JIMMA UNIVERSITY

INSTITUTE OF TECHNOLOGY

FACULITY OF COMPUTING AND INFORMATIC

PROGRAM-COMPUTER NETWORKING

Parabolic Trajectory of UAV For Energy Efficient Approach To Extend Network Life Time In WSN.

By: Girma Debele

A THESIS IS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSITY IN PARTIAL FULFILLMENT FOR THE REQUIREMENT OF THE DEGREE OF MASTER IN COMPUTER NETWORKING WEEK END PROGRAM.

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As member of the board of examiners of the master of science thesis open defense examination, we examined the thesis prepared by **Girma Debele** and certified the candidate. We recommended that the thesis accepted as fulfilling the thesis requirement for Degree of Master of Science in Computer Networking.

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DECLARATION

I declare that the thesis work entitled "Parabolic Trajectory of UAV For Energy Efficient Approach To Extends Network Life Time In WSN" is my original work and under guidance of **Fissaha Bayu(PhD Cand) and Mr Bekan Kitaw.** All sources of material used for this thesis have dully acknowledged and submitted to Jimma university in partial fulfillment the requirement for the award master of Computer Networking

I also hereby declare that this work in partial fulfillment has not been submitted to any other university for any Degree or Diploma

Submitted By

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ABSTRACT

Wireless sensor networks (WSNs) are an important means of collecting data in a variety of situations, such as monitoring large or dangerous areas. To do so these wireless sensor networks use a variety of sensors that are used to collect data locally. These battery-powered sensors naturally make the battery a major problem in that type of network. WSN data retrieval can produce better results using unmanned aerial vehicles (UAVs). Remotely controlled, the UAV has the ability to reach everywhere and accomplish any costly task if done by humans.

Airless Vehicles (UAVs) have gained increasing popularity in WSNs which often use more sensors in a relatively wide area. Since battery capacity is limited, sensors cannot transmit long distances. It is necessary to design effective sensor data collection methods to extend the life of WSNs and improve the efficiency of data collection. In this paper, we consider the state of UAV-enabled data collection, in which the UAV can move parabolic near each SN when it collects data from it and thus reduce the connection distance to maintain the transmission capacity of SNs.

Our goal is to reduce the power consumption of the nodes by reducing the total distance of the nodes from the UAV and avoiding data sales leading to additional power consumption by considering the parabola axis. This work describes the parabolic trajectory of UAVs in WSN data collection with a limited range of communication with a large axis of parabolic pathway techniques. The results show that duplication of data was avoided which avoids the use of node power during communication.

With our new approach we will test the effectiveness of our approach in comparison to the existing line. Performance metrics are used to evaluate the power consumption of a node with a variety of nodes. Functional simulation is performed using the MATLAB simulator. In our proposed method, the total distance of nodes from the UAV up to 46.3% is shorter than other alternatives (linear trajectory). As a result, this reduces global energy consumption by up to 49.2% when compared to our line-up work.

Keywords: UAV, Parabolic trajectory, WSN, power consumption, data redundancy, MATLAB.

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Acronyms

BS Base Station

BN Boundary Node

CH Cluster Head

CDMA Collision Detection Multiple Access

CPU Central Processing Unit

CS Carrier Sense

GPS Global Positioning System

ITS Intelligent Transportation System

KOCA K-Hop Clustering Algorithm

LEACH Low Energy Adaptive Clustering Hierarchy

LoS line-of-sight

MAC Media Access Control

MILP Mixed Integer Linear Programming

MS Mobile Sink

MSRP Mobile Sink Based Routing Protocol

MULEs Mobile Ubiquitous Local area network Extensions

NCC Network control center

PEGASIS Power-Efficient Gathering in Sensor Information System

RSU Road side unit

RTS/CTS Request to Send / Clear to Send

TDMA Time Division Multiple Access

UAV Unmanned Aerial Vehicle

WSNs Wireless Sensor Networks

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

Wireless Sensor Networks (WSNs) involve devices categorized by small nodes, low energy use, limited battery life, low task processing, and low storage capacity. These self-configuring networks are easy to implement and to deploy. In these networks, communications through channels with multiple interferences and computing capabilities to operate at low energy are assessed. Sensor networks should display an optimal performance with reduced delays and provide dependable information with minimum energy use in order to provide precious information for long periods [1]. However, energy use may become a main issue because of the limited battery power. The life span of the nodes should be as long as possible to avoid constant human intervention due to the harsh environment of some of their applications, such as in the study of natural behavior, risk areas, medical industry, domestics, agriculture, battlefields, and home networks [2].

The two data transfer methods used on WSN are: single hop and multi hop [3]. In single hop communication means, the nodes away from the sink use more power than the nodes near the sink and die faster. These dead nodes create a cover hole that leads to data loss. In multi-hop transmission, nodes send data to sink into the central nodes and maintain a route table from source to destination. Medium nodes receive remote node data and transfer it to the sink. This process reduces the power consumption of remote nodes. In this case, a system-oriented approach is the use of a Mobile Sink (MS) that runs within a network area to collect data. Mobile Sink has no power barriers, although strong nodes are limited. Mobile Sink on network reduces power consumption of nodes. It also reduces the use of energy in unnecessary processes [4], such as group formation and choice of CH. MS is regarded as a small field car and collects data on nodes, either single or multi hop. In this way, the contact distance is reduced leading to reduced power consumption and higher power consumption [5].

To evaluate the network performance, one may consider parameters that evidence proper network operation directly influencing the energy consumption of each node. There are local and global parameters. Global parameters display the total energy costs for the network considering each type of energy for each specific activity. In contrast, local parameters provide total energy consumption rates for a single node. This energy depends on the location of the node within the topology regardless of how near or far they are located from the coordinator node and how much traffic is transmitted through it [6].

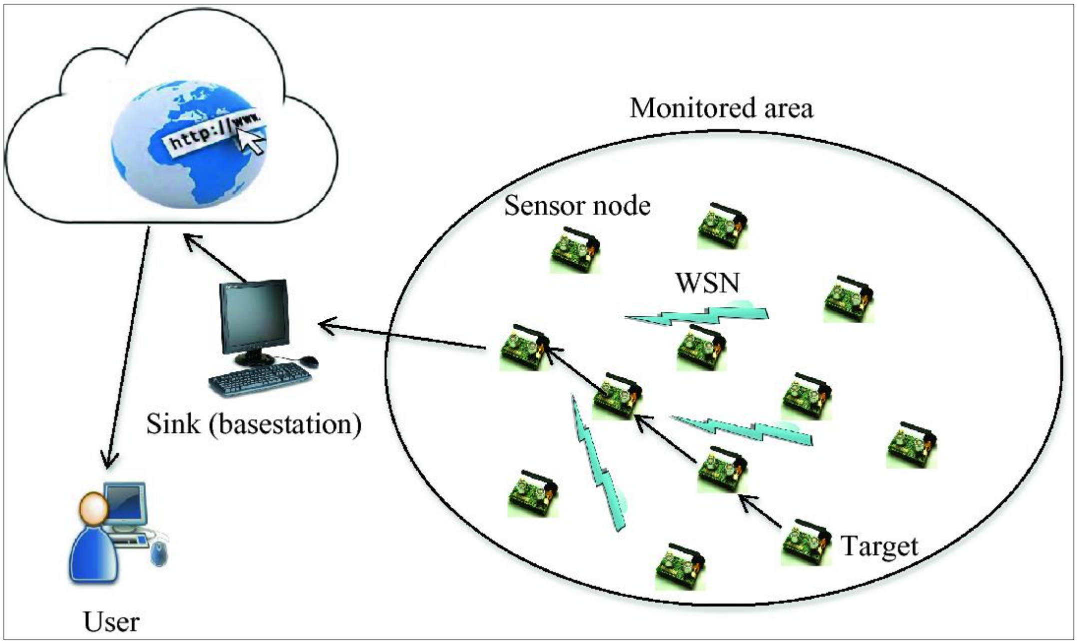

Fig1. Typical architecture of WSN [3]

Wireless sensor networks (WSNs) typically form a large number of cheap sensor nodes (SNs) that are usually powered by fixed power sources such as batteries, which are difficult to recharge once used [7]. Therefore, energy-efficient sensors and SN communication methods are important in prolonging the life of WSNs.

There has been a growing interest recently in the leasing of an unmanned aerial vehicle (UAV) as a WSN low SN mobile data collector [8]. The UAV is able to collect data on SNs in an energy-efficient way, as it can navigate a parabolic pathway and collect data from it only if it travels a short enough distance to each SN. Therefore, the connection distance from each active SN to the UAV is greatly reduced, which maintains transmission capacity across all SNs. It has been shown that short-range (LoS) communication links between UAVs and low-term terminals can be used effectively in UAV-enabled wireless networks to improve operational design of UAV's trajectory [9], [10].   Nodes are sources of information. Such nodes make sense as their main function. They may also forward or transmit messages over the network, depending on the received communication paradigm.

The UAV is a place of information. They collect sensitive data from sensory nodes directly (i.e., by visiting sensors and collecting data from each of them). They can use data from sensors automatically or make them available to users who are interested in the Internet connection.

This paper proposes to significantly reduce the power consumption of data transfer and extend the life of the network; introduces a framework for monitoring parabolic movements in which data collection and transfer is performed using UAVs

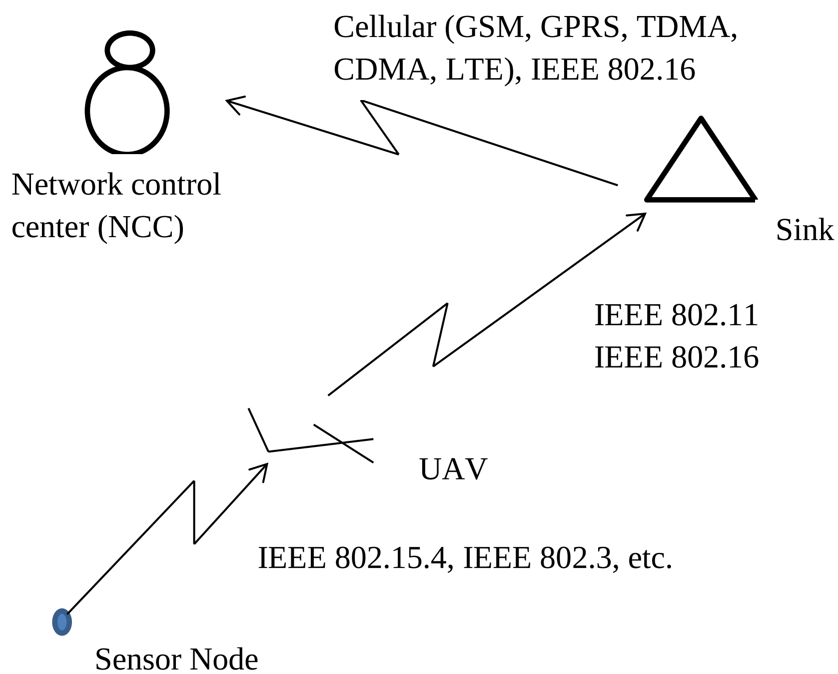

Fig-2 the various protocols at the different links of the network system hierarchy.

data transfer is a dominant function that consumes energy in the sensory area; it has been stated [11] that transmitting 1 Kb at a distance of 100 meters will consume the same amount of power using 3 million commands per local processor (i.e., the cost of sending 1 bit is equivalent to that of making 3000 orders). Since wireless communication is a major consumer of energy in the sensor area, we also consider the problem of transferring data from stationary sensors to mobile data collectors. Our research is primarily aimed at extending WSN life time through the movement of data collectors. We are studying the development problem of increasing network life when mobile data collectors are used.

The solution to the above problem is to have a parabolic trajectory for mobile data collectors to avoid unnecessary data transfer. We demonstrate, through theory analysis and simulation, that our approach has the potential to significantly increase network life.

Sensory nodes collect data from the environment and bring the collected data to the sink node. Each sensor node has one or more sensors, a common purpose Central Processing Unit (CPU) for performing arithmetic and logical operations, and a small amount of storage space.

The power supplied to these sensors is not connected to small, non-rechargeable batteries. The sensor node has a wireless connection where it can communicate with other nodes nearby. Due to the lack of storage space and because the communications are prominent power users in the sensor area, the transmission range of these devices is limited for energy saving purposes. The sensory nodes, located at a distance from the sink area, can report their data in the form of multiple hops. Most sensory networks, once deployed, should operate without human intervention, i.e., stopping, adjusting, maintenance, and adjustment should be done independently.

The Crossbow MICAz mote as an example of sensor nodes, has a low-power microcontroller with standard processing, 128 KB memory, and 512 KB of flash memory. MICAz motes have IEEE 802.15.4 [12] Transceiver compatible radio frequency with a transmission rate of 250 kbps. The MICAz node has an external transmission width of up to 100 m and an internal transmission width of up to 30 m. Commercially available MICAz chips have enough 2X AA batteries for a whole week of full charging [13].

A major lifelong challenge for WSNs comes from the unbalanced use of power across different parts of the network. We are introducing a parabolic trajectory program for mobile data collector to extend the life of the network. Our analysis shows that power consumption is less than the total amount when our method of making an important extension to the entire life of the network. Each sensor node collects data from the environment and sends the collected data to data collectors (UAVs). They wait until the data collector comes to retrieve them. We consider the N network sensor nodes used equally in the sensor field.

The mobile sink travels in a predefined way and collects data from the sensor nodes in single hop. When it finishes data collection at predefined points, it returns to base channel and uploads collected data to base channel. The speed of the moving sink is the same. And a moving sink knows the location of all the senses. The portable sink (UAV) is equipped with unlimited power source, powerful CPU with large memory, long distance, transceiver and GPS.

In WSN collection of audible data can be done in the normal or unconventional way. Data should be continuously collected from sensor nodes in normal mode. Although, in abnormal mode, data should be collected periodically from sensors nodes.

UAV enters the sensory space for the purpose of collecting sensitive data. In large WSNs, multiple sensors nodes are used in the sensor area. Every sensor node has the ability to hear, computer and wireless communication. Each sensor node plays the role of an event detector to monitor specific targets and transmit data to the base station or station (BS) using wireless transmission techniques. Understandably, the sensor nodes need more transmission power to send data when the sink or BS is configured and located farther away from the sensor nodes than when it is close to the nodes. Power efficiency of the sensor nodes is one of the most important factors in increasing the life expectancy of WSNs. A mobile sink is used to increase network flexibility to collect sensory information in large monitoring areas. Because the sink can travel parallel within the sensor area to collect acquisition data, the transmission distances of sensor nodes can be reduced. Sink flow allows for easy data collection and reduces power consumption through sensory nodes [50].

A solution to the above mentioned problem is to have parabolic trajectory of mobile data collectors so that the redundancy of data transmission is avoided. We show, by theoretical analysis and simulations, that our approach has the potential to prolong the lifetime of the network significantly.

1.2. STATEMENT OF THE PROBLEM

In today's world data is collected using sensors that are distributed in the desired location. The standard network where those sensors gather and transmit this collected data to each other is called the Wireless NETWORK (WSN). These senses are limited in a number of ways among which is the power of one. Apart from this, some nodes move naturally and as a result there is a power outage problem. Because of this, reducing this energy consumption is important as it is very difficult to recharge the batteries and these networks aim to achieve greater efficiency in the delivery of information in harsh environments.

An easy way to create a route to wireless nerve networks is direct transmission, where each node transmits its data directly to the sink. If the base station is far away, the cost of sending data directly to that channel will be much higher, and the nodes will die faster. This is because sensor nodes with limited battery capacity and because data transfer or reception consumes more energy than sensory areas performing sensory and computational functions. Energy saving is an important issue for WSNs. To significantly reduce the amount of power used in data transfer and extend the life of the network. In the assembly where the base station is far from the head the head may die and the network has failed. Clustering schemes use high power during cluster construction and CH selections leading to shorter network life. In this paper, we consider the state of UAV-enabled data collection, in which the UAV follows a parabolic path that travels closest to each SNs when collecting data from it and thus reduces the connection distance to maintain the transmission capacity of the SNs.

Therefore, in order to significantly reduce the power consumption of data transmission and extend the life of the network, we introduce a parabolic movement monitoring framework when data collection and transmission is performed using UAVs. Furthermore, in this study with the aim of reducing the power consumption of the nodes by reducing the total distance of the nodes from the UAV and avoiding duplication of data, we aimed at the parabolic model axis while collecting information on network nodes. Therefore, the proposed parabolic navigation system of UAVs in WSNs data collection is superior to both fast-paced and energy-efficient communications.

1.2.1. Research Questions

This study attempts to answer the following questions.

1. Is the existing linear trajectory of UAV energy efficient?
2. How can we reduce the energy consumption that can be caused by the data transmission and the path followed?
3. How to collect the sensed data from sensor in an energy efficient manner?
4. How UAV moves in deployed sensor nodes to extend the network lifetime?

1.3. OBJECTIVES OF THE STUDY

1.3.1 General objectives:

The general objective of proposed system is to reduce the energy consumption used in data transmission of sensor nodes.

1.3.2 Specific objective:

To meet the general objective, the following specific objectives are set in this research work.

- Enhancing data delivery in the existing WSN using parabolic trajectory.
- To reduce transmission distance between nodes and data collector (UAV).
- To avoid data redundancy which is also used for reducing energy consumption by considering axis of the parabola.
- To evaluate the performance of our work with appropriate network Simulator so that to observe variation between proposed approach and the existing one.

1.4. Significance of the Study

The major contribution of this work is that we incorporate a parabolic trajectory of UAV as a communication network facilitator for energy efficient data collection from WSNs which can be used in several applications: such as, emergency application, home monitory, military control and application, environmental monitoring, Vehicular network etc.... Apart from this, the outcome of this work will be used in all WSN to prolonged life time of sensor nodes. In addition to this, the study can be used as a reference material for scholars who work on this area. To discuss and interpret the simulation results to predict future direction.

1.5. Scope and Limitations of the Study

The study focuses on a wireless sensor network with an objective to minimize total energy consumption of WSN by using mobile data collector (UAV) allowing them to move in parabolic path.

- The proposed approach is random parabolic path selection it doesn't select which parabolic path is optimal.

The equation for a parabola is given by:

1. Vertical axis of symmetry

   $(x-h)^2 = 4p(y-k), if\ p > 0$ the parabola open upward and if $\mathrm{p} < 0$

   the parabola open downward.

2. Horizontal axis of symmetry

   $(y-k)^2 = 4p(x-h), if\ p > 0$ the parabola open to the right and if $\mathrm{p} < 0$

   the parabola open to the left.

1.6. Thesis Organization

The remaining Chapters are organized as follows. Chapter 2 presents an overview of the existing literature survey, advantages and disadvantages of WSN integrated with UAV. Chapter 3 introduces related works which are conducted for routing a data and are more related to our work. Chapter 4 presents the design and description of the proposed work, model and algorithms. Chapter 5 provides an extensive simulation study and evaluation of the proposed approach. Finally, the conclusions of the research and recommendations of future works are presented in Chapter 6.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Overview

To achieve the main purpose of this thesis, various resources such as books, research papers, magazines and other documents have been revised. In order to understand the basic concepts of wireless network networks (WSN) and other related areas that assist in our work have been reviewed to achieve the goal of this thesis. This section discusses the function of the wireless sensor network, the router protocols used and other algorithms used in WSN.

2.2 Energy-aware protocols for WSNs

Power awareness is an important issue for the development of WSN communication agreements. In this section, we show how power is stored in another MAC that recognizes power and route contracts. In communication, the MAC protocol provides a way to control access to multiple channels (nodes) in a common physical communication channel. According to [15], the main causes of power loss at MAC level in WSNs are:

1. Collision: one area receives more than one packet at a time.

2. Listening: a node detects an unintended packet.

3. Active listening: the receiver of the package is active, yet no packets are sent to it.

4. Excessive extraction: the node transfers the package to the wrong location.

Several MAC energy-saving protocols have been proposed to mitigate the effect of these features. Collisions are not specific to WSNs and can be addressed using standard access control methods. TRAMA [16] is a WSN MAC protocol that uses Time Division Multiple Access (TDMA) to deal with collisions. WISEMAC [17] and S-MAC [18] are two protocols using Carrier Sense (CS).

Excessive listening and inactivity are reduced using sleep schedules that allow the sensors to shut down their wireless transceiver during sleep periods [18]. To avoid excessive output, a node wishing to connect with another node starts their conversation by sending a handshake control package. Transmission / Deletion Request (RTS / CTS) are examples of those control packets used in the S-MAC protocol.

Route is a process of finding paths between pairs of nodes in a network. In the energy-conscious route, the quality of the method is measured based on its effect on the node energy reserves in the network. Dozens of regulations recognizing the power of WSNs have been reported over the past decade [19]. These protocols are divided into two categories: active and active. Active protocols are those in which the systems are pre-programmed. Active protocols are those where the path is only acquired when needed. Because active protocols create high-resolution connectivity and set-up connections, it is desirable to use active protocols in WSNs [19]. However, some route protocols, classified as functional protocols, are able to detect route routes when flying due to the information nodes they have about their locations. Most of the functional principles of the trail are based on the construction of a tree that is rooted in the submerged area [13] [15] [16]. Once such a tree is built, the nodes bring their data to the sink in a multi-hop way by transmitting it to their parents. The main idea of these regulations can be explained as follows. In the deployment phase, the sink begins the tree-building process by distributing a tree-building package. Each sensor node selects the sensor node, in which it receives the tree construction package, in order to be its parent. When a node joins a tree, it redistributes the tree-building package to its neighbors. Parental choices can be made with different policies. The goal of energy saving may be to select a node near the root of the tree according to the number of hops. Such a policy may reduce the amount of transmission required to bring data to the sink. Once the data production rate for each sensor node is known, line configuration can be used to find the complete route to WSNs. In [17], the problem of finding routes that extend the life of the network was made as a parabolic trajectory for UAVs. Such construction models WSN directly go from sensor nodes to sink node.

The authors of [20] researched the route of a route with a split table and a split table traffic. They introduced two specific plans to reduce the amount of energy used in each problem. Hierarchical routing is a class of behavioral processes in which sensors nodes are subdivided into groups. Each collection has a collection head and several collection members. Collection members report their data to the collection head where the data is collected and delivered to the sink. Processing data in cluster heads saves valuable energy by removing unwanted data, compressing data by compiling computer integrated tasks (e.g., scale, limit, minimum, ... etc), and, consequently, reducing the amount of transmission. The Low Energy Adaptive Clustering Hierarchy (LEACH) is an integrated protocol that uses random rotation of cluster heads to distribute the energy load between nerve nodes in a network [21]. In LEACH, the system works round-the-clock, where each round begins with selecting cluster heads followed by a stable data transfer.

The main topological problem in WSNs stems from the fact that the load in a certain area of the sensor is determined by its distance to the sink: by multi-hop transmission, remote nodes and sink relay data generated across the network, and by single-hop connections, nodes away from the sink deplete their power faster than nodes near the sink. Such a problem is difficult to alleviate when both the sink and the sensor nodes are stopped. Although the sensors node, considered to be small in size and low in cost, difficult to make mobile, it is desirable to have a sensible mobile data collector to balance the load on the network and extend its lifespan. Recently, only a few strategies following that broadcast have been suggested.

2.3 Low-Energy Adaptive Clustering Hierarchy

By the name itself, the Low-Energy Adaptive Clustering Algorithm or LEACH is self-organizing, and a flexible integration protocol. LEACH is used as a random method to distribute power evenly and distribute the load of each node in the sensory network. In LEACH, sensor nodes come together as clusters called space clusters. That local group will have a collection head called a local channel. Once the cluster head has been selected, all other member nodes or non-cluster-head nodes will send their data to the corresponding cluster-head in the cluster. In standard integration algorithms, the sensor node selected as the cluster head will die instantly due to battery drain. Network failure can therefore occur easily, and quickly.

So LEACH has a different way of saving the entire life of the cluster head and the entire network. The LEACH algorithm uses a method called random rotation for the selection of the head of the higher energy group. That is to say, this algorithm will select cluster-head from time to time based on high-power sensor nodes. The cluster-head will only be a local station for a limited time. Then after some time, the cluster-head selection will be repeated based on the same power parameter. In addition LEACH will compress data after collecting data on all other member nodes. And it will send it to the base station. This process will reduce energy consumption and improve the life of the system. If the sensor node is selected as the header in the collection, that header will transmit status to member nodes or non-cluster head nodes of which it is a part of the Wireless Sensor Network.

In a LEACH-based network, where a collection is created or organized, the head of the collection will generate a schedule of their corresponding nodes for their collection. That is, each non-cluster head comes to know its time to transfer data to the cluster head. Therefore without that time all other radio components of member nodes will be turned off. This basic idea greatly reduces energy consumption during idleness. If the cluster-head has all the data from the member nodes, it will compress it and send it to the base station. Sometimes the base station is far from the cluster-head. It will be a very high power transfer. So that cluster head sensor node battery will soon run out. However, another node will be affected as follows but compared to other common algorithms; it works well with energy consumption.

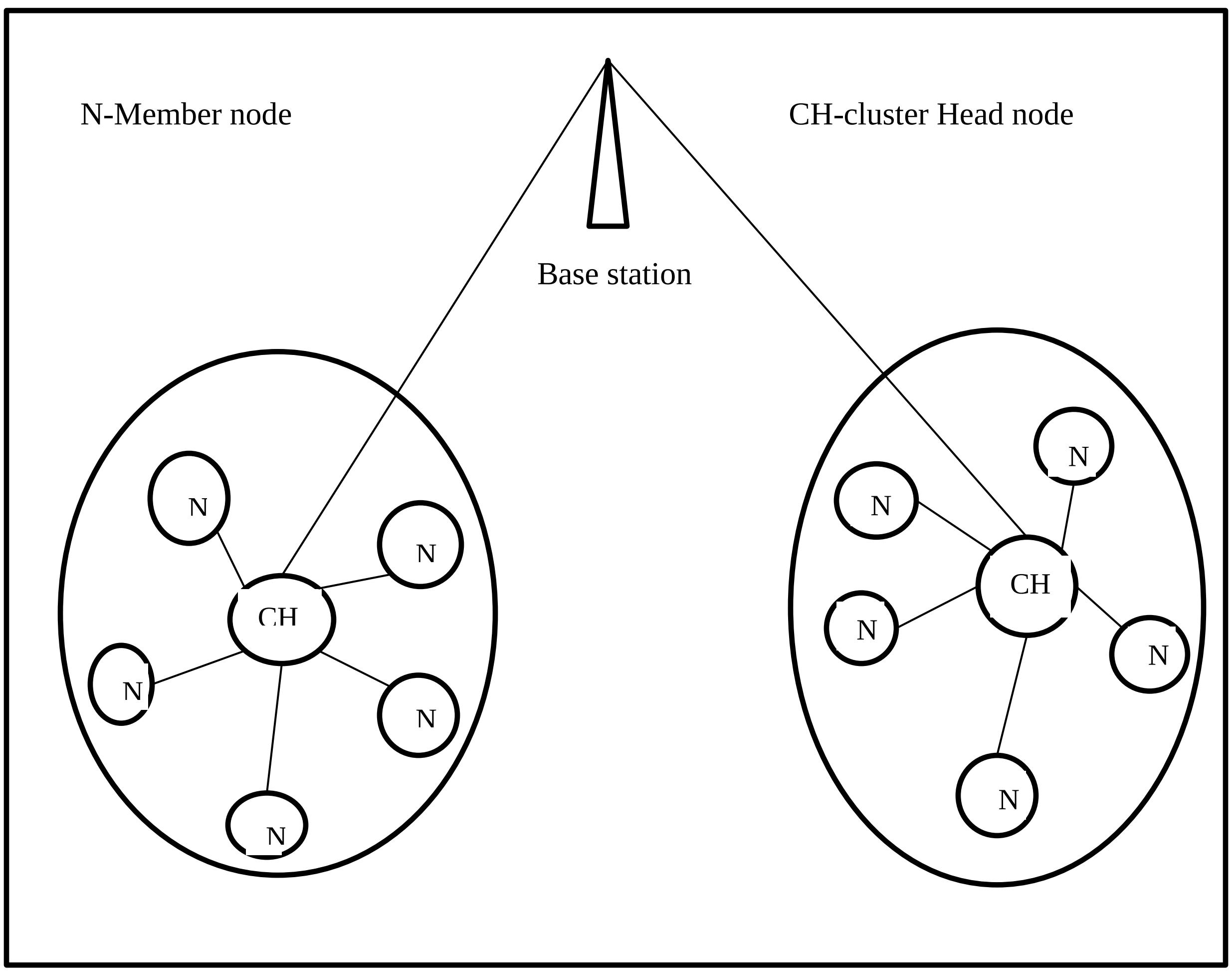

Fig-3 simple LEACH cluster forming approach

As mentioned earlier, the cluster head node battery will soon run out because the base station is located away from the cluster-head. Therefore the nodes in the head of the collection will not be fixed or permanently to measure the energy consumption of all the sensory nerves. For this reason, the node will select itself as the header for them at a certain interval. The following group header will be selected based on the amount of power remaining in the current node. And the remaining activities will take place as mentioned above.

So the above benefits of LEACH or Low Energy Adaptive Clustering Hierarchy make that algorithm as the most popular algorithm for Wireless Sensor Networks.

2.4 Power Efficient Gathering in Sensor Information System

As mentioned earlier the LEACH protocol creates a cluster, the cluster head will find data on all nodes, compress all that data, and send it to the base channel at the end. By random the power consumption is reduced to the LEACH algorithm. But still there are some obstacles in the LEACH algorithm. That assumption, if the base station is far from the collection heads in the collection. Those cluster heads will use extra power to transfer their data to the base station, so that, the cluster head will soon die due to high power transfer power. Network failure may occur due to this situation at any time. Leach is an effective algorithm but still some nodes can die due to LEACH disease.

To address LEACH issues, the PEGASIS protocol (Active Integration in the Sensory Information System) protocol is proof of improvement. In PEGASIS each of the nodes in the group will establish a communication transfer in the immediate area only. So power consumption will decrease while sending data to the base station.

In a Wireless Sensors Network, integration plays an important role in reducing the amount of data transfer from the sensors node and base station. Data collection is nothing but combining one or more packets, which are heard in a different sensory area to produce a single packet. The LEACH protocol is a solution for reducing the use of power in data-collection collections. Each collection collects data and compiles data. Eventually one cluster head will send it to the channel about that effect. These activities will be about random execution. But further improvements are possible through the PEGASIS protocol. This enhancement is obtained when each node connects to the node closest to the Wireless Sensors Network. In PEGASIS, the main idea is to build a chain with each sensor node so that the node will transfer data and receive data to nearby neighboring nodes. That data is constantly moving from one node to another node. And these nodes are integrated into each location and eventually transferred to the primary channel. So here, each location in the server network will eventually exhaust its ability to perform that function. Building a chain is like a traveling merchant.

The simplest way the chain is made is in the form of greed. This method is shown in Figure.4 where each location interacts with the nodes of the nearest neighbor. It also shows that the way to pass the token is that, if a node is between two nodes, then that node will wait for that data from both to nearby locations. After collecting all the data from both nodes, it will press and send it to the base station or the nearest node. In PEGASIS, if any node is not in the communication range, there is an opportunity to use multiple hop transfer methods. When collecting data, no node should be left out; otherwise the data for that node may be lost or misplaced with sequential data. The LEACH protocol is good enough to reach a channel in the middle of the communication range but PEGASIS overcomes the LEACH retreat so that when the base channel is far from the group head. Finally PEGASIS works well in two ways compared to the LEACH protocol.

That is, when transferring data of all sensor nodes to cluster-head after merging, PEGASIS takes very small distances due to the chain method. Then the PEGASIS leader receives data from multiple nodes at a time. The leader node will then send that data to the base station.

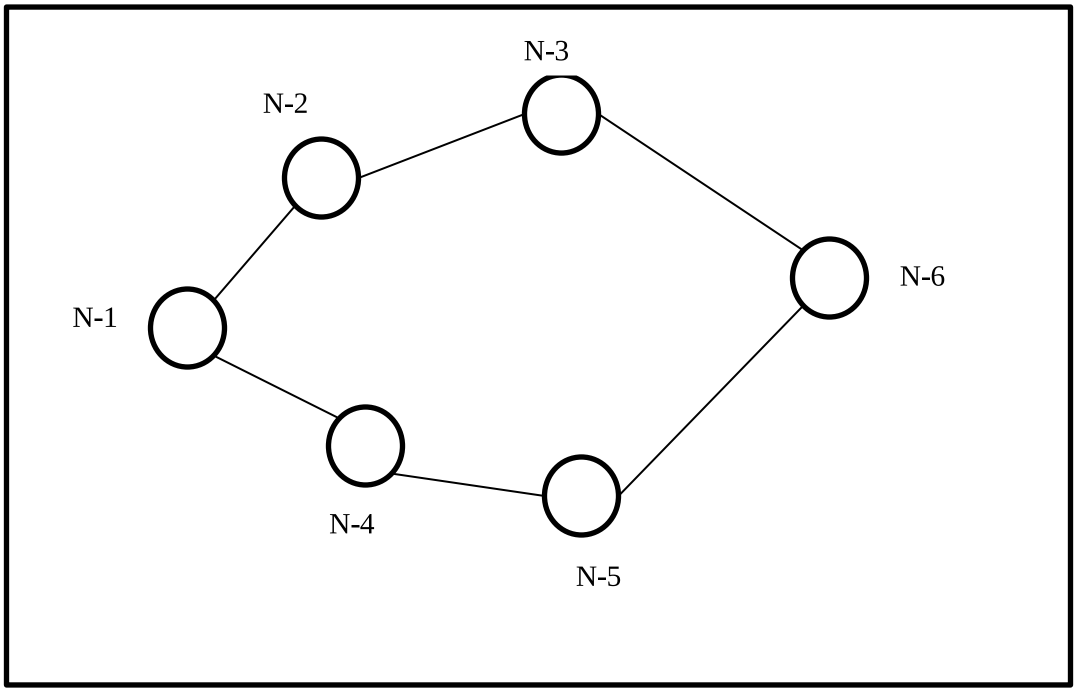

Fig-4 Simple chain and Token passing method

Thus the PEGASIS is the extension of the LEACH in an efficient manner.

2.5 K-Hop Clustering Algorithm

We know that collections are used to determine energy efficiency and flexibility in wireless sensor networks. But in sensory networks we cannot guarantee that collections will not always be stable. Some sensor nodes may interfere with the rest of the collection. So the conflict will happen there. This function is called the scattering problem. That means other sensors nodes in one cluster head will interact or interfere with another cluster form. But this excessive combination is helpful in other types of situations. That is nothing but an Inter-cluster route, local note-taking, and time-synchronization agreements. However, the problem of escaping clutter should be avoided in most cases due to overcrowding. So here, the k-hop clustering algorithm can be used for this kind of situation.

Usually other integration algorithms such as LEACH, PEGASIS will only form separate collections. And that will meet limited conditions. But by using the KOCA protocol, we can create a larger collection and we can manage the power consumption parameter. In a traditional merging algorithm, each node will be for only one set. But not in the case of multi-hop integration or a complex integration algorithm. Here one node may be of more than one group. In the KOCA model there are 3 types of nodes in each collection.

They are given below,

- ❖ Cluster Head (CH)
- ❖ Boundary Node (BN)
- ❖ Member or Normal node

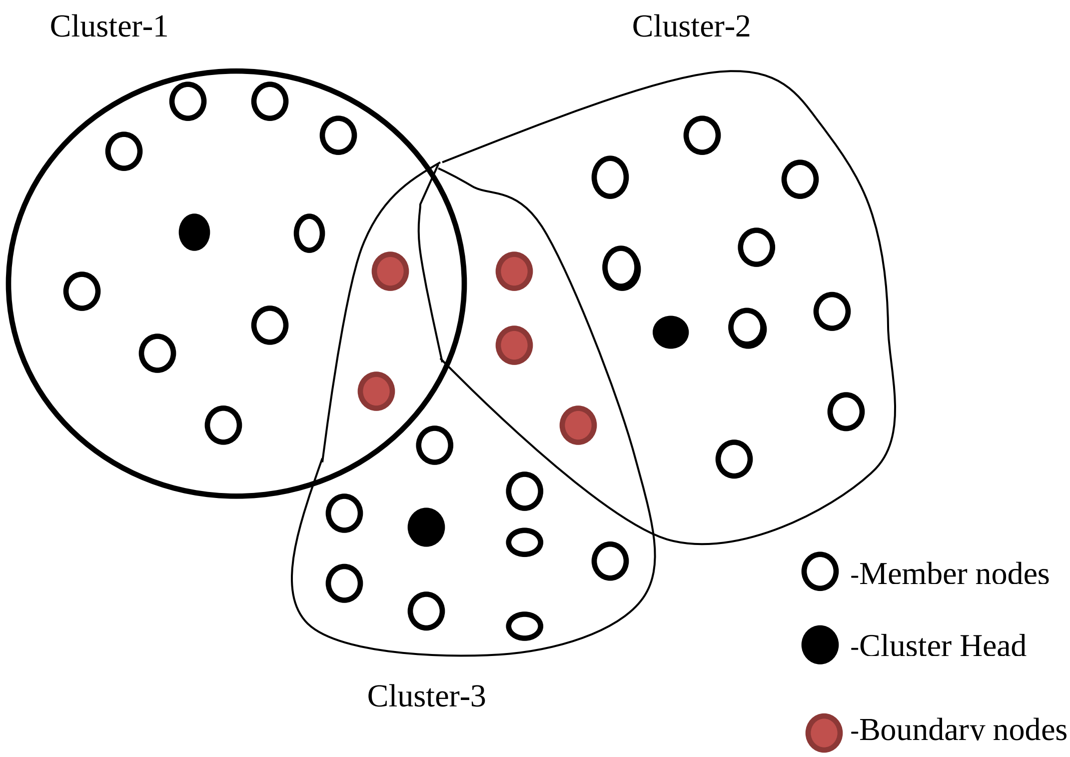

Fig-5 Over lapping Clusters

The head of the collection will choose from time to time. That header will have details of nearby clusters and they also know how to contact them and the boundary node is nothing but, it belongs to more than one network in the sensory network. The boundary node will act as a gateway. Figure.5 shows Member nodes, Cluster head nodes, and Boundary nodes. Collection head selection is similar to LEACH and PEGASIS algorithms. There is no control between selecting a group head and like LEACH and PEGASIS, KOCA sensors also advertise the selected header head for all other non-cluster heads or member nodes.

The KOCA algorithm is a challenging algorithm. KOCA aims to connect isolated clusters. Those scattered clusters will shut down all sensory networks with the help of boundary nodes. These boundary nodes will be in the overlap. The KOCA algorithm introduces a lower overhead compared to other algorithms such as LEACH and PEGASIS. The main idea of the KOCA algorithm is that this algorithm looks for two links. Here to avoid conflict, we can use multiple access protocols to avoid conflict and other MAC protocols such as TDMA can be used for mac layer connection in excessive integration without any conflict.

So multi-hop clustering or scattering is a better algorithm if the wireless sensor network has a very large number of sensor nodes. LEACH and PEGASIS algorithms are very good at reducing energy consumption but by considering a single set. But in an integrated integration algorithm the entire network of nerves is integrated. The corresponding environment is treated in the most efficient way. So this is the best choice for a network with a large number of sensor nodes.

The AODV router protocol is based on the efficient operation of ad hoc wireless networks with a large number of nodes and uses a route acquisition method in streaming mode. AODV can transmit in unicast or multicast mode, utilize bandwidth efficiently, and respond quickly to network changes avoiding network barriers [22]. Each node in the network has a serial number and a unique identifier in the network. This ensures no hassle and avoids counting packets to infinity. To monitor and track routes to neighbors, residential areas send HELLO messages periodically. Notes have a lifetime of each time a node receives a package from a neighbor. At this point, neighbors' entry is updated to the route table. If no input is defined for this neighbor, the node creates a new entry in the route table. Therefore, information from the HELLO package is used by neighbors to notify other nodes that the node itself is still active. This information is used by neighbors to update timers related to that node or, alternatively, to respond non-responsive entries. In fact, AODV maintains time-based circuits in the route tables of each location. Route table installation expires if it is not used later. The time function prevents the use of links to any status marked as unknown for a long time. Other advantages of AODV are high reliability and low bandwidth costs. However, there are disadvantages such as high complexity, additional statistics required, additional memory costs, and the fact that this legal process was designed to operate on a network where there are no malicious nodes.

2.6 Applications of wireless sensor network

Wireless sensor networks have gained much popularity due to their flexibility in solving problems in different application domains and have the power to change our lives in many different ways. WSNs have been successfully used in various application domains such as: **Military applications**: Wireless network networks may be an integral part of military command, control, communication, computer, intelligence, battlefield surveillance, retrieval and targeting programs. Location monitoring: In location monitoring, sensors nodes are used in the area where an object will be viewed. When the sensors receive a hired event (heat, pressure, etc.), the event is reported to one of the primary channels, which then takes appropriate action.

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Fig-6. Military application of WSN [53]

Transport: Real-time traffic information is collected by WSNs to later supply transport models and warn drivers of traffic congestion and traffic problems. This application is able to provide information on the safety message from vehicles as in the case of VANET Intelligent Transportation System (ITS) which is a standard WSN class. In addition, the app provides effective messaging programs in the event of an accident on the road. To do so they can use RSU (Road Side Unit) to act as a BSM data transmission or otherwise the network may use clusters instead of RSU.

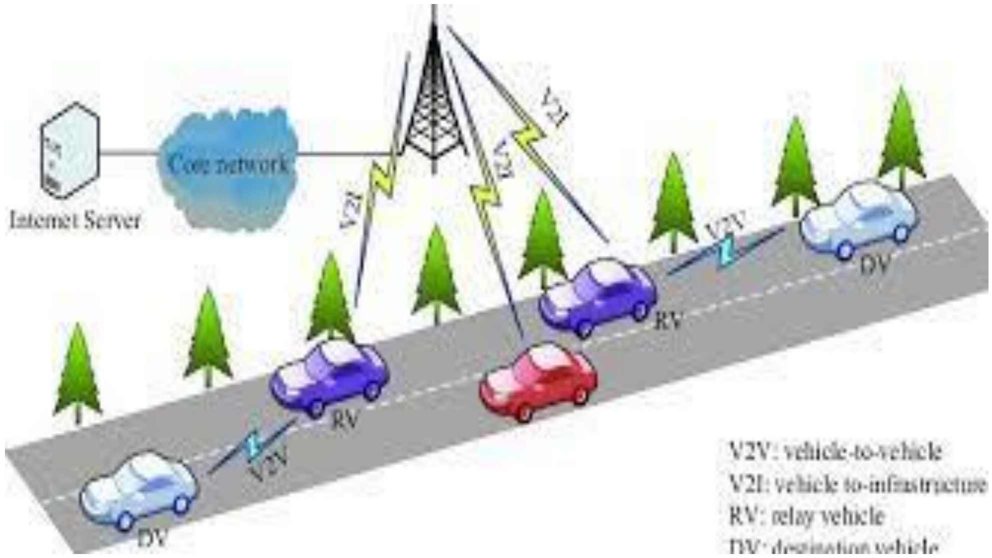

Fig-7. Intelligent Transportation System (As application of WSN)[54]

Health applications: Some of the health network applications support the communication of the disabled, integrated patient monitoring, diagnosis, and drug administration in hospitals, telephone monitoring of personal physiological data, and monitoring and monitoring of doctors or patients within the hospital. As the following statistics show, the patient is connected to the network via sensors (such as Biosensor) and all information will be sent to a central server using a gateway.

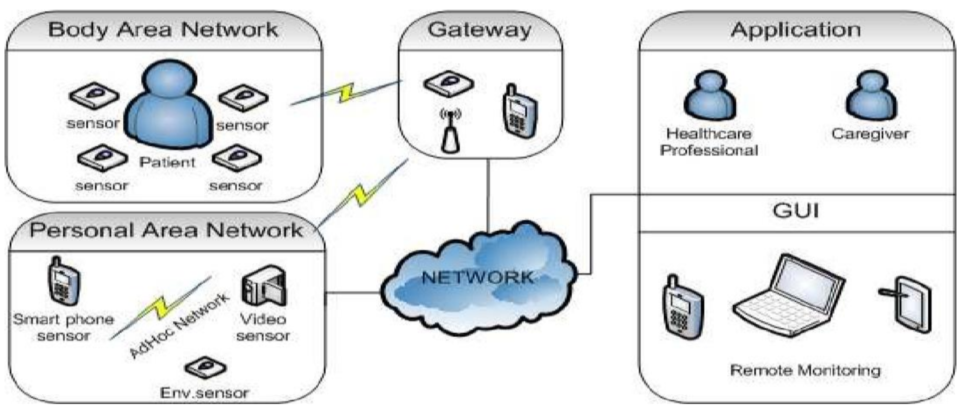

Fig-8. Application of WSN in Health care [55].

Indoor Living Monitoring: This has been the use of sensory technology to protect against the hiring of living to help people in a safe indoor environment. This application has provided many benefits to the user in terms of security. Some of them use wireless technology and Bluetooth technology to provide the service. Apart from this, they are used to detect any attacker at home using a motion sensor like sensor node.

Natural Sensor Network: The term Environmental Sensor Networks has been developed to cover many WSN programs in global science research. This includes hearing volcanoes, oceans, glaciers, forests, etc. It can also be used to monitor industries. Wireless network networks have been developed for machine-based optimization (CBM) as they provide significant cost savings and enable new functionality. In corded systems, adequate nerve implants are often determined by the cost of the wires. Wireless sensors can be used to monitor the movement of buildings and infrastructure such as bridges, flyover, banking, tunnels etc. which makes engineering processes monitor goods remotely without the need for expensive excavation sites.

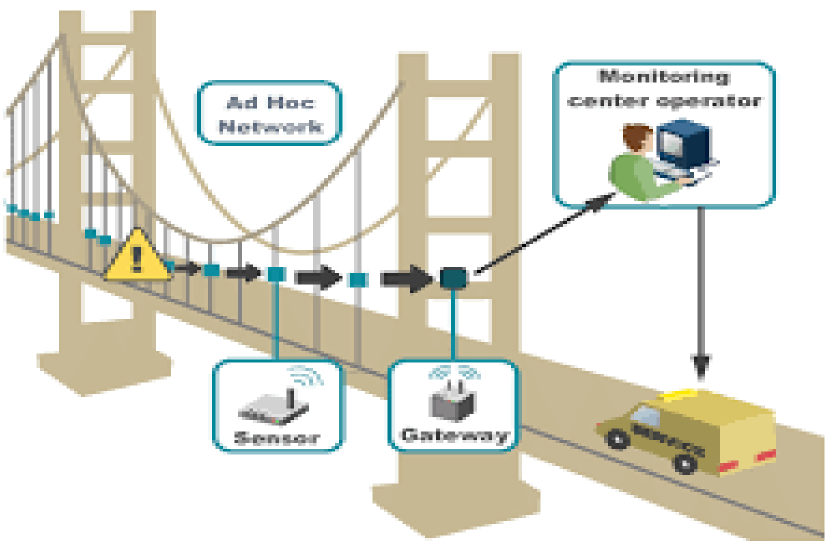

Fig-9. Application of WSN in bridge monitoring [56]

Agricultural sector: using a wireless network frees the farmer from the care of the ropes in a difficult environment. Irrigation automation makes water use more efficient and reduces waste. Apart from this, the UAV Areal Network unlocked UAV can be integrated with WSN to provide fewer applications as is the case below. Paper [49] introduces a component design using the integration of Inactive Vehicle Vehicles (UAVs) and integrated WSN wireless network networks for farm crop monitoring and precise agricultural control. This integration of the Unmanned arial Network with intelligent, ground, and IoT sensors has proven to be a robust and effective solution for effective data collection, analysis, control, and decision-making in those agricultural applications.

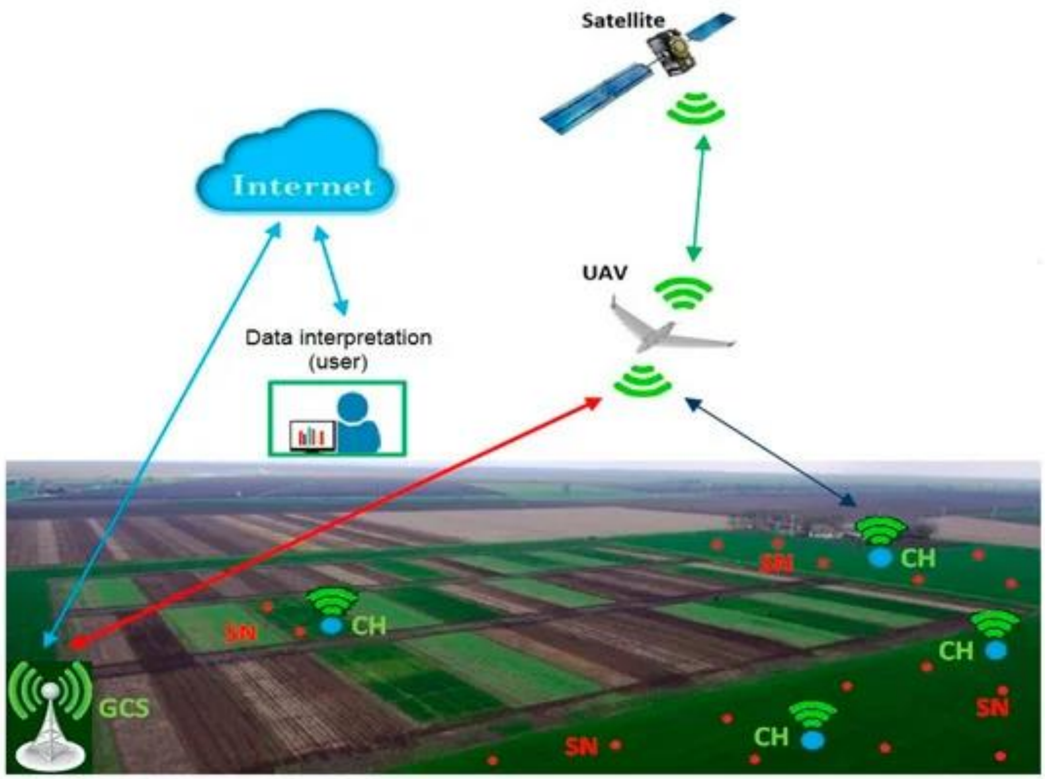

Fig-10. Typical Application of UAV integrated WSN in precision agriculture [52].

The term Environmental Sensor Networks has been developed to cover many WSN programs in global science research. This includes hearing volcanoes, oceans, glaciers, forests, etc. Some of the major locations are listed below:

• Monitor air pollution

• Forest fire detection

• Monitoring of heat trapping

• Landslide detection Building monitoring:

Wireless sensors can be used to monitor the movement of buildings and infrastructure such as bridges, flyover, banking, tunnels etc. which makes engineering processes monitor goods remotely without the need for expensive excavation sites. Industrial monitoring: Wireless nerve networks have been established to improve the state of the art (CBM) as they provide significant cost savings and enable new operations. In corded systems, adequate nerve implants are often determined by the cost of the wires. Agricultural sector: using a wireless network frees the farmer from the care of the ropes in a difficult environment. Irrigation automation makes water use more efficient and reduces waste.

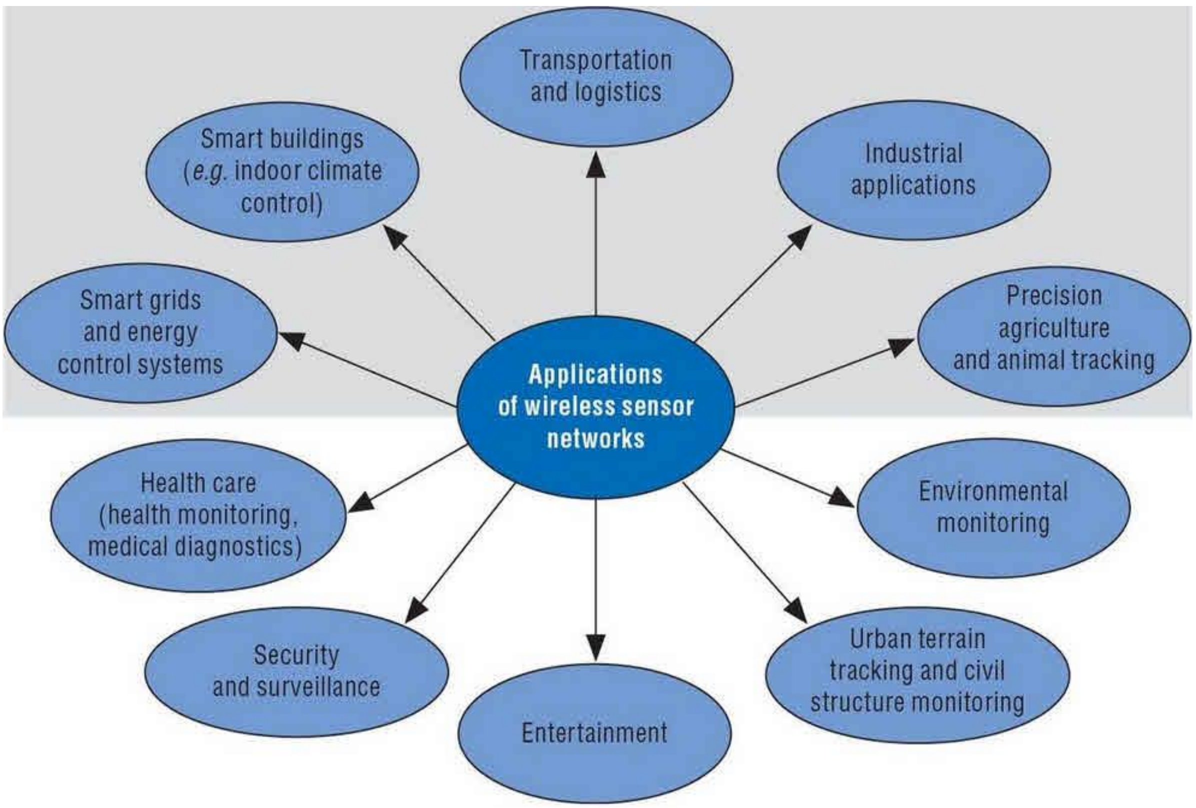

Fig-11. WSN Application [49].

2.7 Design issues of a wireless sensor network

There are many challenges posed by the transmission of sensory networks that are superset of those found on wireless ad networks. Nerve nodes communicate by telephone, loss lines outside infrastructure. An additional challenge is related to the limited power supply, which can often be updated by sensor nodes. In order to extend the lifespan of a network, agreements need to be designed from the outset in order to effectively manage energy resources [49]. Let us now consider the details of each design in more detail.

Error tolerance: Sensors nodes are vulnerable and are often sent to a dangerous area. Nodes can fail due to hardware problems or physical damage or by exhaustion. We expect node failures to be much higher than commonly thought on infrastructure based wireless networks. The protocols used in the sensory network must be able to detect these failures as fast as possible and strong enough to handle a large number of failures while maintaining the overall performance of the network. This is especially important in the development of the route protocol, which must ensure that alternatives are available to rearrange packets. Different shipping locations have different error tolerance requirements.

Extensibility: The sensory networks vary in size from a few nodes to a few hundred thousand. In addition, shipping congestion also varies. In order to collect high resolution data, node congestion may reach a level where the node has several thousand neighbors in their transmission range. Protocols applied to sensor networks need to be standardized at these levels and able to maintain adequate functionality. Production Costs: Because most transmission models view sensor nodes as disposable devices, sensor networks can compete with traditional methods of data collection only if individual sensors are produced at a very low cost.

Hardware Barriers: At a minimum, every sensor area needs to have a sensor unit, a processing unit, a transmission unit, and a power supply. If you prefer, the nodes may have a few built-in sensors or additional devices as a location-enabled system to enable a location-aware route. However, all additional functions come with additional costs and increase power consumption and physical size of the node. Therefore, additional performance always requires balance against cost and low power requirements.

Sensor Network Topology: Although WSNs have advanced in many respects, they continue to be networks with resources tied to power, computer power, memory, and communication power. In these areas, power consumption is very important, which is reflected in the large number of algorithms, strategies, and processes established to save energy, and thus extend the lifespan of the network. Topology Maintenance is one of the most important issues researched to reduce power consumption in wireless nerve networks.

Transmission Media: Communication between nodes is often used using radio communication over popular ISM bands. However, some sensory networks use optical or infrared communication, and the latter have the advantage of being stable and uninterrupted.

Energy consumption: As we have seen, many of the challenges of sensory networks revolve around limited energy resources. Node size limits battery size. Software and hardware design requires careful consideration of energy efficiency issues. For example, data compression may reduce the amount of power used for radio transmission, but use additional power for merging and / or filtering. Energy policy also depends on the application; in some applications, it may be acceptable to disable a small set of notes in order to save power while other applications require all nodes to run at the same time.

2.8. Energy consumption issues in wireless sensor network

Power consumption is a very important factor in determining the health of a sensory network because sensor nodes are usually powered by a battery. Sometimes energy efficiency is very difficult for sensory networks because it involves not only reducing energy consumption but also extending network life as much as possible. Preparation can be done by empowering awareness in all aspects of design and operation. This ensures that power awareness is also integrated into the sensor nodes and the network as a whole and not just on individual nodes. The sensor node typically consists of four sub-systems (51):

• Computing subsystem: Contains a microprocessor (microcontroller unit, MCU) that is responsible for controlling the senses and using communication protocols. MCUs usually operate under a variety of modes for power management purposes. Since these methods involve power consumption, power consumption levels of various types should be considered when considering the battery life of each node.

• Minimum communication system: Contains a short distance radio that communicates with neighboring nodes and the outside world. Radios can operate under different modes. It is important to turn off the radio completely rather than put it in Idle mode where you do not transmit or receive power saving.

• Lower sensory system: Contains a group of sensors and actuators and connects location with the outside world. Energy consumption can be reduced by using lower energy components and energy savings at unnecessary operating costs.

• Lower power supply system: Contains a battery that supplies power to the area. It should be noted that the amount of energy discharged from the battery is tested because if high power is released from the battery for a long time, the battery will die faster even if it lasts longer. Normally the rated current capacity of the battery used by the sensor node is less than the low power consumption. Battery life can be greatly reduced by slowing down the active or active shutdown.

To reduce the total power consumption of the sensory network, various types of protocols and algorithms have been studied so far around the world. Sensitive network life can be greatly enhanced if the operating system, application background and network processes are designed to recognize power. These processes and algorithms must be hardware sensitive and able to use special features of micro-processors and transceivers to reduce the power consumption of the sensor node. This may lead to a custom solution for different types of sensor node designs. The different types of sensor nodes used also lead to different types of sensor networks.

CHAPTER THREE

3. RELATED WORK

The integration program was first introduced to enhance the performance and life of the WSN network. Create clusters in the network area to reduce the distance between nodes. After group formation, CH is selected by member nodes. CHs receive data from member nodes, compile it, and transfer it to the sink. Network life is extended by increasing the data transfer capacity to specific nodes. It is proposed that the model be used to integrate by changing the CH selection method and provide better performance [4].

The route scheme, based on the integration approach, RE-LEACH [23], operates on the same principle as LEACH; however, it looks at the remaining power of the node during the CH selection. Another system, DREEMME, a line protocol based on vertical cluster, reduces the distance between nodes and CHs that ultimately saves transmission power. However, power is still used in the occasional selection of CH.

DYN-NbC [24] uses both compound and MS. In this protocol, the sink goes to the highest point of node congestion, while, in some network network regions, clusters are formed and CH selection is based on the LEACH factor. The flow of the sink and the dimensions of combining energy consumption to a certain degree; however, integration is an energy-intensive process. The MS based uneven clustering algorithm (UC-MS) is proposed [25]. In this program, CH receives data from member nodes and waits for MS to be located nearby to transfer data. Here, the energy consumption of CH is reduced as it sends data to a smaller range; however, energy is still used in group formation and selection of CH.

In [6], the authors proposed a cost-effective use of multiple MS leading to long network life. Use Mixed Integer Linear Programming (MILP) to determine sink locations. They concluded that the use of a robust method of increasing power consumption leads to a significant increase in network life. The authors have used this approach in the dense field.

Amjad et al. [26] proposed the DREEMME route protocol, in which the square area is divided into fixed circles and each ring is further divided into four circuits, while the central circle remains the same. Eight outer circuits are considered clusters (four clusters exist in each inner and outer circle). Each cluster selects CH on the basis of residual power to collect data from member nodes. CHs in the outer ring transmit their data by transmission from CHs in the middle ring, on a small distance basis.

The authors in [27] consider the problem with the speed of the data plan (i.e., MS) in WSN. They consider various situations in which this problem is encountered, such as modeling the Unmanned Aerial Vehicle (UAV) movement that collects structural health monitoring data through nodes. They used MS to avoid multi-hop transfers. These MSs can save node power and increase latency. In this paper, the authors plan an MS framework to minimize data delivery delays. They created a problem and proposed an algorithm to reduce the trade-off between power consumption and data delays.

In [28], authors look at how to integrate and data is collected through CHs from member nodes. MS runs with a defined trajectory and collects data on CHs. Ku

in this way energy consumption is reduced and as a result the system has increased operating capacity. However, CH nodes consume more power during data transfer and end soon. MMSR is proposed [29], in which there are three MSs used in the network and collect data from different parts of the network. MSs travel through different trajectories and collect data on nodes. Notes send sensitive data directly to MS over a small distance. In this way the power consumption of the nodes is reduced.

In [30], the authors proposed a comprehensive framework for studying the trade-off between delay tolerance and network health at WSN-assisted MS. They also created a heuristic discovery of the hop-constrained trajectory of MS. They also propose a cost-effective route protocol, in which MS for the purpose of data collection cuts across a fixed trajectory. Test results show that the proposed algorithm works best in terms of network lifetime improvement.

Basagni et al. in [5] the model is defined, in which the sink runs along the path previously described. They use MS movements near different nodes to reduce power consumption of nodes. As a result, network life increases. The authors have proposed three schemes that represent different solutions for sink movement. One of the schemes calculates the appropriate sink routes and calculates duration of the proposed MILP construction. Also, consider the actual WSN parameters and sink flow. This program extends the life of the network by considering MS movement depending on the cost of the node transfer in a centralized way.

In [31], the authors propose a MS movement pattern that takes a clear form where the MS standing time is greater than the movement time between two non-moving areas. This method is being investigated

with moderate traffic load with MS and leads to improved network life. They also learned the benefits of using MS against a dry sink. The authors mimic both the grid network and the special network structure of the nodes that form the ring.

Using the QVF algorithm for targeted tracking, the authors [32] consider the problem of secure integration in WSNs. They use Bayesian methods of optimal sensitivity selection and malicious node detection to avoid attacks. Also, they consider the trade-off between audio data quality, transfer power, and initial note power. To find malicious locations, use Kullback-Leibler Distance (KLD) between the current target location distribution and the predictive sensor detection.

The authors in [33] presented a model in which two MSs in an existing square network have distinctly defined trajectories. By introducing two sinks, the load is equal and MS speeds up the data collection process and as a result network life time is increased.

Recently, a sequential system has been used to determine the correct route and placement of a single cellular data collector [34, 35]. The problem is described as follows: when looking at the predefined data point where the data collector can be found, find the time the data collector lives in each location (i.e., stay time) and the multi-hop routes from sensors to data collector in each location. This important effect was obtained by recognizing that the orderliness of the various sites visited by the data collector does not affect the health of the network; which really affects the stay time and route route associated with each location.

The function in [36] includes hardware and software software network for using mobile data collectors in underwater WSNs. According to [36], each sensory location collects data and waits for the mobile data collector to get close enough to receive data in a single jump.

The authors [37] attempted to determine the relationship between the number of data collectors and the time required to harvest all data when data collectors followed random trajectories. Both work on [36] and that [37] take a single-hop connection and do not consider the problem of finding a data collector's way.

In [38], that is aimed at striking a balance between increasing the level of communication and reducing the use of UAV power. The deployment and movement of multiple UAVs, used as aerial channels to collect data from low-frequency wireless devices (WSNs), was investigated [39]. The function in [40] increased the minimum output of a wireless network powered by multiple UAVs by optimizing multi-user communication in conjunction with UAVs' trajectory and power control. In [41], the UAV trajectory is designed to reduce the time it takes to complete a multi-broadcast UAV-enabled campaign.

MULE of data is proposed to collect data from sensor nodes and download them to a basic channel, called Extended Mobile Area Network Extensions (NAMES) [42]. At MULE, the mobile viewer collects data directly from the sensor nodes, stores the data in its database, and discards the data to the wireless access point. MULE movement is modeled as a random 2D motion. However, the main disadvantage of MULE is the extended data collection delay as the mobile viewer has to navigate across the transmission line of each sensor node in the network to collect data.

Chen et al. [43] uses a mobile robot to collect data on isolated islands in multi-hop networks. This activity also learns about mobile robot controls and proposes three ways to navigate a portable robot. And warning messages are used to alert a moving robot. Although this method receives data from different parts of the WSN, it may cause delays in long data collection and data loss on large networks.

Zhao et al. [44] Voting-based data collection uses a mobile node and renamed it a relay hop-based mobile data collection (BRH-MDG). They select small sets of sensory nodes as voting points for each subset that includes location data from its related nodes within a certain number of relay hop. Those voting points temporarily store the data in their archive and upload it to the mobile collector when it arrives. To get a set of voting points, they create algorithms that are centered and distributed. And it proves its NP toughness. On large networks, this method gets a large number of voting points and reduces data delays. The overflow of the bathtub occurs whenever a mobile collector visits late at polling stations while these data stores data.

Wang et al. [45] read a moving sink at the edge of the sensory field. The movement of a moving sink moves like a clockwise movement or opposite the clock. Thereafter, the entire network is divided into equal clusters and in each segment, the cluster head is selected based on residual power. They created a data transfer scheme from a common node to a cluster head using multi-hop transmission. Collection heads placed near the center of the clusters consume more power than nodes near the boundary of the cluster. The data collection trip is the perimeter of the sensor area and this affects long data delays.

Wang et al. [46] proposes a competitive integration algorithm and uses a controlled mobile sink to collect data. The moving sink line is designed as points to establish a straight line to it. In the aforementioned route, the mobile sink stops at the designated areas of the park and receives data from the heads of the collection. Collection heads send aggregated data to a mobile sink through a nearby location. In this way, the head of the cluster, away from the moving sink, negatively affects the power balance of the network.

Yuan et al. [47] proposes a mobile sink saving algorithm (EEMSRA) to extend network life. This paper uses the LEACH algorithm to integrate sensor nodes and mobile sinks for data collection. The moving sink decides to move to the next location based on the average strength of each set and the maximum distance to the group heads from the current location of the moving sink. The mobile sink sends the ‘Hello’ package within the group ID and the time parameter to the member nodes before visiting the collection. Collection head receives data from its member nodes and sends it to the mobile sink. Cluster heads are also responsible for selecting the head of the new collection for the next round based on the remaining power of the sensor nodes. This algorithm uses cluster heads to collect data between clusters and transmits a REQ message to obtain the residual power of clusters in cluster heads. Also, every head of the group should respond with an Eavg message (central power of the collection). This may be an additional power load with nodes selected as the header.

Nazir et al. [48] addresses the hotspot problem and suggests a mobile-based routing protocol (MSRP) to extend network life. In MSRP, the mobile sink runs through an integrated sensor network

Summary

Going through all the previous work on the list, we realized that choosing a UAV tracker as a route could improve WSN performance in terms of power consumption and data delivery. With this in mind, we aimed to improve the performance of WSN in our work. In general, our review of recent WSN research has enabled us to raise and identify the gap in our work. So as every function has its contribution but it lacks that it still consumes a lot of energy while collecting data. Our UAV line-saving data collection method is therefore unique and avoids duplicate packet transfers using parabolic axis and reduces total power consumption to extend network life.

CHAPTER FOUR

4. METHODOLOGY

4.1 Overview

As we tried to explain in the previous chapters, reliable data transmission has been an emerging issue in wireless sensor network. Details of WSN, its applications, and the way it works have been explained in chapter 2. There are several works that are done to improve the performance of this network. Some of them uses the clustering approach and others the route optimization approach. Various works have been studied to improve the performance of this wireless network as introduced in chapter 3.

This chapter proposes a parabolic trajectory movement of UAV for energy efficient data collection mechanism. The study focuses on wireless sensor network (WSN) to energy efficiency communication of sensor with mobile sink (UAV). The proposed approach is better than the existing linear trajectory so as to suit WSN characteristics and application. We have made the use of mathematical computation and simulation techniques to prove our work.

Following this overview, in the following sections we describe the details about the techniques and the model developed for our newly proposed approach. In Section 4.2, we describe the highlight of the study design. In Section 4.3, we describe and present our proposed system work flow for UAV (unmanned aerial vehicle assisted) Wireless Sensor Network (WSN). The block diagram of our proposed model is also included in this section. In Section 4.4, we describe the mathematical computation of our proposed work. And finally, the proposed algorithm and sample simulation scenario is described in section 4.5 and 4.6 respectively.

4.2. Study Design

This study is based on a mixed design to the parabolic trajectory of the UAV.

1. Document review design.

2. Test design.

The research is experimental as it transforms laboratory work with the help of computer and MATLAB software. Further, key research findings were collected by the researcher using textual analysis.

 Our goal is to focus on UAV mobility in used sensor networks. .

 Improving the movement of UAV Algorithms.

 Write the MATLAB code algorithm and confirm the result.

 Comparing the results with the results of the current study.

 Presenting results with tables and graphs.

A suitable source of information for this study is books, journals, related online articles, published Articles and test results obtained by typing the MATLAB code of the proposed algorithms.

A parabola can be defined as a curve where any point is at an equal distance from a directrix (a line) and the focus (a point). Thus the distance to the focus should be the same as the distance to the directrix.

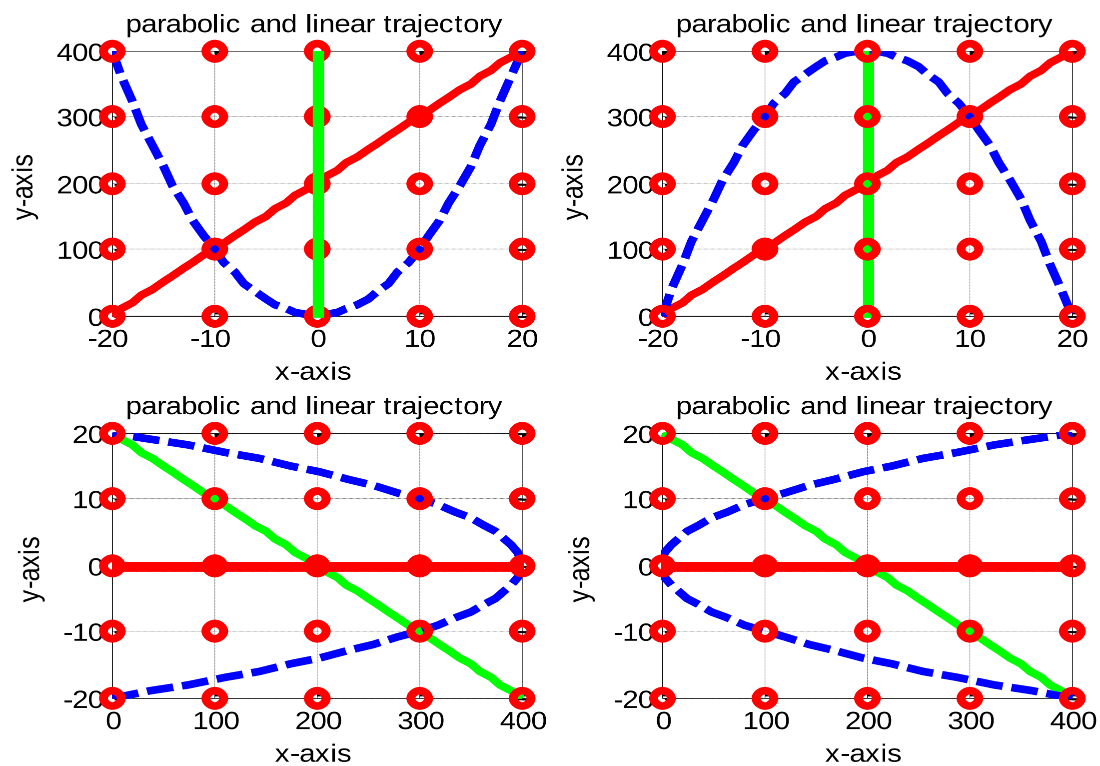

Fig-12 possible parabolic trajectory with axis of parabola.

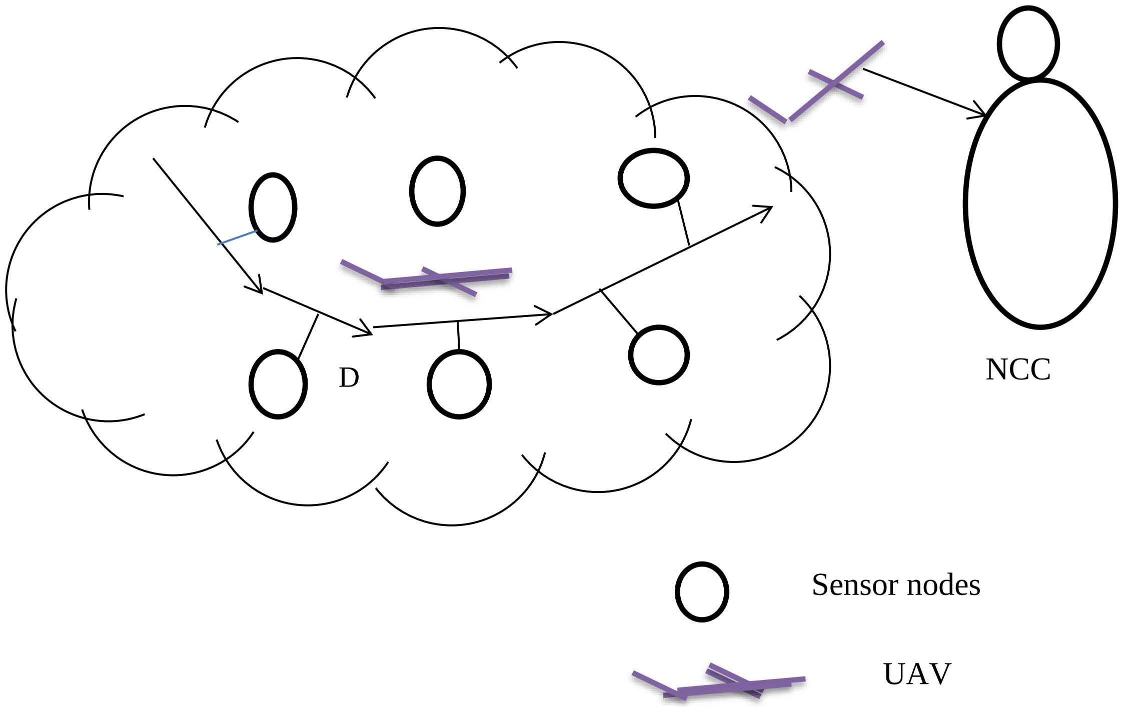

Fig-13 Architecture of mobile sink

Assume, in parabolic trajectory of UAV:

1. We consider energy consumption only during the transmission of sensed data.
2. Sensor nodes are uniformly distributed over the sensing field.
3. UAV visits on predetermined parabolic path and directly receive data from the nodes at the minimum distance.
4. Axis of the parabola which is passes through the vertex (x_o, y_o) that is symmetry to the parabola is considered.
5. Nodes left to the axis of the parabola and nodes on the axis of the parabola communicates with UAV by calculating shortest path when only UAV left to the axis of parabola, and nodes right to the axis of the parabola communicates with UAV when UAV right to the axis of the parabola.

The parabolic path planning algorithm is illustrated step by step as follows.

Input: M(X, Y) (the location of mobile sink), S(x, y) (the location of sensor node),

N (the number of sensor nodes). N1(sensor nodes participated on first transmission) N2(the number of sensor nodes participate on second transmission)

Output: The moving path of the mobile sink. Initialization: M(X, Y)=M (X_i, Y_j)

(The initial location of the mobile sink), k=1 (The number of sensor node locations selected), and count.

Step 1: Comparing first coordinates of sensor nodes(x_i) and UAV(X_i) with first coordinate of the vertex of the parabola(xo) to identify sensors that participates on first and second transmission.

Step 2: The mobile sink calculates the distances between all S(x, y) and M(X, Y).

Step 3: The minimal distance between S(x, y) and M(x, y) is selected.

Step 4: Let k=k+1. If k>N, the end of the task. Otherwise, go to Step 1.

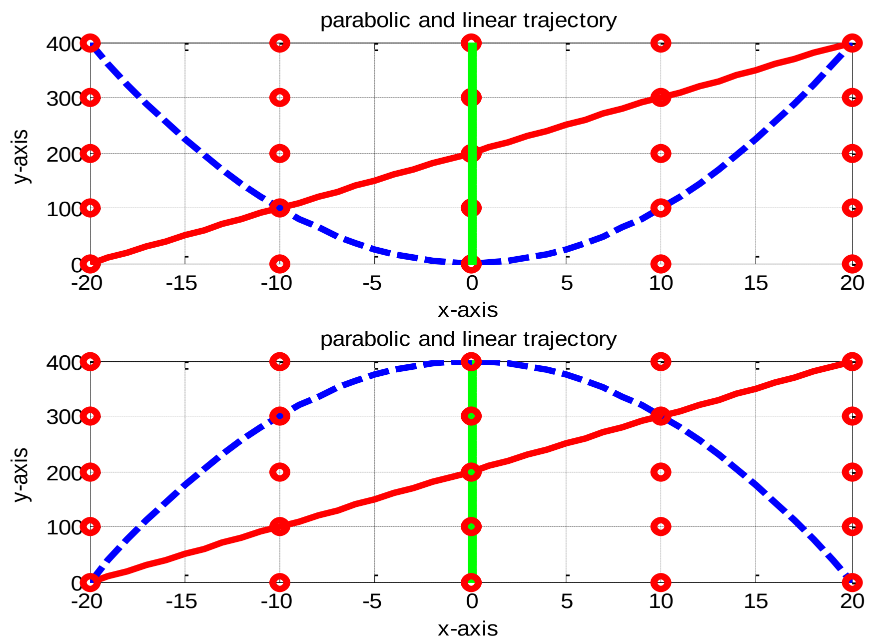

Fig-14 parabolic trajectory with axis of the parabola.

Let node N_i at the location of (x_i, y_j) and location of UAV at (X_i, Y_j).

Let (x_o, y_o) be a vertex of the parabola which is on the axis of the parabola.

When UAV comes to the left of axis of the parabola first transmissions occur.

That is

If $x_i, X_i \leq x_0$ first transmissions occur else

If $x_i, X_i \geq x_0$ second transmissions occur.

Nodes that participate on first transmission do not participate on second transmission.

In this case data redundancy is avoided.

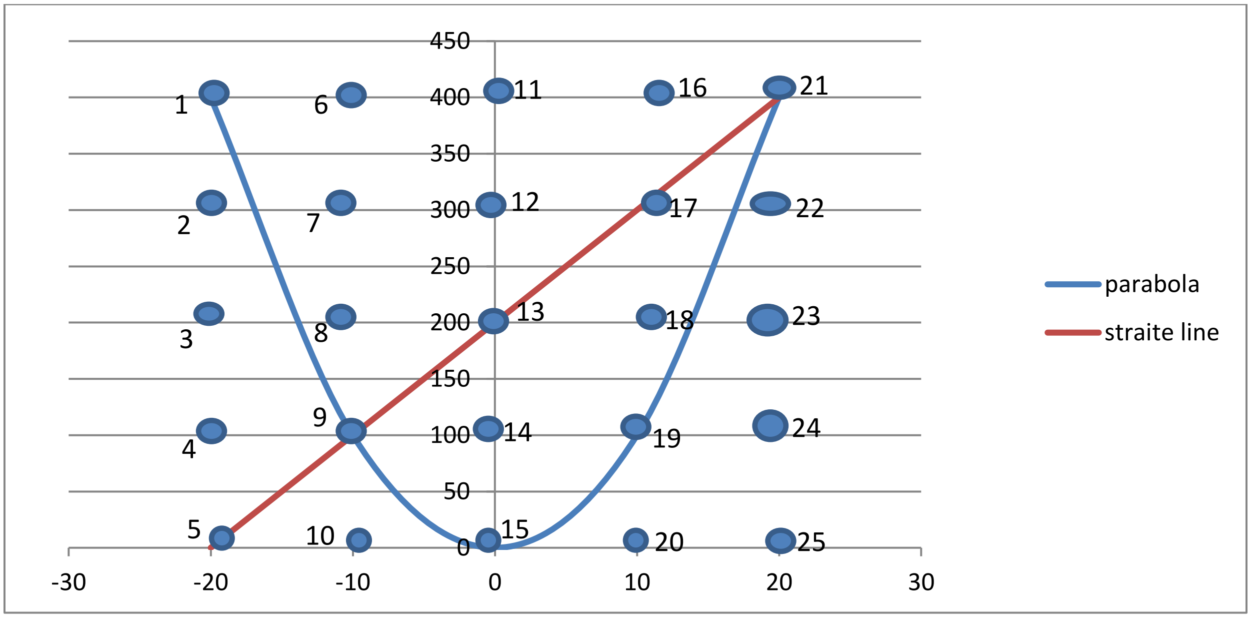

Fig-15. The network model.

In figure-8 above Nodes 1 up to 15 participates on first transmission and nodes 16 up to 25 participate on second transmission.

At Figur-15, there are given set of sensor nodes and their (x, y) location information. Their location information are 1(-20,400), 2(-20,300), 3((-20,200), 4((-20,100), 5((-20,0), 6(-10,400),

7(-10,300), 8(-10,200), 9(-10,100), 10(-10, 0), 11(0, 400), 12(0, 300), 13(0, 200), 14(0, 100), 15(0, 0), 16(10,400), 17(10,300), 18(10,200), 19(10,100), 20(10,0), 21(20,400), 22(20,300),

23(20,200), 24(20,100), 10(20, 0).

These points are used to calculate distance using Euclidean distance formula.

To finding shortest distance from a point to parabolic path, in our case $y=x^2$ in Euclidean distance

$$d^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1)$$

Let shortest distance of (1, 2) from $y=x^2$

$$d = \sqrt{(x-1)^2 + (y-2)^2}$$

In order to take the derivative to do in calculus for the problem we first need to write the equation in terms just a single variable. Use the parabola equation in the place of y.

$$d(x) = \sqrt{(x-1)^2 + (x^2-2)^2} \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (2)$$

$$d(x) = \sqrt{x^4 - 3x^2 - 2x + 5} \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (3)$$

$$d'(x) = \frac{4x^3 - 6x - 2}{2\sqrt{x^4 - 3x^2 - 2x + 5}} \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (4)$$

The shortest distance is when $d'(x) = 0$ this implies that

$4x^3 - 6x - 2 = 0$ Solve for x and plug in your distance formula Equ-2

The minimum is the shortest distance.

The distance from a point to a line is the perpendicular distance of the point to the line

In the case of a line in the plane given by the equation ax+bx+c=0, where a, b and c real constant with a and b not both 0 the distance from the line to a point (x_0, y_0) is

$$(dis(ax + by + c = 0, (x_0, y_0)) = \frac{|ax_0 + by_0 + c|}{\sqrt{a^2 + b^2}} \_\_\_\_\_\_ (5)$$

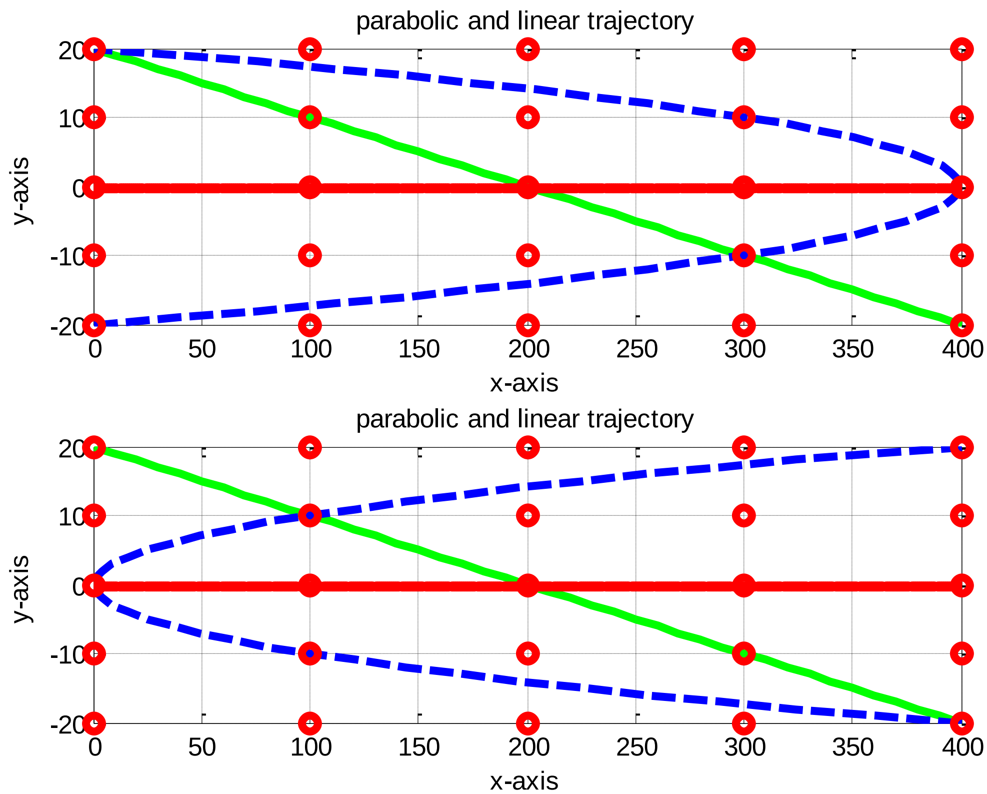

Fig-16 parabolic trajectory with axis of the parabola.

6. Nodes above to the axis of the parabola and nodes on the axis of the parabola communicates with UAV by calculating shortest path when only UAV above to the axis of parabola, and nodes blow to the axis of the parabola communicates with UAV when UAV blow to the axis of the parabola.

When UAV comes to the above of axis of the parabola first transmissions occur.

That is, If y_i, $Y_i \geq y_0$ first transmissions occur else If y_i, $Y_i \leq y_0$ second transmissions occur.

In both case with consideration of vertical axis and horizontal axis

Nodes participate on first transmission

Flow chart for working scenario of our proposed approach

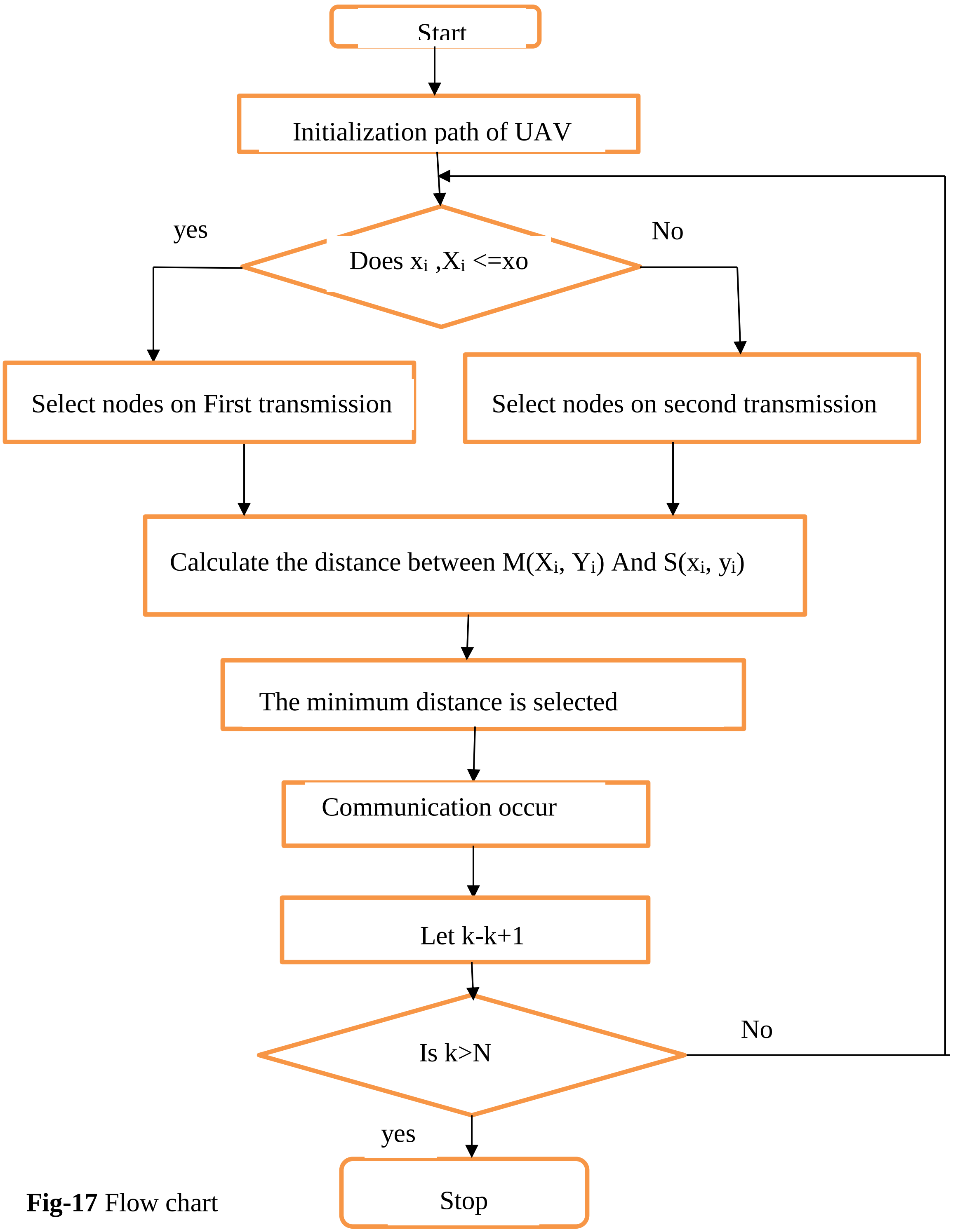

Fig-17 Flow chart

CHAPTER FIVE

5. RESULT AND DISCUSION

This chapter presents complete information about the implementation of our proposed model, the various steps to be followed and the tools used described. WSN performance analysis can be done by designing and using real WSN sites. But due to various limitations such as access to sensory nodes and time limits we designed our WSN topology in a simulated way. In the first case, small mobile devices are used by real systems. In the second method, namely, simulation, invisible models are used to represent real-world scenarios by considering various scenarios and a large range of applications.

In Section 5.1 we present the information for simulation models and the materials used for the task. They first discussed the various network simulations and then compared them in order to select the MATLAB template for our work. We then discussed the working principles of MATLAB in detail. Here is a brief overview of the chapter-by-section content.

5.1 Simulation Model

The simulation model applied in this thesis takes the traffic connection to hosts in the wireless network through the nodes of the wireless sensor networks as an input to the simulation environment (i.e. MATHLAB code, the network simulator and animator) are also used to generate into simulation environment. The file generated from MATHLAB (such as nodes position) has been used to measure the performance of the Algorithm. And, analysis has been performed to find out the impact of our approach in contrast with the linear trajectory.

5.1.1 Simulation Environment

The main purpose of the simulation sites is to provide a visual platform for distributed programs with the required components. At MANET, the detailed level of the simulation location, in most cases, determines the authenticity of the test. However, it does not mean that imitation sites are tested in terms of their detailed levels. In simple terms, a process by which we can build a mathematical model to solve a system the problem is called imitation. To simulate the network as mobile ad networks, numerical simulations can be used where OPNET, Qualnet, and NS2 are just a few of them. For our purpose of imitating the space we use to improve our simulation was MATLAB. The term MATLAB stands for matrix laboratory. MATLAB, developed by

MathWorks Inc., is a software package for efficient numerical and visualization [54]. The combination of analytical skills, flexibility, reliability, and powerful graphics make MATLAB a software package that is the core of scientific researchers. It basically uses Java and C as a developmental language. MATLAB provides a collaborative environment with hundreds of reliable and accurate mathematical operations built-in. These functions provide solutions to a wide range of mathematical problems including matrix algebra, complex arithmetic, precise systems, various scales, signal processing, configuration, indirect systems, and many other types of scientific calculations. A key feature of MATLAB is its editing ability, which is very easy to learn and use, and allows for user-enhanced functions. It also allows access to Fortran algorithms and C codes through external communication [54].

Creating Network Topology

To create a network topology for testing and evaluating our newly proposed approach, we used one of the most widely used WSN simulator, the so called MATLAB software. Here below is sample network topology that we used in our dissertation.

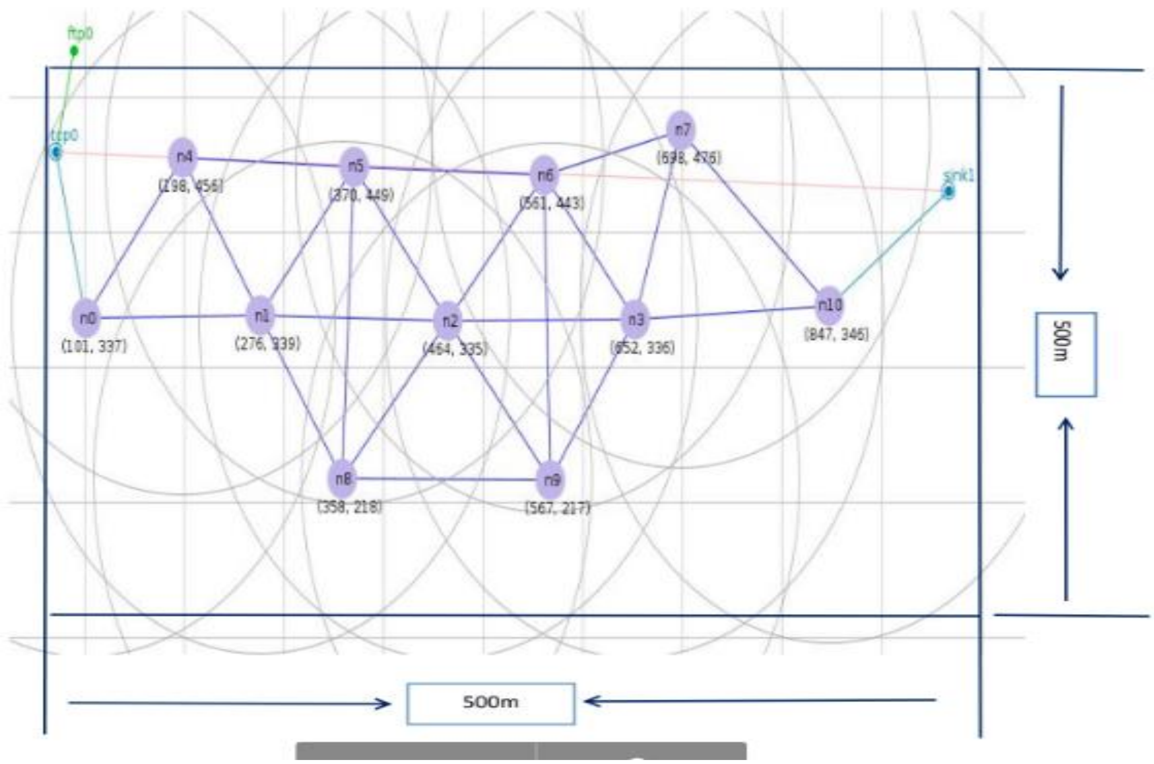

Fig- 18.Sample Network Topology of WSN

The mobile sink moves along the predefined trajectory and collects data from sensor nodes in single hop. Every sensor node is given ID number. The location information and ID of sensor nodes are obtained during the network deployment time. We assume that collected data are not time sensitive and they are saved in memory of sensor nodes. Sensor nodes send their data when a mobile sink visits them. When the mobile sink data gathering, it will communicate with sensor nodes to gets data from them by using Time Division Multiple Access (TDMA) method in one hop. During data-gathering tour of the mobile sink, it visits with parabolic path in the area of deploy.

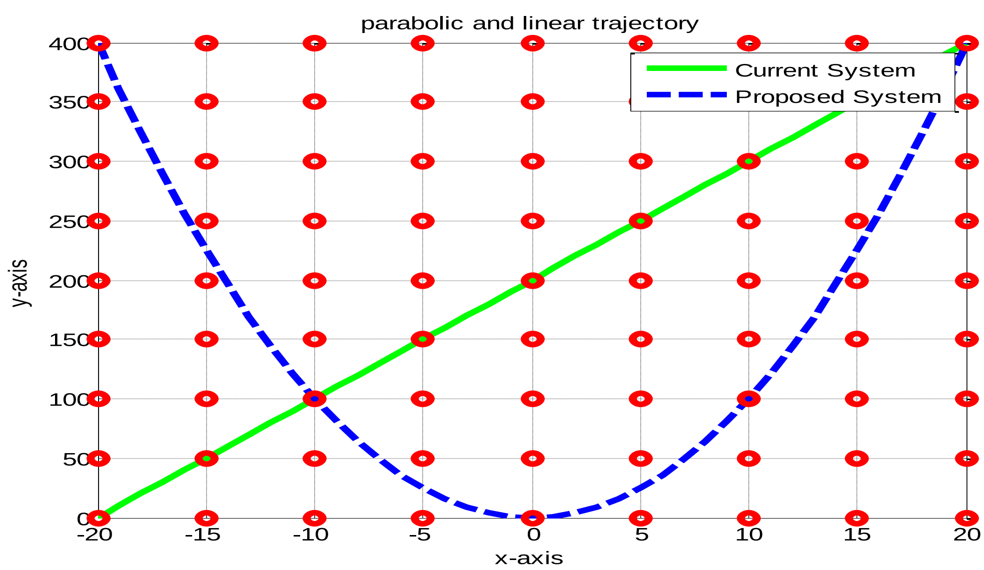

Fig-19 predefined location deployed wireless network sensors.

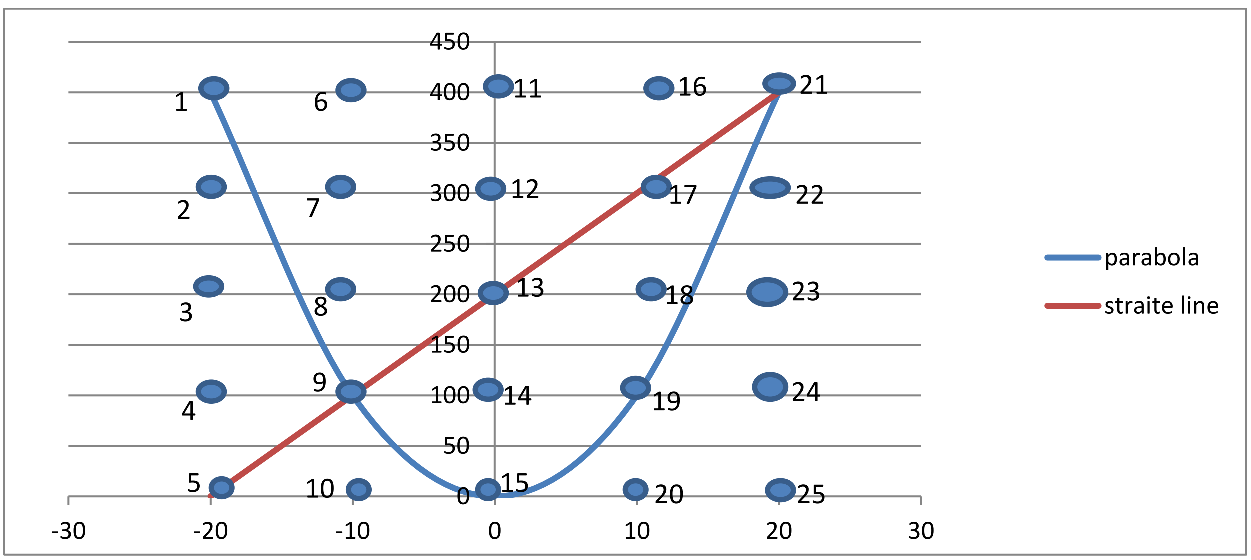

Fig-20 The network model.

Table 4.1. Energy consumption during parabolic and linear trajectory.

Node	x	y	Shortest points on parabola		Distance Between Nodes and parabolic path	Distance between nodes and linear path	Energy used by nodes during parabolic path (E_{used}= E_{tran} x dis)	Energy used by nodes during linear path (E_{used}= E_{tran} x dis)
			x1	y1				
1	-20	400	-20	400	0.001	39.80148761	0.00002	0.796029752
2	-20	300	-17.3227	300.075935	2.678377	29.85111571	0.053567533	0.597022314
3	-20	200	-14.1494	200.20552	5.854209	19.9007438	0.117084173	0.398014876
4	-20	100	-10.0248	100.496615	9.987554	9.950371902	0.199751087	0.199007438
5	-20	0	-2.0771	4.31434441	18.43486	0.001	0.368697118	0.00002
6	-10	400	-19.9937	399.74804	9.996876	29.85111571	0.199937514	0.597022314
7	-10	300	-17.3144	299.788447	7.317459	19.9007438	0.146349174	0.398014876
8	-10	200	-14.1369	199.851942	4.139549	9.950371902	0.082790973	0.199007438
9	-10	100	-10	100	0.001	0.001	0.00002	0.00002
10	-10	0	-1.6126	2.60047876	8.781285	9.950371902	0.175625703	0.199007438
11	0	400	19.9874	399.496159	19.99375	19.9007438	0.399874988	0.398014876
12	0	300	17.306	299.497636	17.31329	9.950371902	0.346265797	0.199007438
13	0	200	14.1244	199.498675	14.13329	0.001	0.282665882	0.00002
14	0	100	9.9749	99.49863	9.987492	9.950371902	0.199749845	0.199007438
15	0	0	0	0	0.001	19.9007438	0.00002	0.398014876
16	10	400	19.9937	399.74804	9.996876	9.950371902	0.199937514	0.199007438
17	10	300	17.3144	299.788447	7.317459	0.001	0.146349174	0.00002
18	10	200	14.1369	199.851942	4.139549	9.950371902	0.082790973	0.199007438
19	10	100	10	100	0.001	19.9007438	0.00002	0.398014876
20	10	0	1.6126	2.60047876	8.781285	29.85111571	0.175625703	0.597022314
21	20	400	20	400	0.001	0.001	0.00002	0.00002
22	20	300	17.3227	300.075935	2.678377	9.950371902	0.053567533	0.199007438
23	20	200	14.1494	200.20552	5.854209	19.9007438	0.117084173	0.398014876
24	20	100	10.0248	100.496615	9.987554	29.85111571	0.199751087	0.597022314
25	20	0	2.07713	4.31446904	18.43986	39.80548761	0.368697118	0.796029752
Total energy used in parabolic path data collection and linear path data collection							3.91616306	7.960397522

Table 4.1 shows that in parabolic trajectory distance between nodes and UAV is reduced.

In our proposed approach, the total distance of nodes from UAV is up to 46.3% shorter than in other approaches (linear trajectory). Consequently this reduces global energy consumption up to 49.2% when we compare our work with linear trajectory.

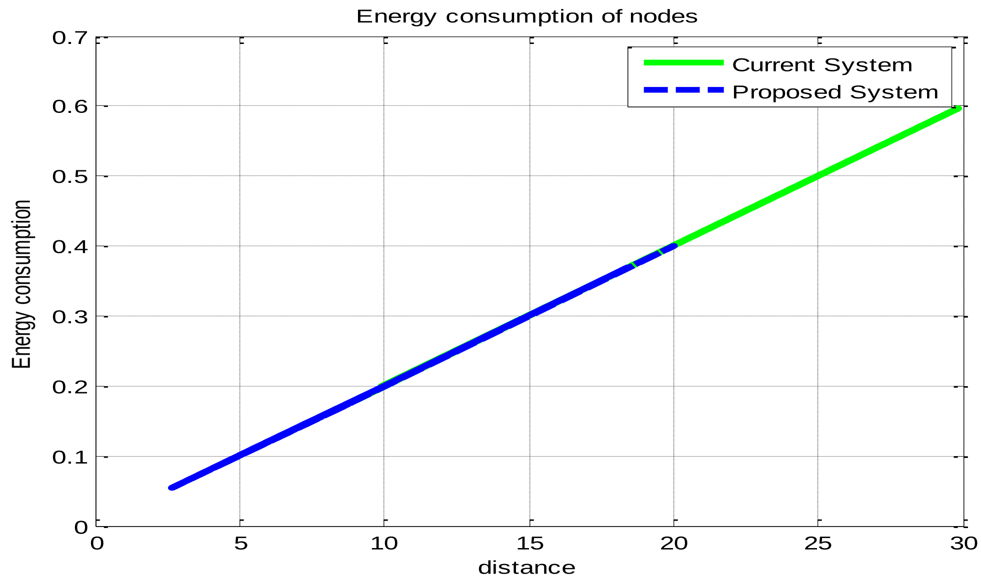

Fig-21 Distance and Energy consumption of nodes.

Figure 21 shows that proposed system reduce total distance between nodes and sink consequently reduce more energy than current system.

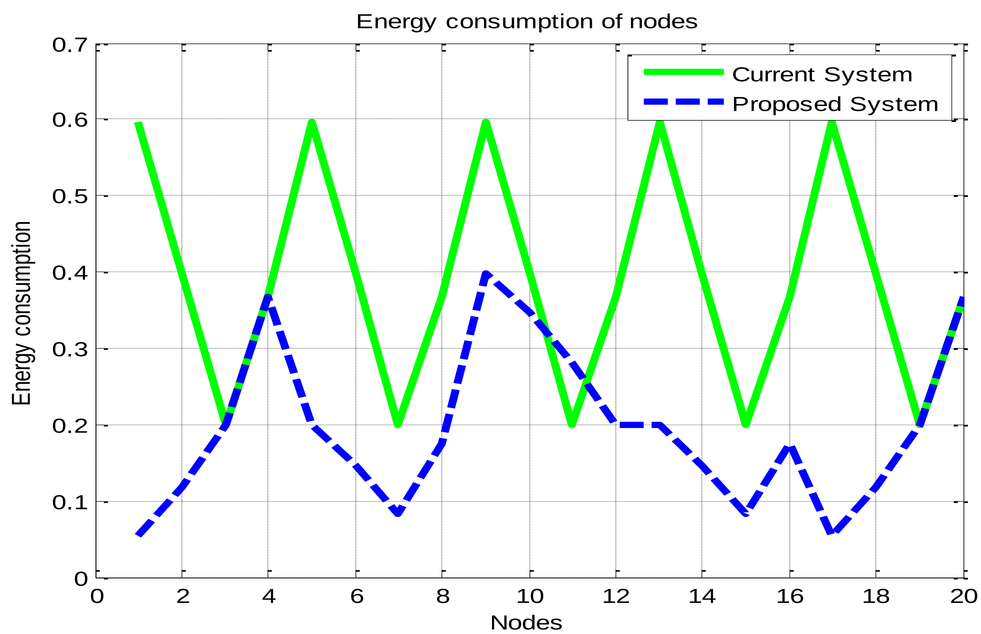

Fig-22 Energy consumption of nodes.

Fig 22 is the graphical comparison of the two systems against energy consumption. It indicates our system outperforms better than the linear one.

Table 4.2: Energy comparison of the existing linear trajectory system and our proposed approach.

Node	Our Approach	Existing System
5	0.06869711	0.08902
10	0.175625703	0.199007438
15	0.199340553	0.258014876
20	0.215625703	0.287022314
25	0.268697118	0.366029752
30	0.301616306	0.410397522
35	0.364633322	0.498700152
40	0.4056622	0.543337617

Here below is the graphical comparison of the two systems against energy consumption. It indicates our system outperforms better than the linear one.

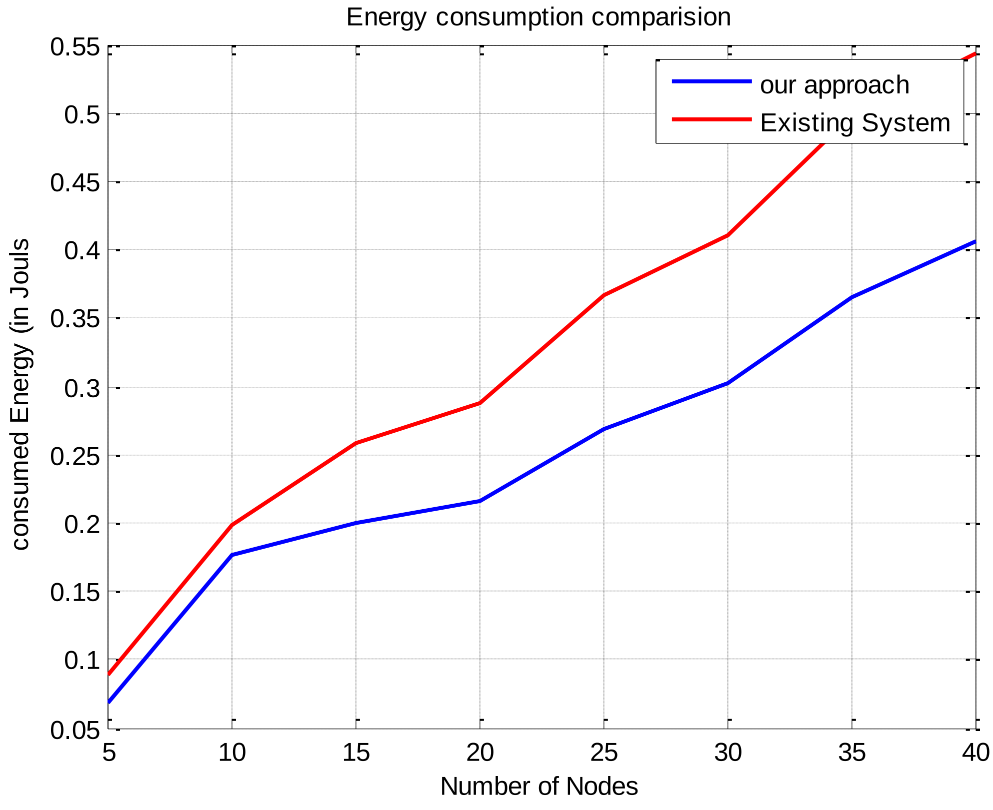

Fig-23 Energy consumption of nodes.

Figure 23 shows that proposed system reduce more energy than current system.

CHAPTER SIX

6. CONCLUSION AND FUTURE SCOPE

6.1. Conclusion

The development of a path planning scheme is a challenging issue in wireless sensor networks with mobile sinks. For the sake of load balancing and lifetime prolonging in WSNs, we propose a scheme for data gathering using a mobile data collector that parabolic trajectory. A mobile data collector is introduced, like mobile base station (sink). It visits predetermined parabolic path and directly receive data from the nodes with the minimum distance. To avoid redundant data we use axis of the parabola. This and the Single-Hop data gathering scheme provides considerable energy savings and increase node and network lifetime. In proposed approach, the total distance of nodes from UAV is up to 46.3% shorter than in other approaches (linear trajectory). Consequently, this reduces global energy consumption up to 49.2% when we compare our work with linear trajectory.

6.3. Future Work

The proposed algorithm is random parabolic path selection one can search for optimal parabolic path by moving a parabolic up-down and left-right. Not only the path but also by selection area of deploys weather a circle, a rectangular or a square is the best.

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