the presentation of cascading timeouts, which also balances data flows on various transmission paths. In [15] despite the fact that source nodes are close to the sink node, numerous other unnecessary nodes in the networks are included to engender interests and setup gradients to the entire system. Because of this, DD generates unnecessary movement amid data transmission. It also achieves energy wasteful data aggregation because sources don't know where to forward data for aggregation. In DD, data are collected just by shot if the gradients are established as a typical way for all sources nodes. As a result, numerous nodes engaged with amassing data are energy wasteful.

An outstanding aggregation mechanism TAG [17]: a Tiny Aggregation service for specially appointed sensor networks. It is a data-driven convention, which is based on a tree structure aggregation and is specifically designed for checking applications. This means all nodes should deliver significant data intermittently. The execution of TAG consists of two primary phases: (1) the distribution phase, where queries are disseminated to the sensors and (2) the gathering phase, where the accumulated sensor readings are directed up the aggregation tree. The distribution phase passes by a broadcast message from the sink keeping in mind the end goal to sort out the sensor nodes into a tree. As for most tree-based schemes, TAG might be wasteful in case of dynamic topologies or connection/gadget failures. The trees are especially sensitive to failures at middle of the road nodes as the related sub tree may wind up disconnected.

In cluster-based data aggregation, nodes are assembled into clusters, with one cluster head (CH) for each cluster. Members of a cluster send packets to their cluster head by means of single-jump or multihop correspondence; the cluster head aggregates got data and forwards the results to the sink by means of single-bounce or multi-jump correspondence. Critical design issues in clustering systems incorporate energy consumption adjusting, cluster head arrangement, and deciding the ideal number of cluster heads. Low energy adaptive clustering hierarchy (LEACH) [34] is a broadly known case of this sort of algorithms. It protects from battery lessening and stability in nodes energy consumption. In any case, it wastes energy amid Cluster Head (CH) selection phase and uses a gigantic measure of energy when CH is everywhere distance from the sink. In addition, it doesn't certification of good CH distribution. In Low energy adaptive clustering hierarchy-centralised (LEACHC)[14]the base station initiates incorporated calculation to choose the CHs as indicated by their area data. It forms better adjusted Clusters. Be that as it may, it wastes energy to achieve worldwide data and not robust. Hybrid energy-efficient distributed clustering approach (HEED) [21] is another normal clustering calculation in WSNs and the cluster head race strategy of it is straightforwardly identified with node's residual energy. In any case, HEED did not assess arrange structure that causes the unevenness of energy consumption about the cluster. Power-efficient gathering in sensor information system (PEGASIS)[27] convention is an upgrade over LEACH. Keeping in mind the end goal to expand arrange lifetime, nodes are composed to shape a chain, so that they have to discuss just with their closest neighbors. This reduces the power required to transmit data per round as the power depleting is spread consistently finished all nodes. Power efficient data gathering and aggregation protocol (PEDAP)[22], a sort of least spanning tree is constructed to limit energy consumption in WSNs, yet the residual energy of the sensor node is ignored.

Energy efficient clustering algorithm (EECA) for data aggregation have been proposed [23] by considering the node's residual energy as well as the normal distance to its neighbors ,the cluster head is selected and an aggregation tree is constructed to save energy on correspondence. In [26] authors proposed a novel cluster-based data aggregation convention which divides organize into grids with unequal size, the network encourage far from BS has greater size and more nodes. The CHs revolution is performed in every matrix. In spite of the fact that the CHs in the grids which are further far from BS consume more energy in each round, these grids have more nodes to partake in CHs pivot and share energy load to adjust energy dissipation. Some of the researches performed for enhancing aggregation in sensor organize used specialized branch of computational insight, for instance entropy and data hypothesis, wavelet hypothesis, Brownian movement and so on [29] a novel data aggregation technique based on wavelet entropy (DAWE) accommodated sensor arrange [11]. The authors have executed the aggregation strategy at cluster members as well as cluster head levels. Be that as it may, the spatio-fleeting relationship among the cluster members in the same cluster is not considered in this mechanism. In significance research in [12] the authors have given an energy proficient and loss less data aggregation scheme for sensor arrange scenario. In [10] Brownian Motion is connected to show the data gathering process, which reduces excess in the sensed data by performing filtration at sensor node of system hierarchy. Subsequently entropy based aggregation is performed at sensors, trailed by wavelet based data aggregation at cluster head resulting in limited number of bundle transmissions. In[19] authors have proposed data density connection degree based clustering technique for data aggregation. In [20] authors proposed to use versatility for joint energy replenishment and data gathering. A multi-practical portable substance, called SenCar was utilized, not just as a versatile data authority meandering over the field to accumulate data through short-run correspondence yet in addition as an energy transporter that charges static sensors on its movement visit by means of wireless energy transmissions.

TEEN (Threshold Sensitive Energy Efficient Network Protocol)[8] another enhanced calculation of LEACH it restrains needless data transmission by cushion mechanism to decrease data stream in the networks, sequentially can save energy of sensor nodes so as to delay the lifetime of networks. APTEEN [44] that uses an improved TDMA schedule to effectively consolidate question taking care of. It provides a mix of proactive (by expecting nodes to occasionally send data) and receptive (by influencing nodes to respond promptly to time-to basic situations) policies. SEP (Stable Election Protocol) [28] it is a heterogeneous proactive convention, which consumes energy from the nodes having high energy and increase the stability time frame and lifetime of the system. M-LEACH [32] it is suitable for vast size system however it suffers from hotspot and restricted scalability. As the utility of WSNs is being acknowledged, in hindsight the various challenges identified with sensor networks are going to the fore, one such issue is the dynamic organization of the sensor nodes in an observing territory.

Table III. Comparison of Probabilistic Approaches

Protocols	**Distributed/ Centralized/ Hybrid**	**CH Uniform Distribution**	**Overhead in CH selection**	**Residual Energy**	**Delay**	**Hops**	**Overhead to join a cluster**
LEACH	Distributed	No	Low	No	Low	1	Low
LEACHC	Centralized	Yes	High	Yes	High	1	High
TL-LEACH	Distributed	No	Medium	No	Medium	2	High
HEED	Distributed	Yes	High	Yes	High	1	Low
EECS	Distributed	Yes	Low	Yes	Low	1	Low
EEHC	Distributed	No	Low	No	Low	k	High
MRPUC	Distributed	Yes	Low	Yes	Low	1	Low
PEACH	Distributed	No	Low	No	Medium	k	Low
S-WEB	Hybrid	Yes	Low	Yes	Medium	1	Low
EEUC	Distributed	Yes	Low	Yes	Low	k	Low
SEP	Distributed	No	Low	Yes	Low	1	Low
DEEC	Distributed	No	Low	Yes	Low	1	Low
TEEN	Distributed	No	Low	No	Low	k	Low

Ozturk et al.[38] were the first to use the ABC metaheuristic to direct the movements of sensors in a sensing field for maximizing coverage area. The authors used a sensor network that comprised of both static and mobile sensors. Bhondekar and Vij [39] proposed a node deployment approach using the genetic algorithm. The authors used a multi-objective fitness function whose parameters included field coverage, sensor overlap error, network energy etc. Every deployment was coded as bit string sequences and each was evaluated using the fitness function.

Zou and Chakrabarty[40] suggested a new approach using a probabilistic localization algorithm along with virtual forces (VF) for maximizing coverage area. The VF algorithm uses a force directed approach for moving the sensors to improve the coverage. The VF algorithm had the advantage of minimal computational overhead and one-time sensor repositioning. Wu et al.[41] used a metric called DT- score on the basis of which a deployment sequence was generated. DT- score aims at maximizing area coverage in a static environment with obstacles. The initial deployment of sensors was done using a contour based method to minimize the number of holes which were later filled using Delaunay tri-angulation. Kukunuru et al.[42]proposed a new approach that used particle swarm optimization (PSO) for maximizing coverage area at the same time decreasing the distance between the sensors. Wang et al.[43]put forward a new approach for energy efficient coverage in WSN using distributed PSO and Simulated Annealing (SA).The fitness of a solution was gauged on the parameters of coverage and energy consumption. For reducing the energy intake, the authors proposed the use of a hybrid algorithm comprising of PSO and SA. The local best and the global best solutions of the PSO are calibrated and corrected using SA which is per-formed on the nodes of the sensor network. Wang et al.[37]suggested a dynamic deployment strategy for coverage control in sensor networks using Biogeography Based

Optimization (BBO) meta-heuristic. In BBO, the initial solutions are called 'habitats 'and the fitness function is called the Habitat Suitability Index (HIS). New solutions are generated by using two operations called the migration operation and the mutation operation. Banimelhem et al.[36]proposed a GA based algorithm for reducing the number of holes left after the random deployment of static sensor nodes. They suggested an algorithm that not only guides the mobile nodes to cover the holes by calculating their best position, but also determines the minimum number of mobile sensors required to achieve the objective. Chen et al.[35]proposed a memetic based multi-objective optimization of the coverage problem in sensor networks. In their work, the authors propose the use of multiple local searches to find better deployment sequences that had high area coverage, efficient node utilization, and increase network lifetime.

Because of the vast powerful nature of wireless channel, conventional metrics used such as jump tally by and large difficult to give an exceptionally dependable way estimation in Wireless Sensor Networks (WSNs) and most likely consumed more energy in correspondence . AODV is a standout amongst the most usually used steering convention for the two MANETs and WSNs. Be that as it may, in WSNs, when the versatility is high, AODV needs to discover new paths to the destination much of the time as the effectively established links breaks because of node development [33]. In [31] authors proposed a novel steering approach using a subterranean insect state enhancement calculation which uses fake ants. every insect chooses the following bounce, also the pheromone focus sum attends to the node's outstanding energy by this technique ,the subterranean insect selects a node with longer life time. AntNet [30] is based on the standard of subterranean insect settlement improvement. In AntNet, every node maintains a steering table and an extra table containing statistics about the activity distribution over the system. In [25] the AntHocNet calculation has been proposed which consists of both receptive as well as proactive components. In AntHocNet a source node responsively sets up a way to a destination node toward the start of every correspondence session.

CHAPTER 4: Genetic and Metaheuristic techniques in WSN

Wireless sensor systems have enlarged notable recognition on account of their versatility in dealing with issues in different application spaces and can change our lives in an extensive variety of ways. WSNs have been adequately associated with differing application spaces. Clustering in wireless sensors network is a significant aspect that decides the lifetime of the system. Even many of the well-known clustering methods have been designed keeping in mind the energy consumption and network scalability. The aim of clustering has always been on finding clusters set, reducing overall power consumption in the network, and the lifetime enhancement of the network. The increase in the lifetime comes as a result of proper load balancing among the sensor nodes. In this thesis, a cluster head selection algorithm, GWO, is proposed to increase the lifetime of the network. The proposed algorithm is a meta-heuristic technique, compared with other algorithms, and indicate the better performance of as compared to other algorithms.

Some of the optimization techniques that have been proposed earlier and gained popularity are Genetic Algorithm (GA), Ant Colony Optimization (ACO), and Particle Swarm Optimization (PSO) etc.

4.1 Ant colony optimization

The ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. Artificial Ants stand for multi-agent methods inspired by the behavior of real ants. The pheromone-based communication of biological ants is often the predominant paradigm used. Combinations of Artificial Ants and local search algorithms have become a method of choice for numerous optimization tasks involving some sort of graph, e. g., vehicle routing and internet routing.

Paper [48] proposed an energy-effective QoS routing algorithm. The algorithm speeds up the convergence of ant colony algorithm by using SNGF to optimize routing candidate nodes, the pheromone is defined as a combination of link load and bandwidth delay, Then, in order to balance the energy consumption of network , node energy is used as the control factor of the ant colony algorithm. The nodes with high energy, which satisfy the QOS requirements and high energy of nodes as the next-hop routing, Simulation results showed that the protocol was effective in prolonging the life cycle of the network and balancing energy consumption.

4.2 Particle swarm optimization

Particle swarm optimization (PSO) is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. It solves a problem by having a population of candidate solutions, here dubbed particles, and moving these particles around in the search-space according to simple mathematical formulae over the particle's position and velocity. Each particle's movement is influenced by its local best-known position, but is also guided toward the best-known positions in the search-space, which are updated as better positions are found by other particles. This is expected to move the swarm toward the best solutions.

In [44], particle swarm optimization (PSO) technique has been proposed to solve the problem of optimization in clustering nodes. This approach works similar to the swarm of bees or birds and tends to find a best solution for the described problem while working in group. These meta-heuristic methods evaluate the solution on the basis of some fitness function thereby reducing the energy consumption [44, 45].

4.3 Grey wolf optimization

Another optimization approach proposed in [1] is Grey wolf optimizer method. This method is inspired from the hunting approach of the grey wolves which are considered to be top predators. Grey wolves generally move in pack of around 5 to 12 individuals. This optimizer actually works similar to the hunting behaviour of the grey wolf‟s pack. The hunting behaviour of the pack can be explained briefly as follows (Fig. 8):

1. Tracking, chasing and approaching the prey.
2. Pursuing, encircling and harassing the prey until it stops moving.
3. Attacking the prey.

The leader of the pack is called as alpha. It can be a male or female which makes decision on hunting, wakeup time, sleeping place etc. The rules/orders made by alpha are to be obeyed by the rest of the pack/group. Hence alpha possesses the to-most level in the hierarchy [1, 2]. The next order in the grey wolf pack is beta. The beta wolf is responsible for advising the alpha in decision making process and to make alpha‟s decision to be followed by other lower level pack. Beta can be male or female. He/she is responsible to maintain discipline among the pack. In case of alpha‟s death or similar circumstances, beta is the appropriate candidate to take alpha‟s place.

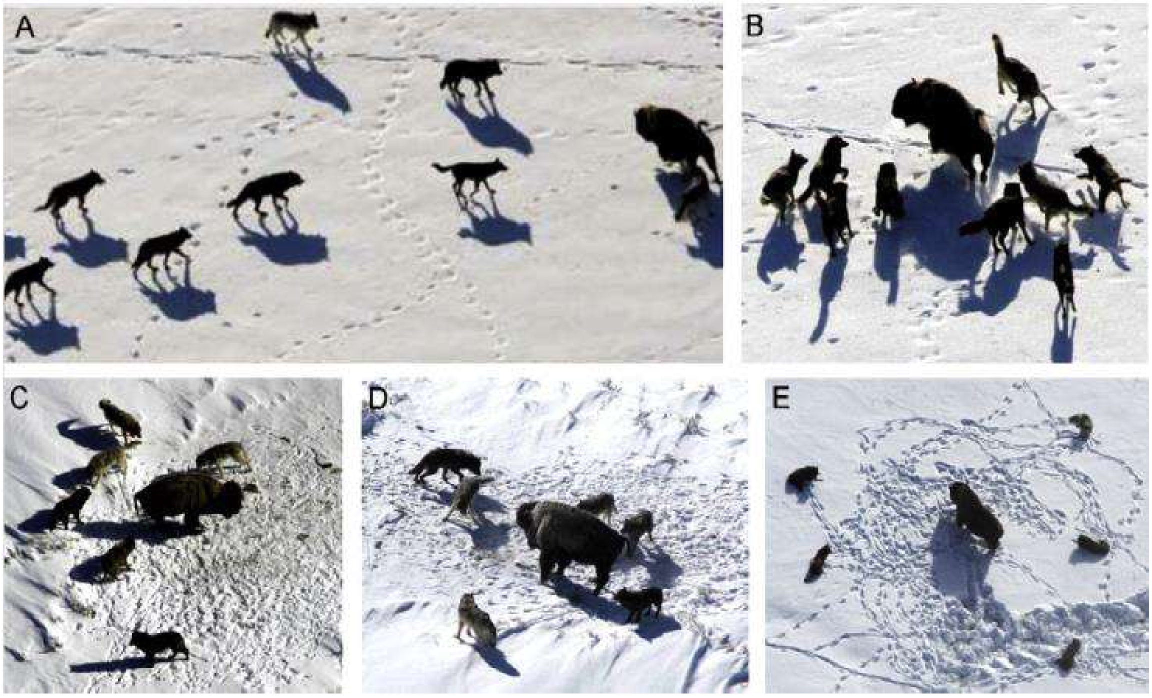


Fig. 8: Hunting behaviour of the pack [1]

The lowest level in the grey wolf hierarchy is omega. This category of wolf is dominated by all other wolves and has to surrender to the dominant wolves. Omega wolves have to follow all the orders given by the superior wolves. They are even allowed to eat at last when all other wolves finish eating. From this, it seems that omega wolves are not as important as other wolves.

Another level is delta level in the hierarchy. Delta wolves come at lower level than alpha and beta but at higher level than omega. Delta wolves have to surrender in front of alpha and beta but they dominate omega. This category of wolves is comprised of caretakers, elders, hunters and scouts. So there overall responsibility is to safeguard the pack and take care of pack concerning their heath and food. The hierarchy of grey wolves is shown in Fig. 9.

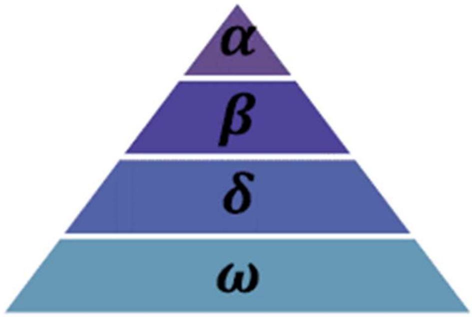


Fig. 9: Grey Wolf Hierarchy[1, 2]

The best solution in mathematical representation of social hierarchy of wolves while designing Grey Wolf Optimizer (GWO) is considered to be alpha ‘α’. The 2nd and the 3rdbest solutions are ‘β’ and ‘δ’ respectively. The hunting decisions are taken by α, β and δ wolves whereas ‘ω’ (omega) wolves obey above 3 wolves. Fig. 10 depicts the possible hunting locations and encircling behaviour of wolves.

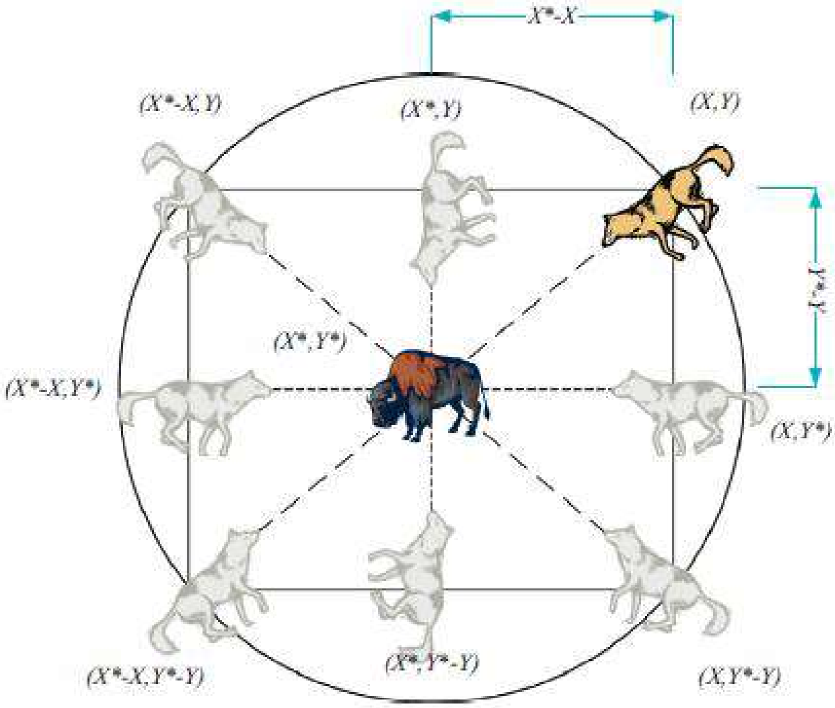


Fig. 10: Possible hunting locations and encircling behaviour of wolves [1,2]

The encircling behaviour of the wolves around its prey can be represented mathematically as follows:

$$\vec{D} = |\vec{C}.\vec{X}_p(t) - \vec{X}(t)|$$

$$\vec{X}(t+1) = \vec{X}_p(t) - \vec{A}.\vec{D}$$

Where, X is the position vector of the wolf, A and C are coefficient vectors and t is the current iteration

GWO in WSN: In recent work [46] GWO is adapted and applied to solve cluster head selection problem. Results were compared with conventional protocol in different deployments. It successfully increases network lifetime and stability period.

In [46], cluster head selection is done by finding those cluster heads which minimises the following equation:

$$J = \sum_{j=1}^{x} \sum_{i=1}^{k} ||x_i^j - c_j||^2$$

Where x^j_i is node i in cluster j, c_j is the head for cluster j, and x^j_i- c_j is the distance between node and the cluster head.

In the next chapter our proposed technique for implementing GWO in WSN is described.

CHAPTER 5: PROPOSED WORK

In this chapter we adapt GWO technique for wireless sensor network. This addresses the WSN problem of optimising:

- Formation of clusters
- Selection of cluster head

To solve this problem a fitness function is required and optimised accordingly.

5.1 Cluster Formation and Cluster Head Selection

Clusters are formed by a group of nodes and moderated by one single node called cluster head. This head performs extra functions than other nodes such as data aggregation. The role of nodes is to gather the data from the environment around with fixed sensing rate. They are connected to the head of the cluster. All sensors in single cluster send the collected data packets cluster head. Each cluster head compress and aggregate the data packets and forward it to the base station.

Formation of clusters is designed based on the fitness function. Finding the cluster head nodes (N) that minimizes this equation is the objective of optimization.

$$F(P_i) = E_1(P_i) + \mu\, E_2(P_i)$$

$$E_1(P_i) = \sum_{k=1}^{K} \sum_{\forall n_{k_j} \in C_k} \frac{f\left(n_{k_j}, CH_k\right) - E_{min}}{E_{max} - E_{min}}$$

$$E_2(P_i) = \sum_{k=1}^{K} \frac{g(CH_k,BS) - E_{min}}{E_{max} - E_{min}}$$

$$f\left(n_{k_j}, CH_k\right) = \begin{cases} s^2\left(n_{k_j}, CH_k\right) & if\ s\left(n_{k_j}, CH_k\right) \le d_0 \\ s^4\left(n_{k_j}, CH_k\right) & if\ s\left(n_{k_j}, CH_k\right) > d_0 \end{cases}$$

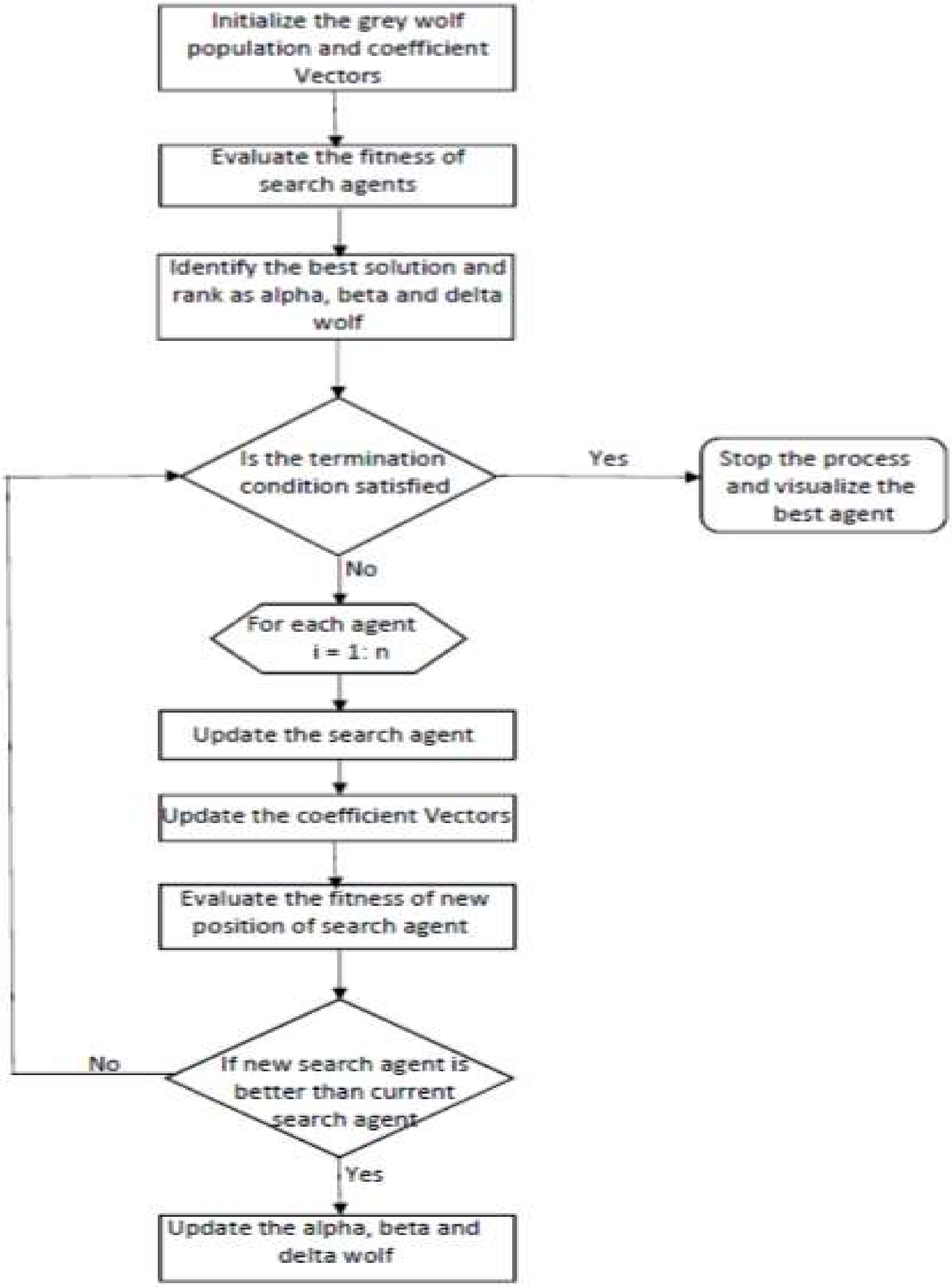
$$g(CH_k, BS) = \begin{cases} d^2_{CH_k,BS} & if\ d_{CH_k,BS} \le d_0 \\ d^4_{CH_k,BS} & if\ d_{CH_k,BS} > d_0 \end{cases}$$

$$s(n_i, CH_k) = \frac{\min(s_{n_i,CH_k})}{\forall k = 1,2,\ldots,K}$$

Where, $d_{i,j}$ is the distance between node i and node j; s is a function that finds the minimum distance cluster head for a given node; f is a function whose value for a given node is proportional to the energy consumed in communication between the node and its cluster head; similarly g signifies the energy loss due to cluster head and base station communication; E_{max} and E_{min} are the maximum and minimum energy loss in the network. C_k is the k^{th} cluster in a solution.

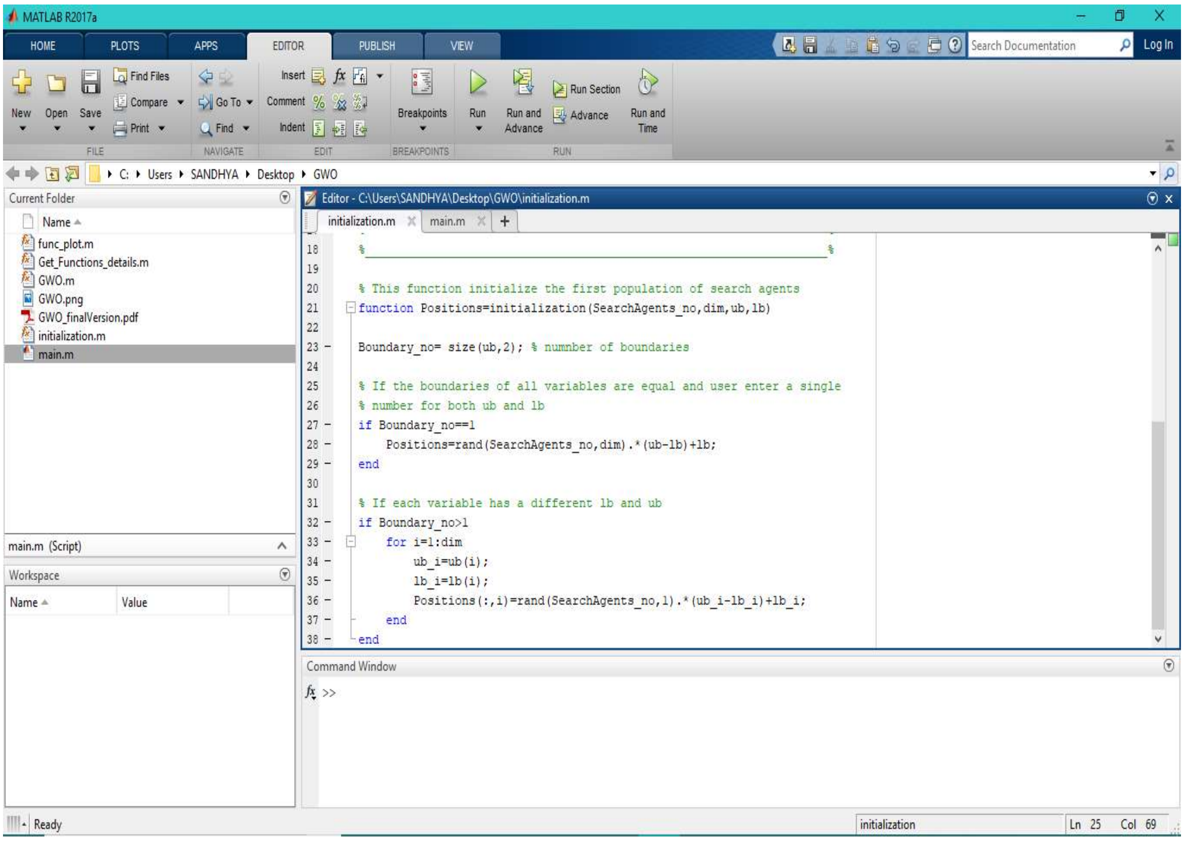
E_1 and E_2 are two normalized functions that represent the energy dissipated in intra-cluster communication and due to communication between sink and CHs respectively. F is the fitness function and aim is to minimize this function.
μ is a controlling parameter for controlling the distance between base station and cluster heads. The higher the value of μ shows the closer CHs from BS. K is the number of cluster heads. K random nodes are choosen as cluster heads and remaining nodes join the cluster whose CH is at minimum distance from it. Then the value of fitness function is evaluated for each node.

5.2 Illustration



The proposed GWO implementation targets the randomly deployed stationary nodes. It assumes m nodes that represent the CH search agents (wolves), ($CH = CH1, CH2 \ldots CHm$). In order to mimic the positions of the wolves in GWO, and since changing the position of a static sensor node is not possible, the search agent's position (candidate CH) is represented by $\overrightarrow{CH_i}$ in a two-dimensional space that represents the nodes' positions ($Pos_i(t) = x_i(t), y_i(t)$). The final solution is obtained by considering the nearest node to the best search agent position (α position).

At the start, nodes with higher energy are considered for Cluster heads.
Then in iteration, for each non-cluster head node paired with each considered cluster heads and fed to our fitness function.
Those providing optimized results are taken and thus clusters are formed.



CHAPTER 6: SIMULATION AND RESULT

This chapter consist of two parts: first part shows the result of our implementation of GWO with four different deployments and two parameters and the second part compares our results with the recent work dine in [46].

Tool Used: The simulation of the above algorithm has been carried out using MATLAB. The network parameters used are same as used in previous work of [46]. Results are examined on four different WSN deployment.

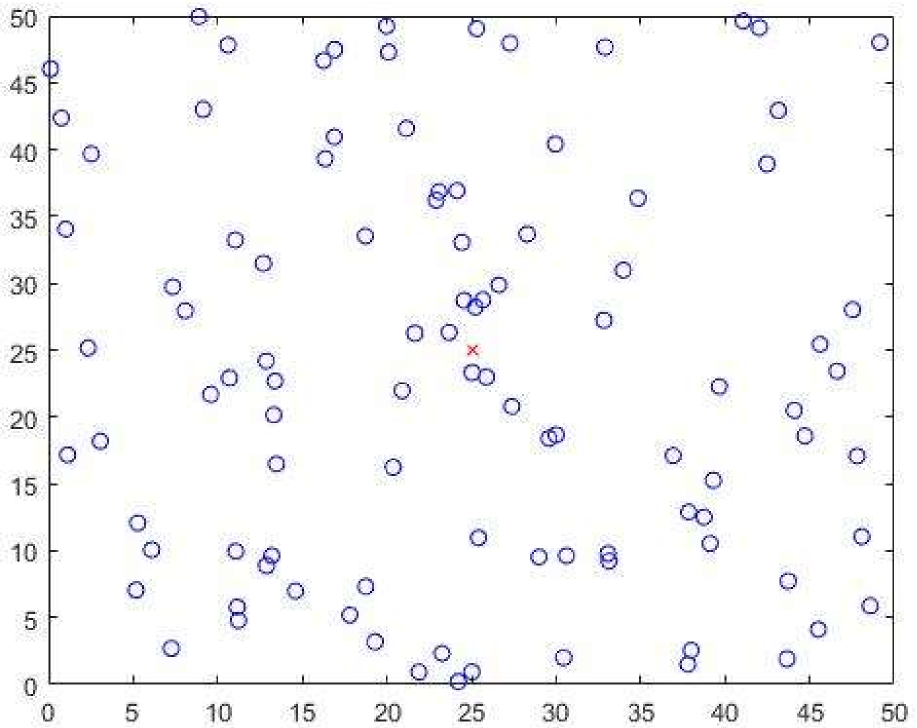


Fig 11. Random Sensor Network

6.1 Simulation and result of our proposed technique

Generated results with different deployments and different parameters are shown and explained in the following:

TABLE IV: Network Model Parameters

ID	Area	No. of nodes	Base Station
A	70 X 70	25	35,145
B	100 X 100	100	50,175
C	250 X 250	150	125,325
D	300 X 300	175	150,375

A. The network area is a 70m*70m field with 25 sensor nodes randomly uniformly distributed over the network area. The base station is located at x=35m and y=145m coordinate. Each sensor node is given an initial energy E0=0.5J. The energy is consumed as per the radio model.

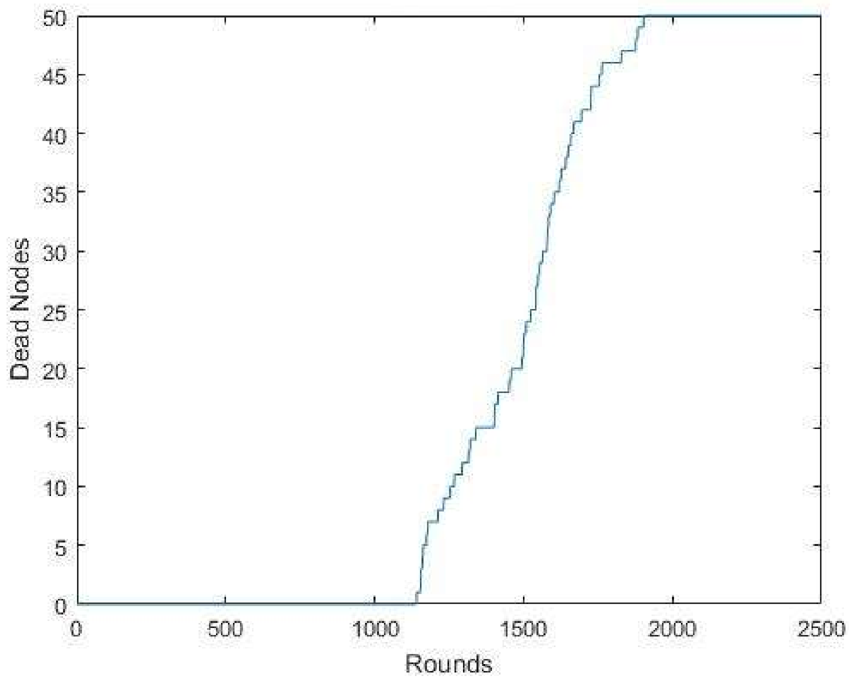


Fig 12. Result 1

B. The network area is a 100m*100m field with 100 sensor nodes randomly uniformly distributed over the network area. The base station is located at x=50m and y=175m coordinate. Each sensor node is given an initial energy E0=0.5J.

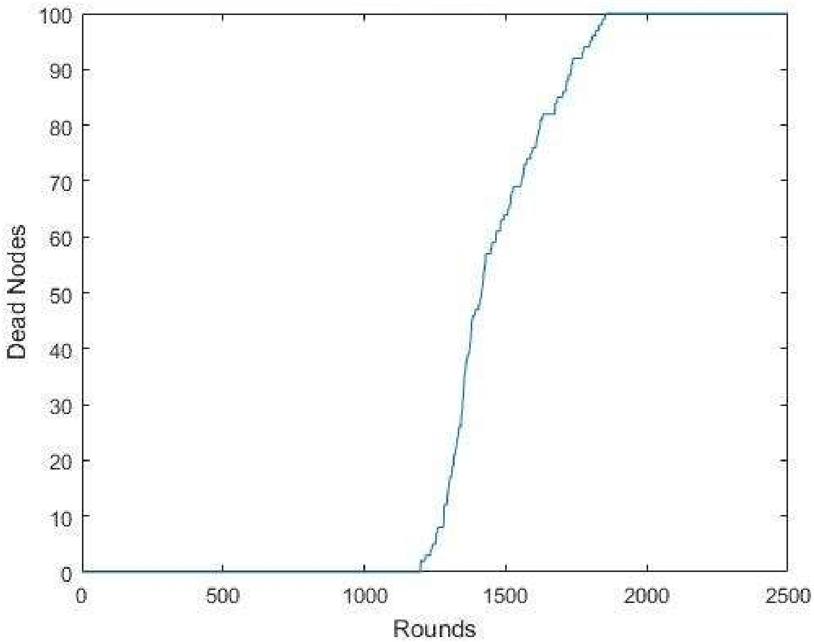


Fig 13. Result 2

C. The network area is a 250m*250m field with 150 sensor nodes randomly uniformly distributed over the network area. The base station is located at x=125m and y=325m coordinate. Each sensor node is given an initial energy E0=0.5J.

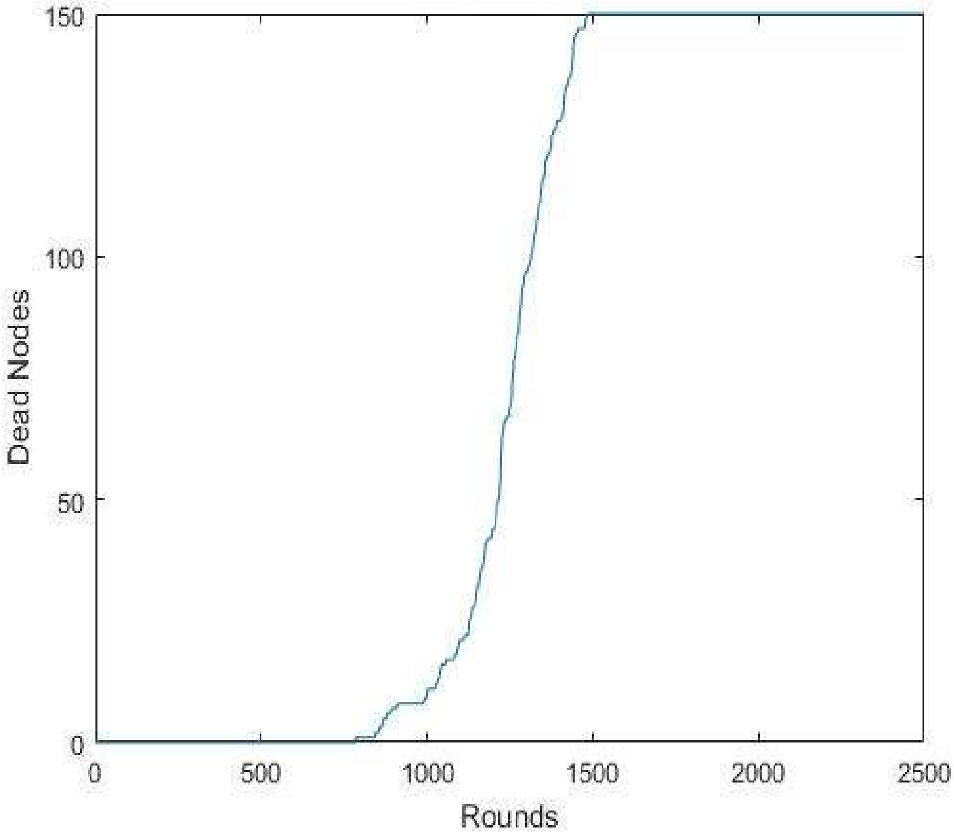


Fig 14. Result 3

D. The network area is a 300m*300m field with 175 sensor nodes randomly uniformly distributed over the network area. The base station is located at x=150m and y=375m coordinate. Each sensor node is given an initial energy E0=0.5J.

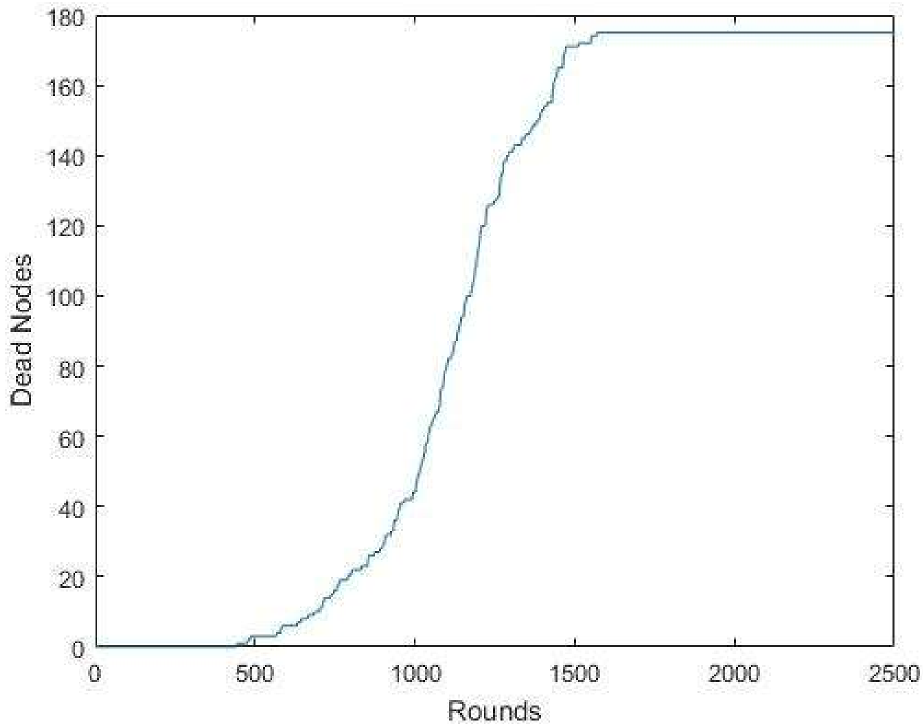


Fig 15. Result 4

6.2 Implemented results compared with recent work [46].

Results from [46] are taken and compared to our results with different deployments and parameters.

TABLE V: WSN Lifetime Analysis

ID	Lifetime	Results from [46]	Our Results
A	FND LND	1146 1307	1200 1775
B	FND LND	1029 1321	1225 1611
C	FND LND	769 1389	799 1490
D	FND LND	274 1568	481 1601

Lifetime is total activation time of the WSN. It is measured by the total number of active nodes from the network initialization to the death of the last node.

• First Node Death (FND): is the total active time of the WSN till the death of the first node. The longer this interval is, the more stable will be the network.

• Last Node Death (LND): is the total active time of the WSN till all the network nodes die. This measures the network lifetime. Table V shows the round number for FND and LND. The longer the FND the better optimization is achieved.

This simulation shows, in comparison to the results of [46], our simulation results are better in terms of better FND and LND values.

CHAPTER 7: CONCLUSION & FUTURE SCOPE

Conclusion: In this thesis, an algorithm, GWO (Grey Wolf Optimisation) algorithm, is proposed for clustering problem, with the aim to optimally select cluster heads in the wireless sensor network. The central focus of the proposed algorithm is to partition the WSN with optimal cluster heads. The algorithm successfully enhances the lifespan of the wireless sensors network. The algorithm also maximises the stability period of the network.

Simulated work in MATLAB is compared with the work in [46]. Results are compared for four different WSN deployment. The results show that the proposed technique is better than previous work done in terms of network lifespan, stability period and reliability.

Future Scope: Genetic and metaheuristic technique has shown good improvements in WSN in many recent works. Other evolving metaheuristics like Bat, bees, glow-worm swarm, spiral, and whale etc. can be applied in WSN for data aggregation as well as routing. These can be applied for clustering and cluster head selection and can optimise the functionality to gain better network performances.

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