ENERGY EFFICIENT MODIFIED LEACH PROTOCOL FOR WIRELESS SENSOR NETWORKS (WSN)

A DISSERTATION

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

OF

MASTER OF TECHNOLOGY

IN

SOFTWARE ENGINEERING

SUBMITTED BY

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CANDIDATE'S DECLARATION

I, VIVEK KUMAR, Roll No. 2K20/SWE/27 student of M.Tech. (Software Engineering), hereby declare that the project Dissertation titled **"Energy Efficient Modified LEACH Protocol for Wireless Sensor Networks (WSN)"** which is submitted by me to the Department of Software Engineering Department, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associate ship, Fellowship or other similar title or recognition.

Place: Delhi

Date: 25-05-2022

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CERTIFICATE

I hereby certify that the major project titled "**Energy Efficient Modified LEACH Protocol for Wireless Sensor Networks (WSN)**" which is submitted by VIVEK KUMAR, Roll No-2K20/SWE/27 SOFTWARE ENGINEERING DEPARTMENT, Delhi Technological University, Delhi, in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree to this University or elsewhere.

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ACKNOWLEDGEMENT

I am highly grateful to the Department of Electrical Engineering, Delhi Technological University (DTU) for providing this opportunity to carry out this project work.

The constant guidance and encouragement received from my supervisor **Prof. RUCHIKA MALHOTRA** of Department of Software Engineering, DTU, has been of great help and inspiration in carrying my present work and is acknowledged with reverential thanks.

Finally, I would like to expresses gratitude to all faculty members and staff of Software Engineering Department, DTU for their intellectual support in my M.Tech study at DTU.

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ABSTRACT

Numerous researches have been done for minimization of the consumption of energy on wireless sensor networks (WSNs). The reason behind such research is because of a large number of applications in this field. We have proposed a method for the same in our paper. We have implemented various approaches to minimize the energy consumption and based on various results which are calculation of cluster count, Communication between the packets and lifetime matrices which are number of alive and dead node. The techniques implemented in the system are simple leach, I-leach, modified I-Leach and the Multi-Hop Clustering Routing method in Leach. On comparing all the techniques, it is found how the suggested technique performs which is Multi-Hop Clustering Routing is better in network lifetime as well as in terms of stability period.

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CHAPTER 1
INTRODUCTION

1.1 Background

Wireless sensor networks, also known as WSNs, are a type of communication network that is made up of a large number of nodes that are spread out in different locations all over the world. Wireless sensor networks also go by the acronym WSN. These nodes are equipped with microsensors, and the network as a whole operates wirelessly. The explosive growth in popularity that wireless sensor networks (WSNs) are currently experiencing is having a positive impact on a wide variety of industries, including the military, which is just one of those industries. WSNs are gaining popularity in a wide variety of industries, including the military in addition to other parts of the economy. This trend is expected to continue in the foreseeable future. They work together in groups, coordinate their efforts, and collect data from the environment around them, among other things, in order to gather and process information from a particular location. Following the conclusion of this stage, the data will be sent to the base station in order for those data to be processed at that location. Despite the fact that wireless sensor networks (WSNs) have been in existence for a considerable amount of time, these networks are now considered to be indispensable components of assets that are based on the Internet of Things (IoT) [1, 2, 3]. These components are required for a wide variety of different kinds of applications to function properly in a wide variety of different settings. The Internet of Things presents a wide range of potential opportunities for the implementation of a wide variety of different kinds of application scenarios. Monitoring the environment and providing medical care are two examples of these potential outcomes. Another scenario that has the potential to be realized is the creation of smart cities. [4] In terms of their overall functionality and performance, sensory networks have the potential to be significantly more powerful than ad-hoc networks. This benefit could be measured in many orders of magnitude higher than the competition. This is due to the fact that sensory networks have a significantly higher total number of nodes when compared to other types of networks [5]. In order for wireless sensor networks to be successful, one of the most significant challenges that must be conquered is the development of routing algorithms that have a low energy consumption. This issue is among the most important challenges that wireless sensor networks need to overcome (WSNs). Once the process of installing particular nodes in the network has been finished, those nodes cannot be removed or replaced after the installation process has been finished successfully. This is true even for nodes that have previously been installed in that location without incident.

Because of the way in which these connections are made, the efficient utilization of node power and the regulation of its distribution are inextricably linked to the successful operation of the network. Hierarchical routing protocols are the most popular types of routing protocols for use in wireless sensor networks. This is due to the fact that they are the most energy-efficient and the most widely used type of routing protocol for use in wireless sensor networks. They have seen a rise in popularity over the past few years as a direct result of this, which has led to the rise in popularity. This has led to the rise in popularity. Create bits in the network and assign a (CH) to each bit so that it can connect cluster nodes, also known as member nodes, to the base station. The base station is also referred to as the head node. Bits is another name for the individual member nodes in a tree. It is recommended that you organize the network in this manner (base station). Because it must retrieve the data from a variety of sources, compile it, and then distribute it to the BS using a method that is designed to keep the total amount of power consumption as low as is possible, the CH uses a significant amount of energy while it is in the process of collecting the data. This is because it must distribute the data to the BS using a method that is designed to keep the total amount of power consumption as low as is possible. This is because the CH transmits the data to the BS using a method that was developed with the goal of cutting down on the total amount of power that is used, which explains why this is the case.

The LEACH [1] system is the oldest hierarchically constructed system in the world, and it accomplishes its objective by transmitting information through a large number of information clusters that are extremely similar to one another. One-hop routing is a method that facilitates the transmission of data from the CHs to the BS in a single step, eliminating the requirement for any additional hops that may be necessary. In order for this method to function in an appropriate manner, the assistance of a routing mechanism is required. When employing this method, one must be aware of the many restrictions that must be observed in order for the endeavour to be fruitful. When it comes to the overall amount of energy that is used up, it should go without saying that CHs that are situated at a location that is further away from the BS use up a greater quantity of energy than CHs that are situated at a location that is closer to the BS. This is because CHs that are situated at a location that is further away from the BS have to travel a greater distance to reach the BS. A direct consequence of this is that clusters that are physically located geographically further apart from one another in space have a higher risk of extinction than clusters that are physically located geographically closer to one another in space. The LEACH direct transmission technique is not useful for large-scale networks because it creates interference with distribution load balancing and shortens the working lifetime of the network. Both of these issues reduce the amount of time the network is able to function effectively. This is due to the fact that it decreases the amount of time during which the network is able to effectively function. Because of the interference that it causes and the reduction in the working lifetime of the network, it is impossible for this method to effectively balance distribution loads. This is because of the reduction in the working lifetime of the network. There is one more thing that should be taken into consideration, and that is the frequency of data transfers. The frequency of data transfers differs from one node to the next in the network, and it is based on the amount of data that is stored at each node in the network. Because of its impact on the efficiency of the network as a whole, this is an essential consideration to keep in mind at all times. This is an important aspect that must be taken into consideration. Because of this differentiation, nodes that have high activity will pass away more quickly than nodes that have medium activity, which will, in the long run, result in an imbalance of energy between network nodes.

In order to derive meaningful information from the data that was gathered by the sensor nodes, which are battery-powered and have a limited amount of power, it is necessary for them to perform extensive processing and computing in order to accomplish this task. This is because in order to derive meaningful information from the data that was gathered by the sensor nodes, it is necessary to derive meaningful information from the data. In order to collect metadata that can be analysed during later stages of the development process, a large number of devices have been connected with one another and made to communicate with one another. Utilization of the Internet of Things has made the accomplishment of this goal conceivable (IoT). This action, in addition to wasting energy that is easily accessible, will have a negative effect, over the course of a longer period of time, on the network's viability and stability. If you choose data packet routing pathways that use the least amount of total energy throughout the path, you can extend the lifetime of a wireless sensor network. This is accomplished by selecting the pathways. You will be able to route the packets more effectively as a result of this. This is referred to as energy efficiency, and it is possible to achieve it by designing data packet routing pathways that are as energy efficient as is humanly possible. The creation of a network that consumes the least amount of energy possible is one strategy for improving energy efficiency.

1.2 Overview of Key Issues

With the assistance of modern sensor technology, it is now possible to design and develop a wide range of applications that make use of wireless sensors. As will be elaborated upon in greater detail further down on this page, this topic will be discussed. The various sensor technologies that are currently in use are broken down into their respective sections and summarised in Appendix A, which can be found at the end of this document. The various sensor technologies that are currently in use are broken down into their respective sections and summarised in Appendix B, which can be found at the end of this document. Sensors are currently available on the market in a variety of different configurations, in addition to the generic (multi-purpose) nodes and gateway (bridge) nodes that are already present. In order to collect data from the environment that is being monitored, it is necessary to configure a generic sensor node, also known as a sensor node that can serve multiple purposes. A wide variety of sensors are able to measure a wide variety of physical characteristics, including electro-magnetic fields, for example, which are just one example of the physical characteristics that can be measured. Other examples of physical characteristics that can be measured include lighting, temperature, humidity, barometric pressure, velocity, acceleration, and acoustics. These can all be added to the list of characteristics that have already been discussed. Nodes in this network perform the function of gateways or bridges between the sensor network and the base station. These nodes are responsible for collecting data from generic sensors and transmitting it to the base station. It is now possible for gatekeeper nodes to operate with significantly increased processing power, battery life, and transmission (radio) range than it was previously possible for these things to be possible. An enterprise wide wireless network, also known as an EWSN, is typically composed of a mixture of generic and gateway nodes that are strategically placed throughout the network in order to provide coverage throughout the entirety of the organisation.

A wide variety of jobs, as shown in Figure 1, can be organised into three categories, and each of those categories can be further subdivided into subcategories. Additionally, as shown in Figure 1, each of those categories can be further organised into subcategories. As shown in Figure 1, this categorization will make it much simpler to develop applications for wireless sensors that make use of sensor technologies.

The first group of people who had any kind of interaction with the system were the ones who were given it, and to this day, it is still in operation. As was just mentioned, each individual sensor node possesses the potential to independently operate as a self-sufficient system in its own right.

As a consequence of this, amongst other things, the development of new platforms, operating systems, and storage schemes is required in order for various kinds of application software to be run on a sensor system, as well as for the development of sensor systems themselves. This is a prerequisite for the development of sensor systems.

There are two types of communication protocols available, both of which are used to ensure that communication between an application and a sensor network is as seamless as possible. XMPP and HTTP are two examples of communication protocols.

Communication between sensor nodes is also made possible through them, which is essential for the proper operation of the system as a whole. Most importantly and perhaps most significantly, services can be designed and built that will increase both the overall performance of an application while also increasing both overall efficiency of the network and its supporting infrastructure.

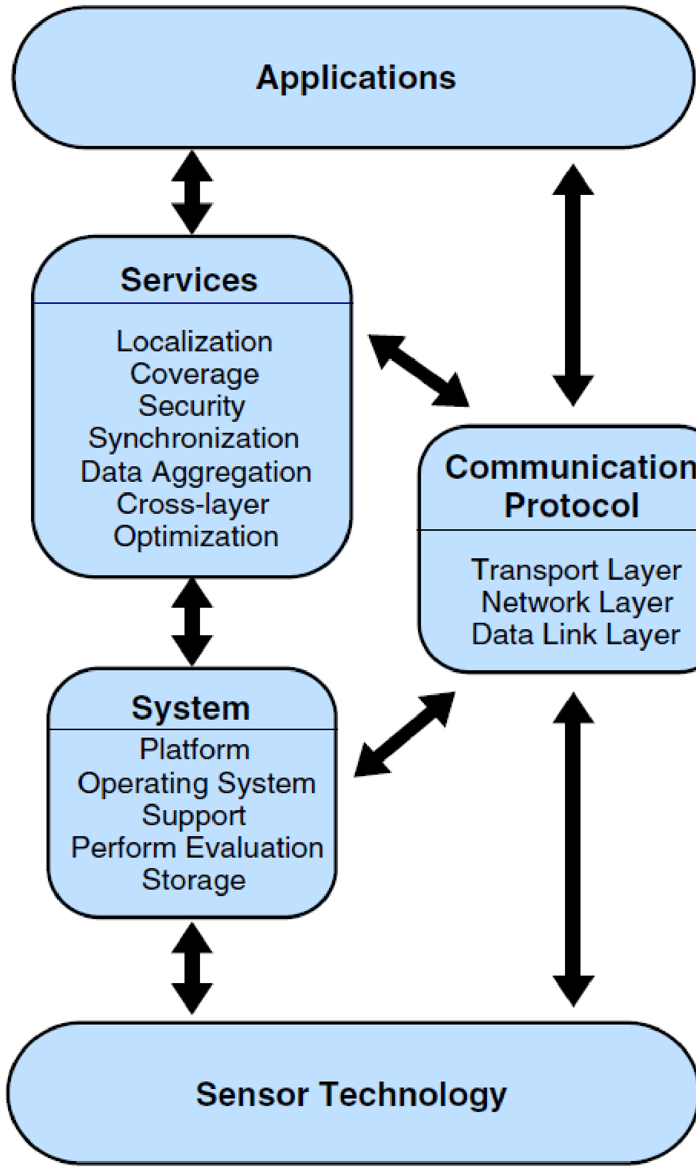


Fig 1 Various Issues Classification in Wireless Sensor Network

1.3 Classification of WSN Applications

WSN applications can be classified into two categories:

It is necessary to keep a close eye on the things that need to be watched and tracked down (see Fig. 2). Various monitoring technologies can be used for a variety of purposes, including indoor and outdoor environmental monitoring, health and wellness monitoring, power monitoring, inventory location monitoring, factory and process automation, seismic and structural monitoring, to name a few examples of applications. Besides keeping track of objects, animals, humans, and automobiles, tracking applications can be used to keep track of a variety of other things as well, including people and animals. Object tracking applications are particularly useful for tracking objects such as people and animals. While there are numerous options available, the examples in the following section will highlight some applications that have been successfully deployed and tested in a real-world environment, despite the fact that there are many different options available. PinPtr [2] is an experimental counter-sniper system designed to detect and locate shooters on the battlefield. It is currently in the testing phase. The program is currently in the testing stage. On the battlefield, it was designed with the goal of detecting and locating shooters, which it accomplished. Because of the dense deployment of sensors, when muzzle blasts and shock waves caused by a shot occur, the system is able to detect and measure the time of arrival of the blasts and shock waves, providing valuable information. Using sensors, base stations can locate the shooter on a battleground by relaying their readings to a central command station, which then uses this information to determine where he or she is on the battlefield (such as a laptop or PDA). The PinPtr system, which is comprised of an acoustic sensor board that performs multiple functions in conjunction with second-generation Mica2 motes, is a fully functional system that can be used in a variety of applications. Every one of the three acoustic channels that are integrated into the design of each multi-purpose acoustic sensor board is manufactured by Xilinx and is designed with a Spartan II FPGA and the three acoustic channels mentioned above. TinyOS is an operating system platform that, among other things, manages a wide range of functions, such as task scheduling, radio communication, time management, and I/O processing, to name a few examples. A few of the middleware services that have been developed on TinyOS and are used by this application include time synchronization, message routing with data aggregation, and localization.

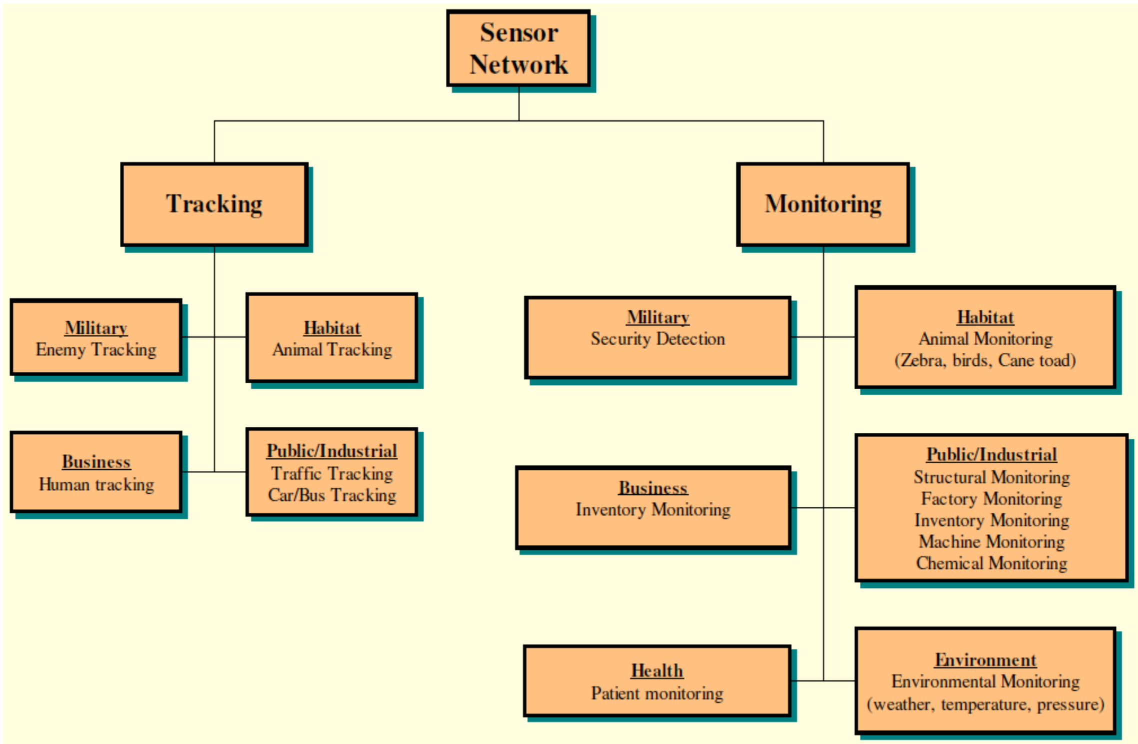


Fig 2 Sensor Application Classification

CHAPTER 2

LITERATURE REVIEW

1. One of the papers that were presented at the conference was titled "The Internet of Things (IoT): Applications, Investments, and Challenges for Enterprises." This paper was written by Lee I and Lee K in 2015 and presented at the conference. The Internet of Things (IoT) is a new technology paradigm that is envisioned by this paper. The IoT is a worldwide network of machines and devices that are capable of communicating with one another.

   The Internet of Things (IoT), also referred to as the Internet of Everything (IoE) or the Industrial Internet, is a term that describes a network of connected devices. Other names for this network include the Internet of Everything (IoE) and the Industrial Internet. The Internet of Things (IoT), despite the fact that it is still in its infancy, is widely recognised as one of the most important areas of future technology, and it is receiving significant attention from a wide variety of industries, including the automotive industry. Even though it is still in its infancy, the Internet of Things is widely recognised as one of the most important areas of future technology. The purpose of this article is to discuss three categories of Internet of Things applications that can be used by enterprises to increase customer value by improving the overall customer experience, as well as how these applications can be put into practise. This article discusses a number of different technologies related to the Internet of Things, in addition to three categories of Internet of Things-related goods and services for consumers.

   This article delves into the technologies that are essential to the successful deployment of internet of things-based products and services, and it does so throughout its body. The justification of technological projects frequently makes use of both the net present value method and the real option approach, both of which are investigated in this section. Both of these methods and approaches are commonly used. A description of the real option approach, in addition to an illustration showing how the real option approach can be applied to investment in the Internet of Things, are both included in this article. This article provides a concise summary of the author's final thoughts on five technical and managerial challenges that have been discussed in greater detail in a previous article.

2. T. Qiu, M. Han, M. Li, and Y. Zhang worked together on a paper that was published in 2017 and is available for online download. The paper is titled "A self-recoverable time synchronisation for sensor networks of the healthcare Internet of Things" and was written by T. Qiu. M. Han, M. Li, and Y. Zhang contributed to the paper. According to the authors of this paper, significant advancements in sensor networks for healthcare have been made in recent years. These advancements have made it possible to integrate real-time health data by connecting bodies and sensors together in a network.

   Body sensors have to be precisely time synchronised with one another in order for them to work together in an efficient manner when it comes to monitoring health conditions and the use of medications. Time synchronisation protocols in sensor networks for the Internet of Things in healthcare are extremely important because, in order for them to be efficient, they need to be self-healing and possess a high level of accuracy. Because body sensors are typically used in conjunction with unstable energy sources, it is possible for nodes to become unresponsive as a result of a lack of power. This is because it is possible for nodes to run out of power. As a consequence of the presence of this factor, time synchronisation protocols operate at a lower level of both efficiency and robustness. Stable root nodes are necessary in order for tree-based protocols to function as time references, and it is imperative that these nodes be accessible at all times.

   In the event that there is not a root node available, the process of time synchronisation will not be able to be finished. We propose a Self-Recoverable Time Synchronization (SRTS) scheme for healthcare Internet of Things sensor networks in order to find a solution to this issue. A recovery timer is started whenever candidate nodes are dynamically elected. This is done to make certain that the nodes are not lost during the election process. The candidate node whose timer runs out first will be in charge of selecting a new root node. This new root node will then be followed in the selection process by the remaining candidates until all of the candidates have been eliminated.

The two-point least-squares method, when combined with the MAC layer timestamp, was used to accomplish the goal of significantly enhancing the accuracy of the PBS. This was done in order to achieve the desired result of significantly enhancing the accuracy. SRTS makes use of the SRP and RRP models, both of which are prevalent in the industry and are utilised by a lot of other companies as well. As a consequence of this, our strategy performs better than PBS in terms of accuracy while consuming roughly the same amount of energy as the latter method does. We make use of the NS2 network tools in order to determine how successful our approach will be. The results of the simulations show that the time synchronisation protocols SRTS perform better in terms of self-recovery than the time synchronisation protocols STETS and GPA when tested at various network scales. Additionally, in comparison to the PBS, the TPSN boasts superior accuracy as well as clock drift compensation, making it the superior option to go with.

3. Lazarescu MT introduced the concept of the Internet of Things (IoT) in 2013, and it describes how the Internet Protocol (IP) can be used to create a virtual representation of virtually any real-world object, ranging from a car to a teacup to an entire building and even individual trees in a forest, all through the use of Internet Protocol. 4. The Internet of Things (IoT) is a concept that describes how the Internet Protocol (IP) can be used to create a virtual representation of (IP). It is able to provide ubiquitous generalised access to the status and location of any "thing" that we are interested in, which is a service that we value, which is why it has attracted our attention. This is a service that we value, which is why it has attracted our attention.

Wireless sensor networks (WSN) are an excellent choice for the long-term acquisition of environmental data for Internet of Things (IoT) representation and representation as a result of their cost-effectiveness. This is because IoT represents and represents things online.

The functional design and implementation of a complete WSN platform are outlined in this paper, which covers the entire process from beginning to end. This platform, which can be used for a variety of Internet of Things applications, enables the creation of applications for long-term environmental monitoring, such as long-term monitoring of the weather.

It is important to consider the application requirements for a low cost, a large number of sensors, rapid deployment, long lifetime, low maintenance, and a high level of service quality when designing the platform and all of its components. These are just some of the factors that need to be considered.

4. Recent technological developments in wireless communication and networking have made it possible, among other things, to design large-scale networks and small sensor units that are both low-power and multifunctional in terms of their processing capabilities. While there have been significant strides made in recent years in the field of energy harvesting technologies, the amount of energy that can be harvested from sensors remains a finite resource. This presents a challenge when it comes to the creation of routing protocols that can be used between sensor nodes and base stations.

   This study proposes a multi-hop graph-based approach for an energy-efficient routing protocol (MH-GEER) in wireless sensor networks with the intention of evenly distributing energy consumption between clusters and, as a result, extending the lifespan of wireless sensor networks. MH-GEER is an acronym that stands for multi-hop graph-based approach for energy-efficient routing protocol in Wireless Sensor Networks (WSNs). This paper discusses MH-GEER node clustering and multi-hop routing path selection in the context of node clustering and multi-hop routing path selection. During the phase in which clusters are being formed, a structure that is analogous to that of a low-energy adaptive clustering hierarchy is being established. Clusters are being formed centrally, and cluster heads are being chosen from a pool of candidates that is distributed throughout the phase (LEACH).

They have developed a strategy for determining energy levels throughout the entirety of the network by taking a probabilistic and intelligent approach to the problem. They then used this information to select the next hop in a manner that is both probabilistic and intelligent. When the single-hop conventional LEACH protocol is used in conjunction with MHGEER, the results of the performance evaluation show that energy depletion in distant clusters is reduced while also ensuring that load balancing in a network is achieved. This results in an increase in the lifetime and stability of the network.

5. Kumar, V., S. Jain, and S. Tiwari discussed the algorithms that can be used to make wireless sensor networks (WSNs) more energy efficient in their paper that was published in IEEE Transactions on Information Technology and titled "Energy efficient clustering algorithms in wireless sensor networks”. They explained that, in particular for Wireless Sensor Networks (WSNs), the paths for data transfer are chosen in such a way that the total energy consumed along the path is kept to an absolute minimum in order to maximise the network's lifetime. This is done in order to ensure that the network is able to function for the longest possible amount of time.

   The clustering of sensor nodes, which makes data aggregation and scalability easier to achieve, is a common practise in situations where scalability and data aggregation are considered to be important considerations. We are able to construct hierarchical WSNs by clustering sensor nodes together. This enables us to make more efficient use of the limited resources that each sensor node possesses and, as a direct result of this, enables us to lengthen the lifespan of the network as a whole.

   In this paper, our goal is to present a survey of the most recent clustering algorithms that have been reported in the published research on wireless sensor networks. This type of research is considered to be the state-of-the-art in this particular field (WSNs). This paper presents a taxonomy of clustering algorithms for use in wireless sensor networks. The taxonomy is organised around an energy-efficient clustering algorithm as its central organising principle. In addition, for your convenience and enjoyment, we have provided you with a timeline as well as a description of LEACH and its offshoots that can be found on the World Wide Web.

6. In their paper titled "Descendant of LEACH-based routing protocols in wireless sensor networks," R.P. Mahapatra and R.K. Yadav describe a routing protocol that is a descendant of the LEACH protocol. They describe a routing protocol that is a LEACH protocol offshoot in this paper. This protocol is a descendant of the LEACH protocol. According to the findings of this research paper, wireless sensor networks (WSNs) are currently being implemented in a wide variety of applications across a wide range of settings, including industrial, military, and civilian spheres of operation.

   The developments in wireless communication technology, which are covered in greater detail throughout the body of the paper, are responsible for some of this phenomenon. When a wireless sensor network (WSN) is created, it is composed of a large number of sensor nodes that are dispersed in a haphazard manner across the entirety of a specific geographical region. There is an issue with the restricted amount of power that is available in a node, and the battery in the node cannot be replaced because of the restricted amount of power that is available. When attempting to estimate the lifespan of a WSN, a great deal of emphasis should be placed on the longevity of each sensor node that is connected to the network.

   As a result of the fact that the sensor node is accountable for sensing and transmitting data from the environment to the sink, the routing schemes for data forwarding in wsn need to be efficient and make efficient use of the battery power of the sensor node in order to extend the network's lifetime. The most important challenge that is being worked on right now in the area of wireless sensor networks is the creation of a routing protocol that is efficient in terms of its use of energy (WSN).

Hierarchical routing is one of the techniques that scientists have developed to extend the life of wireless sensor networks (WSNs). These techniques, which are currently in the beginning stages of development, are one of the techniques that scientists have developed. Another technique for routing data is called multihop routing, which is currently in the preliminary stages of its development. In this piece of work, both a timeline of the evolution of descendant hierarchical routing protocols and the results of a recent survey of such protocols are presented. The survey was carried out recently. In addition to that, these protocols are being evaluated in relation to one another using a wide range of distinct assumptions and standards as evaluation criteria.

7. A paper titled "Wireless sensor network survey" was just recently published. This paper was written by J. Yick, B. Mukherjee, and D. Ghosal. It is a compilation of surveys of various papers that have discussed the most important aspects of wireless sensor networks, as well as their own research on the subject. The paper was recently published. Wireless sensor networks (WSNs), as the authors of this paper explain, have a wide range of important applications, some of which include remote environmental monitoring and the tracking of moving targets. In recent years, there has been an increase in the availability of sensors that are not only more intelligent but also smaller, more affordably priced, and more intelligent. This has made it possible for this to take place. Over the course of the past few years, these sensors' prevalence in homes and places of business has steadily increased.

   A good number of these sensors come fitted with wireless interfaces, which make it possible for them to communicate with one another and, as a consequence, create a network of sensor nodes in the process. The design of a WSN must consider a number of factors, including the environment, the design objectives of the application, the cost of the system, and the limitations imposed by the hardware and software. The application has the greatest influence on the design of a WSN, which must take these and other factors into account.

A survey on sensor networks in IEEE Communications Magazine in 2002]. It does so by using contributions from [W. Su, Y. Sankarasubramaniam, and E. Cayirci's Sensor networks in IEEE Communications Magazine in 2002] and [I.F. Ak Following the top-down introduction of several new applications, a bottom-up review of the literature is conducted on various aspects of wireless sensor networks. This is followed by a conclusion that summarises the findings of the investigation, which brings the whole thing to a close.

According to the findings of this paper, the problems can be broken down into three distinct categories of challenges: the internal platform and the underlying operating system; the communication protocol stack; and the provisioning and deployment of network services and infrastructure, to name just a few topics (see Figure 1). There have been significant developments in each of these three categories, and there have also been new challenges in each of these three categories. We will examine each of these new challenges in greater detail below.

8. The title of a paper that was published in 2010 was "Developed distributed energy-efficient clustering (DDEEC) for heterogeneous wireless sensor networks". Wireless sensor networks are described by the authors of this paper as being made up of a large number of low-cost and power-constrained sensors. These sensors are responsible for gathering data from their surroundings and sending it to a base station in a cooperative manner, rather than sending it individually. It is a significant challenge that must be overcome to increase the lifetime of wireless sensor networks while simultaneously reducing the amount of energy that these networks consume.

   In order to accomplish this goal, it is common practise to make use of methods such as clustering and other similar approaches. Developed Distributed Energy-Efficient Clustering scheme is the name that we have given to the clustering strategy that we will be proposing and evaluating as part of this investigation. This clustering strategy will be used for heterogeneous wireless sensor networks. Altering the likelihood that someone will be elected to lead the cluster in the first place is one way that this method works toward its ultimate objective of making the process more dynamic and productive. According to the simulations, our protocol outperforms the Stable Election Protocol (SEP) by approximately 30 percent when it comes to network lifetime, and it outperforms the Distributed Energy-Efficient Clustering (DEEC) by approximately 15 percent when it comes to the first node to die.

9. Gaba, Gurjot & Monga, Himanshu & Kansal, Lavish & Miglani, Rajan. (2016) in 2019, published a paper titled "I-LEACH Protocol for Wireless Sensor Networks" in International Journal of Multimedia and Ubiquitous Engineering. 11. 279-292. In this research paper, wireless sensor networks (WSN) have gained a significant deal of significance due to its potential applications in maritime engineering, human tissue research, and animal life research. In cases when battery replacement is impractical, the utility of WSN is limited due to the small battery contained within the node. This paper provides a remedy to this issue through research. The LEACH procedure, which is considered the earliest technique for Energy Conservation in WSN, inspired this work. With the introduction of node fabrication, however, this protocol must be changed to meet the essential requirements. Intelligent LEACH (I-LEACH) is superior to MOD-LEACH in terms of increased lifetime, according to an analysis (a variant of LEACH). The results demonstrate a 54 percent increase in network lifetime compared to MOD-LEACH, assuring extended connectivity and dependability.

10. Nahar, Khalid & Ra, N.A. & Al-Khatib, Ra'ed M. & Barhoush, Malek & Abdul Halin, Alfian in 2019, published a paper titled "MPF-LEACH: modified probability function for cluster head election in LEACH protocol" in International Journal of Computer Applications in Technology 60(3):267. In this research paper, they have refined the Cluster Head (CH) election probability function to enhance the LEACH algorithm (thresholds). The ability of a retired CH to run for office again was made easier. The objective is to utilise CH residual energy to extend the network's service life. The implementation of a new threshold ensures

that the probability value for a CH is greater than zero. To enhance the original LEACH protocol, we implemented a newly conceived research technique. The upgrade focuses on enhancing the WSN's throughput and durability. This is accomplished by increasing the likelihood that an expired CH that was removed from the list due to insufficient residual energy will be reselected. Multiple tests were conducted to determine the efficacy of the MPF-LEACH procedure we proposed. Experiment results indicate a substantial improvement in network resilience and throughput. Using the CH residual energy, we have increased the election probability threshold of the original LEACH protocol. Due to the additional chance for a CH to be re-elected, the lifespan of the network has been lengthened.

11. "Energy-efficient modified LEACH protocol for IoT application" was published in 2018 by the Institution of Engineering and Technology. Wi-Fi sensor networks have many uses, according to this article (WSNs). The Internet of Things (IoT) allows Internet-based interconnection of diverse objects and devices. Unlike mobile ad-hoc networks, WSNs are concerned about battery life, which affects network durability. Wireless sensor networks' energy consumption has been studied extensively. Hierarchical clustering reduces WSNs' energy consumption. A threshold limit for cluster head selection is introduced in this study, along with a power level change across all nodes. For each round of the proposed enhanced LEACH protocol, the number of surviving nodes is increased by 1,750 rounds, extending the WSN's lifetime. The proposed method outperforms current energy-efficient protocols in node density, size, and energy consumption scenarios.

CHAPTER 3

WSN STATE ESTIMATION

3.1 MODELLING OF THE SYSTEM

LEACH is a TDMA-based medium access control (MAC) system that uses a combination approach to distribute power in order to provide balance between network sensors. This is done in order to keep the sensors from interfering with one another. After being processed by the nerve notes, the data is then sent on to be transmitted to BS via CH. CH, which is a sensor node for the cluster, can only communicate with BS out of all of the nodes in the cluster. Following that, the data will be made available to the end user in the online environment that they utilize. The LEACH methodology is organized in the form of circles, and each circle is comprised of two primary stages that are referred to as "setting" and "solid state."

During the initial stage of the configuration procedure, clusters are created, and a CH node is selected. During this phase, the selection of CH nodes also takes place. Every node contributes to the process of selecting the CH, which consists of assigning a random number between 0 and 1, with the CH being any of those numbers. This process is repeated until the CH has been selected. If there are fewer member nodes than the threshold that T specifies, this node will be chosen as the CH (n). Even TDMA schedules are distributed to each individual member of the group by the leader of the group.

$$T(n) = \begin{cases} \dfrac{1}{1 - p\left(r\text{mod}\,\dfrac{1}{p}\right)} & \forall n \in G \\ 0 & \text{else} \end{cases}$$

where

- ⇨ p is taken as the required amount of the sensor nodes which may be CH,
- ⇨ r current round, along with the G node group don’t participate in selection of CH in previous 1 / p round.

Because the selected CH area in cycle r isn't permitted to be voted in next 1 / p rounds, every sensor of the group has an equal probability of being CH. As a result, power dissipation in the network is evenly distributed between the sensor nodes.

In between of intensity, cluster nodes use TDMA schedule for transferring sensory data into appropriate nodes. Any node can transmit data while all nodes are asleep. Internal conflict in the group can be avoided in this way [16]. The protocol's main goal is to improve energy efficiency by selecting random numbers depending on rotation.

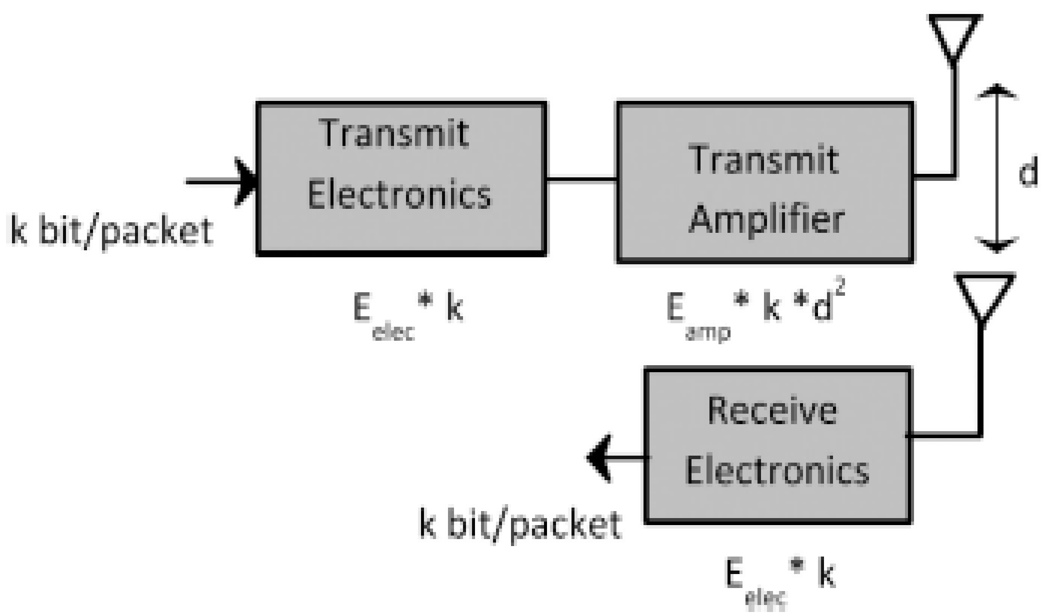


Fig. 3 LEACH Protocol Phases

In our modified protocol [17], we communicate using the first-order radio energy concept, as represented by fig. 3.

Radio model of first-order can be separated in two types that are classified into the distance among the sensing as well as the receiving nodes: free space as well as the multi-path fading [18]. Communication channel is expected of being symmetrical, amount of energy that is wasted when bits are being sent to a node hundreds of metres distant by the sensor nodes may be calculated using the formula [19].

$$E_{\mathrm{Tx}}(k,d) = E_{\mathrm{Tx\_elec}}(k) + E_{\mathrm{Tx}}\mathrm{amp}^{\mathrm{amp}}(k)$$

$$E_{\mathrm{Tx}}(k,d) = \begin{cases} E_{\mathrm{elec}} * k + E_{\mathrm{fs}} * k * d^2, & d \le d_0 \\ E_{\mathrm{elec}} * k + E_{\mathrm{amp}} * k * d^4, & d > d_0 \end{cases}$$

Likely, energy taken in by a sensor node to receive packets is represented by

$$E_{\mathrm{Rx}}(k) = E_{\mathrm{Rx\,elec}}(k) + kE_{\mathrm{elec}}$$

Where

- ⇨ E_{elec} is transmitter's or receiver's energy consumed for every bit,
- ⇨ E_{amp} and E_{fs} are transmission amplifier parameters for the multi-path fading as well as for the free-space models, respectively.

In addition to the overhead information, each packet actually contains the data. Information about packets, such as the coding scheme used to transmit data in a secure manner, the encryption mechanism used for the purpose of maintaining security, as well as the addresses of the basis and end point, is stored in the overhead bits. This information can be retrieved when necessary.

No matter the size of the packet, there is no difference in the amount of overhead that is incurred. Because of this, the overhead spectrum and the energy usage may be negligible, which leads to a decrease in the energy efficiency of wireless sensor networks as well as the spectral efficiency. In addition to that, the level of output that was achieved has reached a new high.

The N_{data} data bits in packet as well as N_{overhead} the overhead bits are E_{data} and E_{overhead} respectively, if the energy related to every data bit and overhead bit is. The overall energy of the packets is calculated using the following formula:

$$E_{\mathrm{Packet}} = N_{\mathrm{data}} \times E_{\mathrm{data}} + N_{\mathrm{overhead}} \times E_{\mathrm{overhead}}$$

A system's efficiency is determined by

$$\eta = \frac{N_{\text{data}} \times E_{\text{data}}}{E_{\text{packet}}} \times 100$$

The efficiency will be nearly identical when the value of is large. The amount of energy spent in each round must be determined in order to create a threshold limit for selection. We estimate this energy threshold value using our suggested method in order to conserve energy and extend network longevity.

CHAPTER 4
PROPOSED TECHNIQUE

1. Simple Leach
2. I-Leach
3. Modified I-leach (random Probability Function)
4. Multi-hop clustering routing-method in LEACH

Simple Leach

Based on TDMA, the Leach protocol is a MAC protocol. The primary objective of this protocol is to extend the lifespan of wireless sensor networks by reducing their energy consumption. It consists of a setup phase and a steady phase. The "round" is the unit of the Leach protocol. Each "round" consists of a "cluster setup phase" and a "steady state storage phase." This is done to reduce unnecessary energy expenditures.

I- Leach

Wireless Sensor Networks can only exist so long as the nodes continue to function. Sensor Nodes are miniature, battery-powered modules. Consequently, constant power consumption depletes the battery and kills the node. The network continues to function as long as the nodes remain alive. Utilizing I-LEACH significantly increases the number of nodes that are still alive.

Modified I-leach (random Probability Function)

The Cluster Head (CH) election probability function is modified to improve LEACH. A CH who had previously held office was more likely to be re-elected. The intention is to utilize CH's excess energy to keep the network operational for longer. As a means to raise the election probability threshold, the Probability Function for LEACH Protocol (MPF-LEACH) was proposed. We propose that the MPF-LEACH method utilize the CH residual energy to increase the WSN's lifetime and data transmission rate.

Multi-hop clustering routing-method in the LEACH

In the LEACH-based phase, the multi-hop clustering strategy seeks to improve the delivery of selected facts to connect with others on the multi-hop approach to BS. That's why the network data transmission efficiency should be maintained at all times while the network is operating [7]. In most cases, WSN sensors are used randomly, no matter how far away from the network, and use a high amount of power to transmit data. In this case, the power of the sensor node will expire. This issue arises from Leach such that the protocol accepts that every participant transmits the data to the BS directly. This has an impact on network longevity as well as coverage region, as sensor nodes positioned distant from the BS will rapidly deplete their energy supply.

The routing table must be set up at this stage, which is the most important. An announcement message in the routing table is used to calculate the distance between the furthest zone and the zone closest to BS. It can take one of four routes, with the amount of energy expended varying depending on which one is chosen.

- Case 1: If the CH is in Zone 1 or $CH_{d-BS} < d'$, the data is immediately forwarded to the BS. The following equation is used to calculate the transmission energy:

$$E_{Tx}(k) = k\left(E_{\text{elec}} + \varepsilon_{fs} {CH_{d-BS}}^2\right)$$

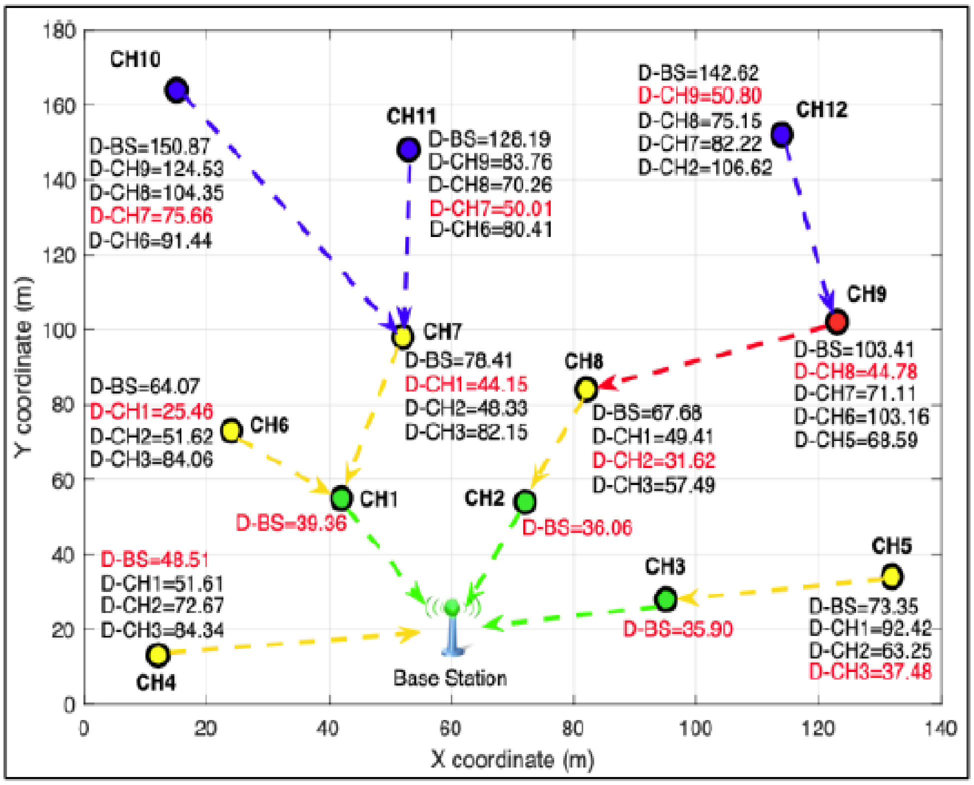


Fig 4 Routing Phase in Multi-hop clustering routing method

- Case 2: Data is forwarded to an in Zone 2 with a minimum distance value if the CHs of Zone 2 or the CHs ($CH_{d-BS} \geq d'$) and ($\mathrm{CH}_{d-BS} < 2d'$), in transmit data to an in Zone 2 with a least value of distance.

$$E_{Tx}(k) = k\left(E_{\text{elec}} + \varepsilon_{fs} CH_{d-Z1}^{2}\right)$$

When CH_{d-Z1} the distance between them is sufficient, the data in Zone 2 is transmitted to everyone in the Zone 2.

- Case 3: The CHs of Zone 3 or in the ($\mathrm{CH}_{d-BS} \geq 2d'$) and ($\mathrm{CH}_{d-BS} < 3d'$) transmit data with least distance to Zone 3.

$$E_{Tx}(k) = k\left(E_{elec} + \varepsilon_{fs} CH_{d-Z2}{}^{2}\right)$$

When CH_{d-Z2} the distance between them is sufficient, the in Zone 3 broadcasts its data to the entire Zone 3.

- Case 4: If CHs are present in Zone 3 or its vicinity $(\mathrm{CH}_{d-BS} \geq 3d')$ and $(CH_{d-BS} < 4d')$.
- If $(\mathrm{CH}_{d-BS} \leq \mathrm{CH}_{d-Zn})$, is the case, the sends its data to the directly. The transmission energy is as follows:

$$E_{Tx}(k) = k\left(E_{\text{elec}} + \varepsilon_{mp} CH_{d-BS}{}^{4}\right)$$

If$(CH_{d-BS} > CH_{d-Zn})$

- If $(\mathrm{CH}_{d-Zn} < 2d')$, uses the free-space concept of energy transmission to send data to an over a short distance in the n-th zone.
- $E_{Tx}(k) = k\left(E_{elec} + \varepsilon_{mp} CH_{d-Zn}{}^{2}\right)$

  where $\mathrm{CH}_{d-\mathrm{Zn}}$ = the data from the zone is sent to all of the zones in zone n-1

Figure 5 can be used in the scenarios below. Figure 3 shows that, depending on the zone acquired, everyone chose the other for the next hop. For example, the closest to can send data directly to without having to go through another.

Other members of the same zone, on the other hand, can sort from zone 4 to zone 1 and send data to the other zone's nearest member. Additionally, it can transfer data to a zone that is not immediately adjacent to it if the distance to BS is close enough.

During the routing step, the technique is shown in Fig 5. The routing table is based on the shortest data transfer distance between the higher and lower zones. The combined data is transferred to the zone division is based on distance among BS as well as the CH. Data can be delivered directly to BS by nodes that are closer to it. Cases 1 through 4 will be followed by the selected CHs stationed further away.

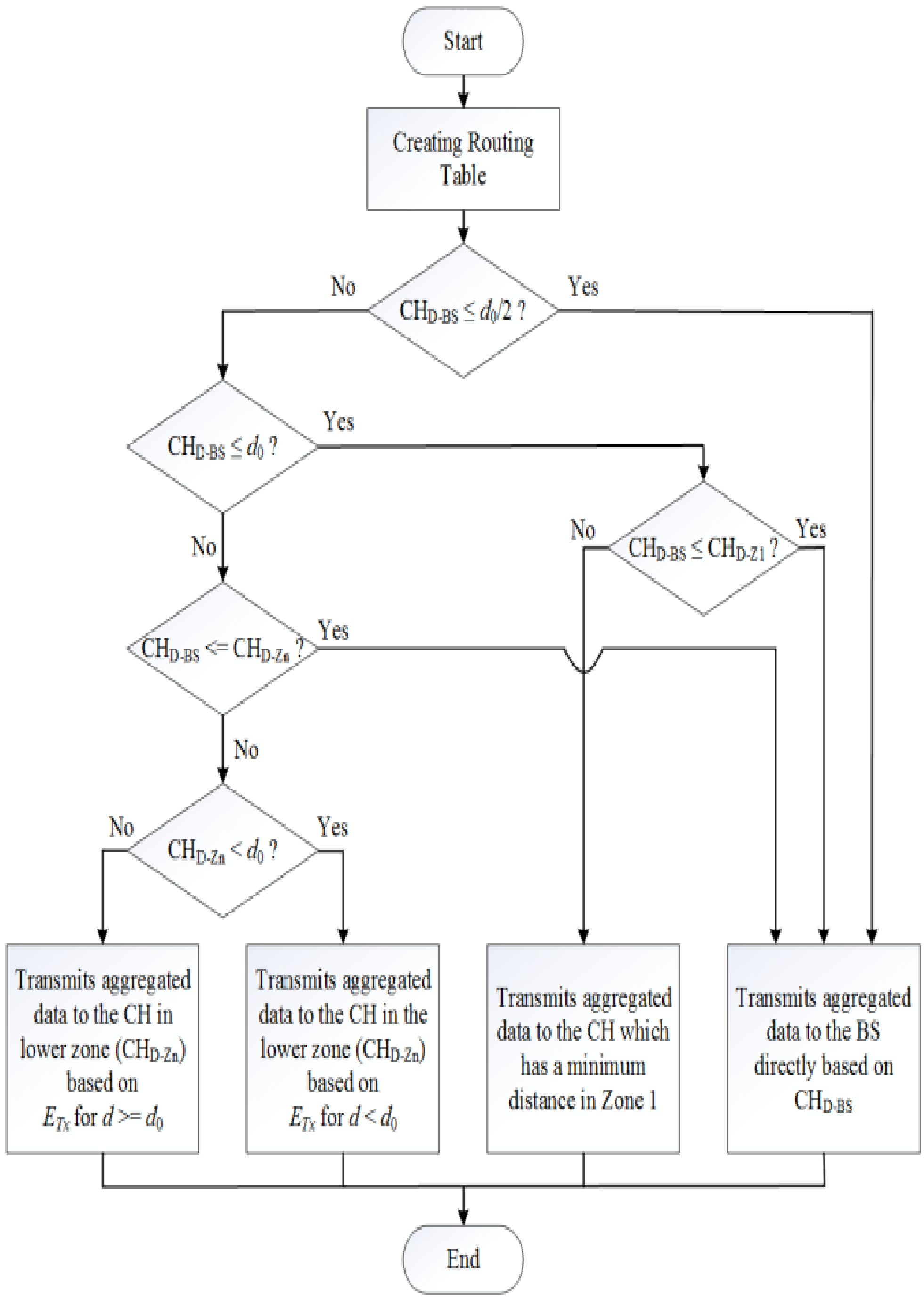


Fig 5. Multi-Hop Routing phase flow chart in LEACH.

CHAPTER 5

SIMULATION RESULTS AND DISCUSSION

The proposed technique is used to produce the results simulated based on parameters that are listed in the table 1. Table To create distinct visualisations, a simulation in MATLAB is run for 2000 rounds of iterations. The packet size in this study is 4000 bytes, which is a reasonable size.

As a result, in comparison to the total packet energy, the overhead energy is negligible, and it can be overlooked. As a result, throughout the simulation, the proposed Multi-hop clustering routing mechanism in LEACH. CH protocol has been compared to many current energy-efficient protocols, while ignoring the energy associated with packet overheads.

On many metrics, such as count, durability of the network, residual energy as well as the throughout, simulation findings clearly show that the Multi-hop clustering routing technique in the LEACH protocol outperforms all three strategies mentioned above, namely I-LEACH, LEACH, and Modified I-LEACH protocol.

Table 1. Parameters for simulation

Symbol	Description	Value
X_m	X-axis Distance	400 m
Y_m	Y-axis Distance	400 m
N	total sensor nodes	100 nodes
$P_{\mathrm{Tx}}, P_{\mathrm{Rx}}$	Total network energy	0.5 J
E_{mp}	energy dissipation: receiving	$0.0013/\mathrm{pJ/bit/m}^4$
E_{fs}	energy dissipation: free space model	$10/\mathrm{pJ/bit/m}^2$
E_{amp}	energy dissipation: power amplifier	$100/\mathrm{pJ/bit/m}^2$

E_{DA}	Energy dissipation: aggregation	5/nJ/bit
d_0	reference distance	87 m
I	packet size	4000bits

Output Results:

1. Results achieved using Simple Leach

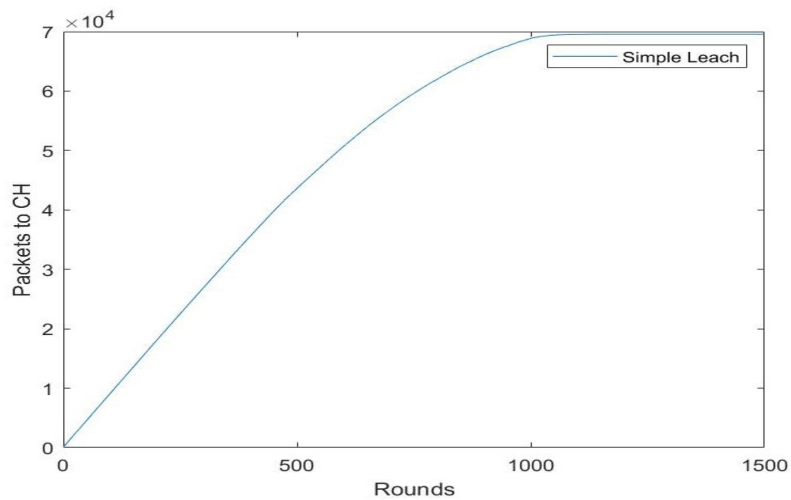


Fig 6a.

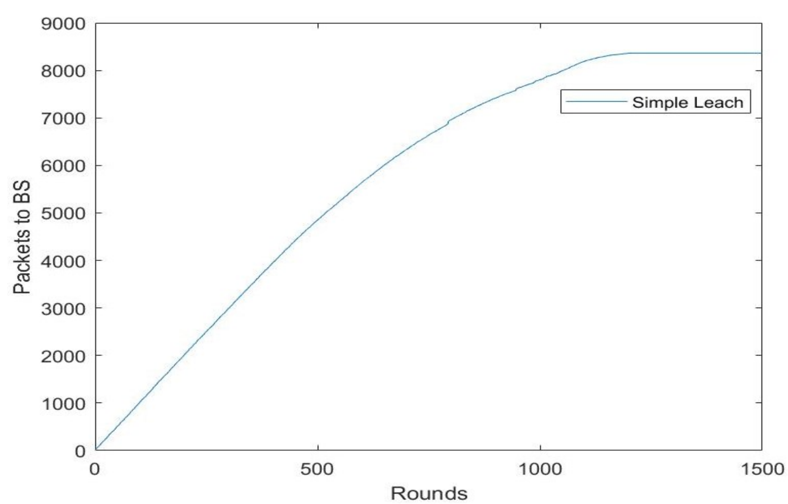


Fig 6(b)

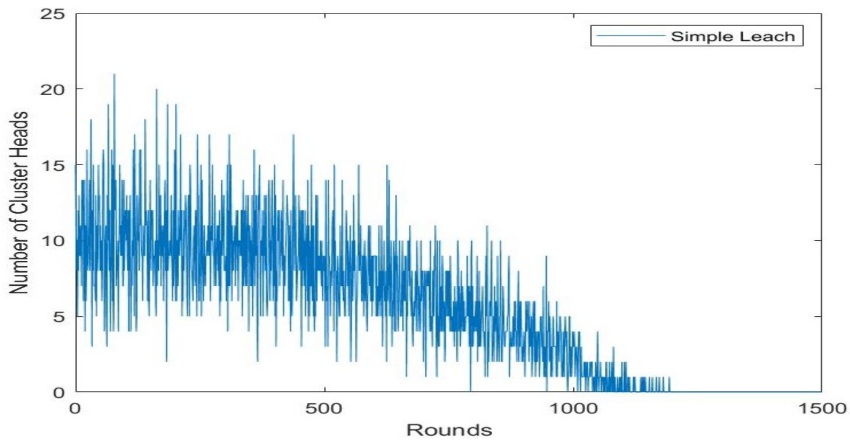


Fig 6(c)

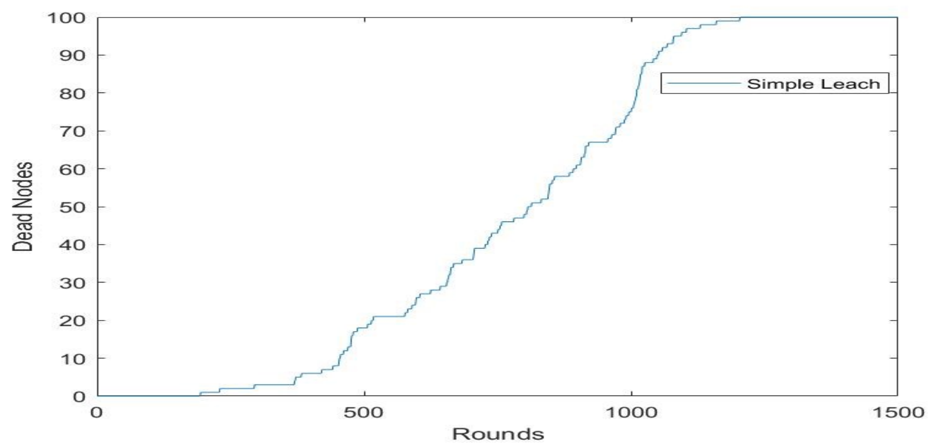


Fig 6(d)

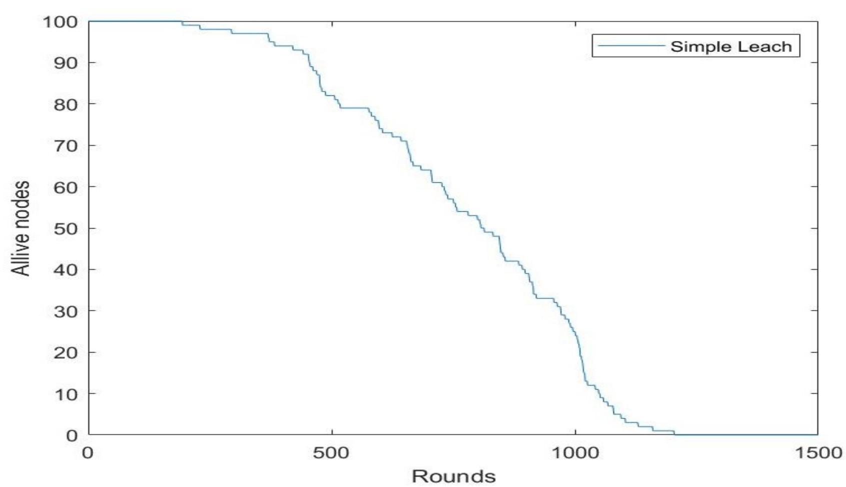


Fig 6(e)

Fig. 6. (a), (b), (c), (d), (e) Output Response of Calculating Various Parameters using Simple Leach Method

2. Results achieved using I-Leach

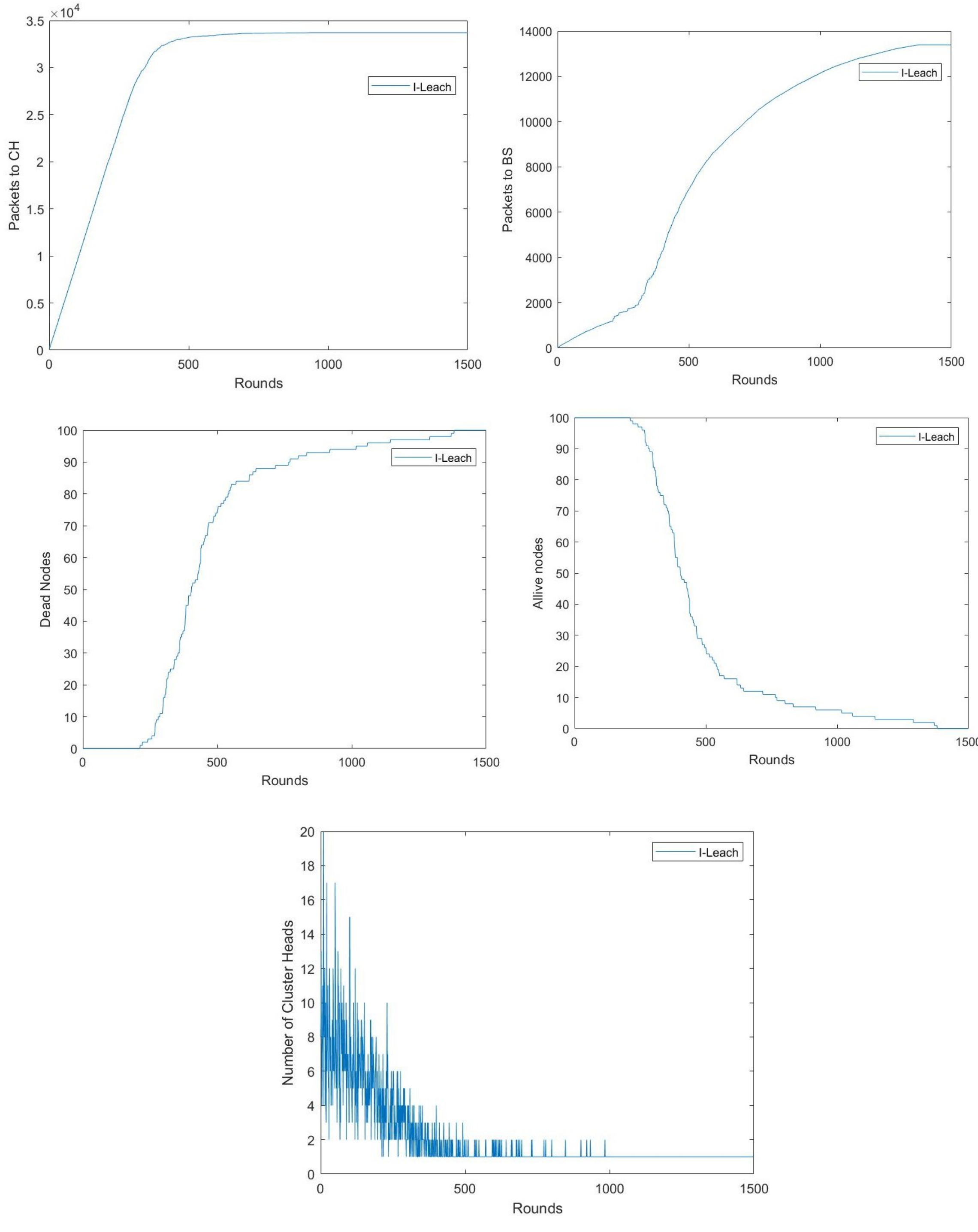


Fig.7 Output Response of Calculating Various Parameters using I-Leach Method

3. Results achieved using Modified I-Leach

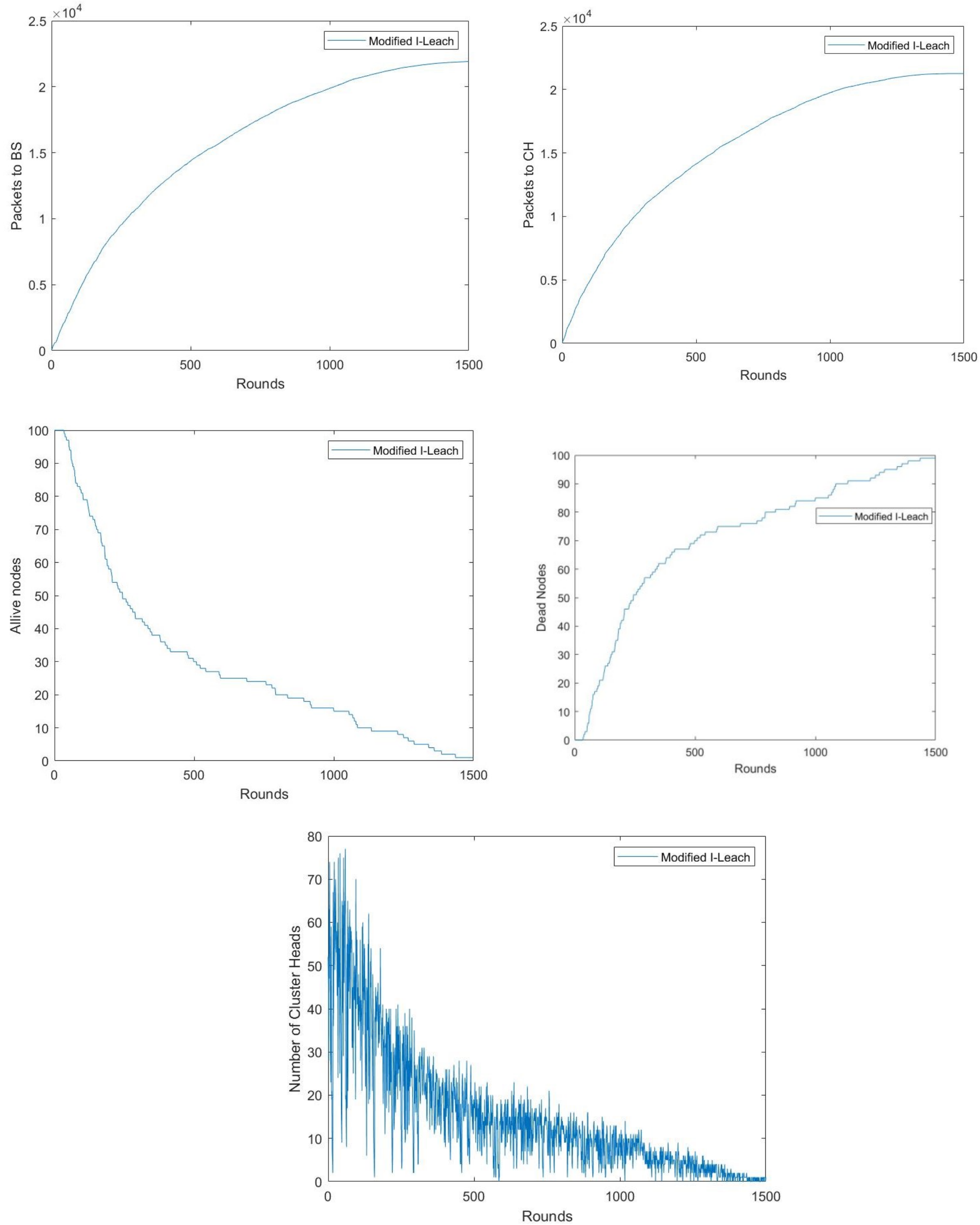
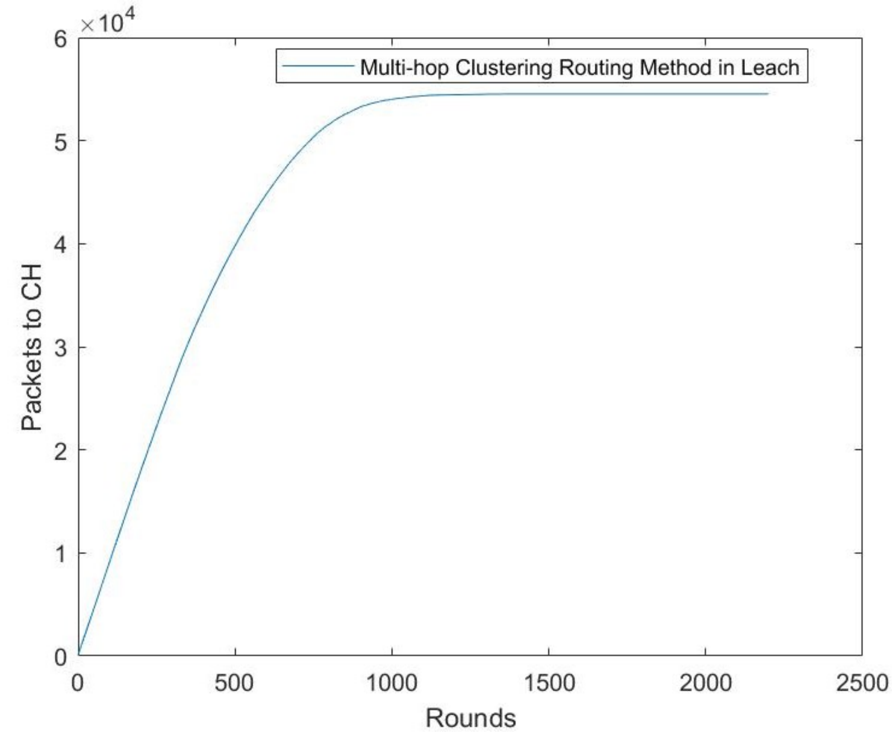
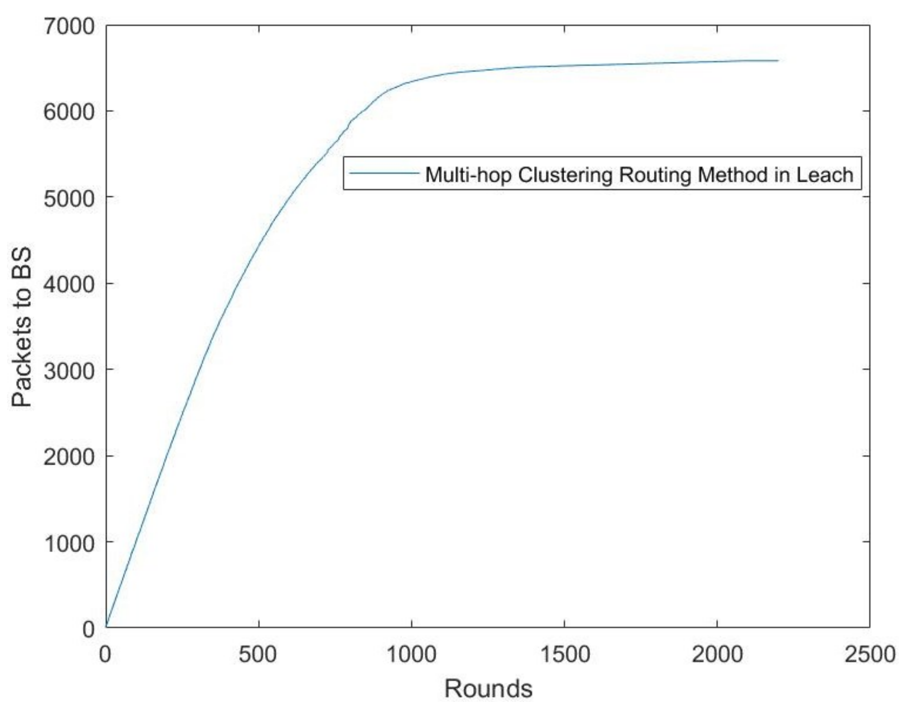


Fig. 8 Output Response of Calculating Various Parameters using Modified I-Leach Method

4. Results achieved using Multi-hop Clustering Routing Method in Leach





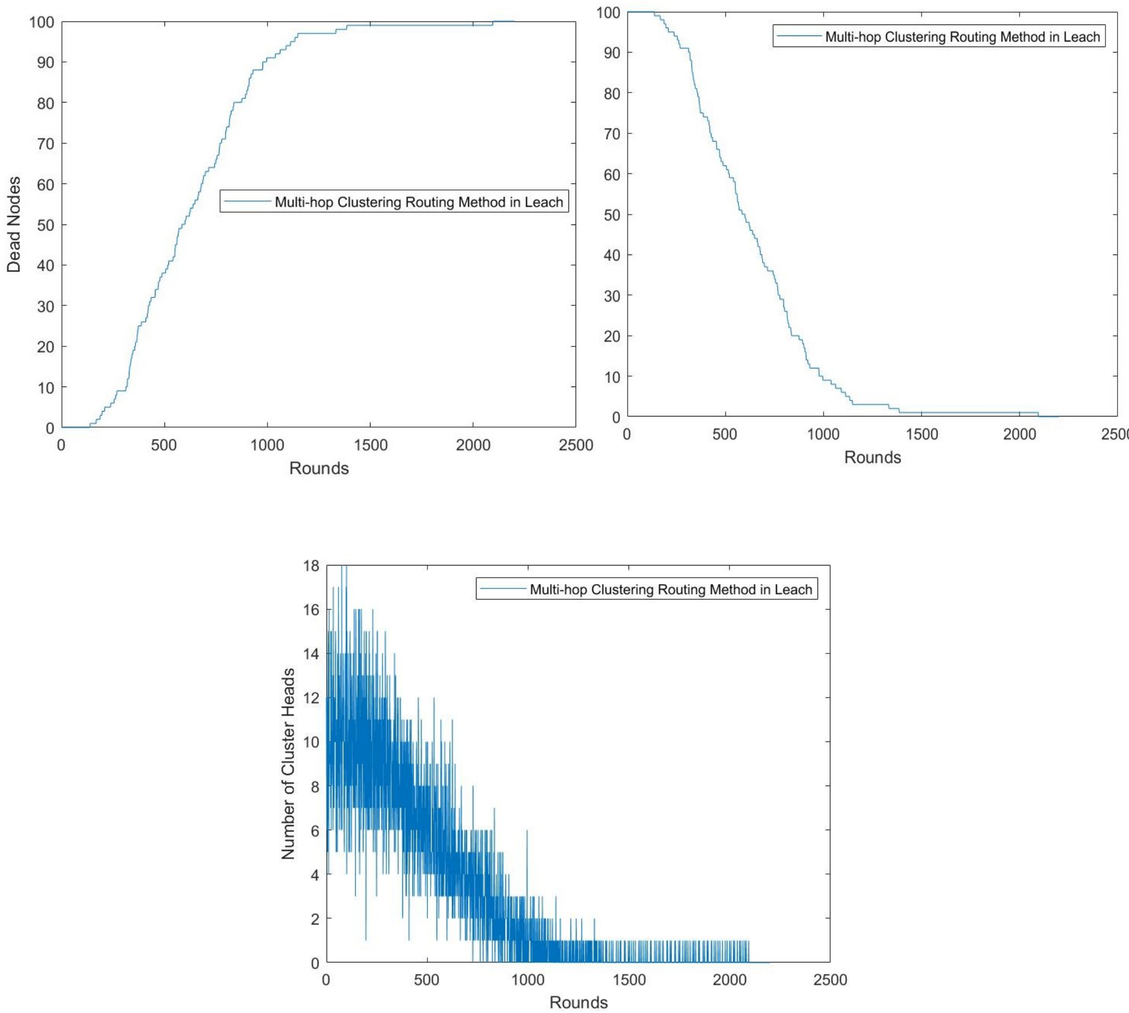


Fig. 9 Output Response of Calculating Various Parameters using Multi-Hop Clustering Routing Method using Leach

CHAPTER 6

CONCLUSION AND REFERENCES

6.1 CONCLUSION

The LEACH technique has proven to be popular among WSN researchers, demonstrating its importance. For various applications, different LEACH descendants have been developed. This is something we have discussed in this paper.

We have implemented various approaches to minimize the energy consumption and based on various results which are calculation of cluster count, Communication between the packets and lifetime matrices which are number of alive and dead node. The techniques implemented in the system are simple leach, I-leach, modified I-Leach and the Multi-Hop Clustering Routing method in Leach.

When the LEACH protocol is changed to include a threshold power level for replacement criterion, the number of CHs for the multi-hop clustering routing strategy increases to 1903 rounds, compared only 850 rounds for the inefficient replacement method as well as to 1750 rounds for I-Leach depicted in Fig. 10.

The quantity of the data bits delivered to the BS determines efficiency of any routing strategy. The algorithm improves as the throughput increases. The throughput of the multi-hop clustering-routing technique has been significantly higher than the other protocols studied, as shown in Fig. 14. The quantity of the data bits sent to in LEACH is limited to 2.7×10^4, but this number rises to 3.0×10^4 in I-LEACH, and to in the multi-hop clustering routing strategy, as shown in Fig 13.

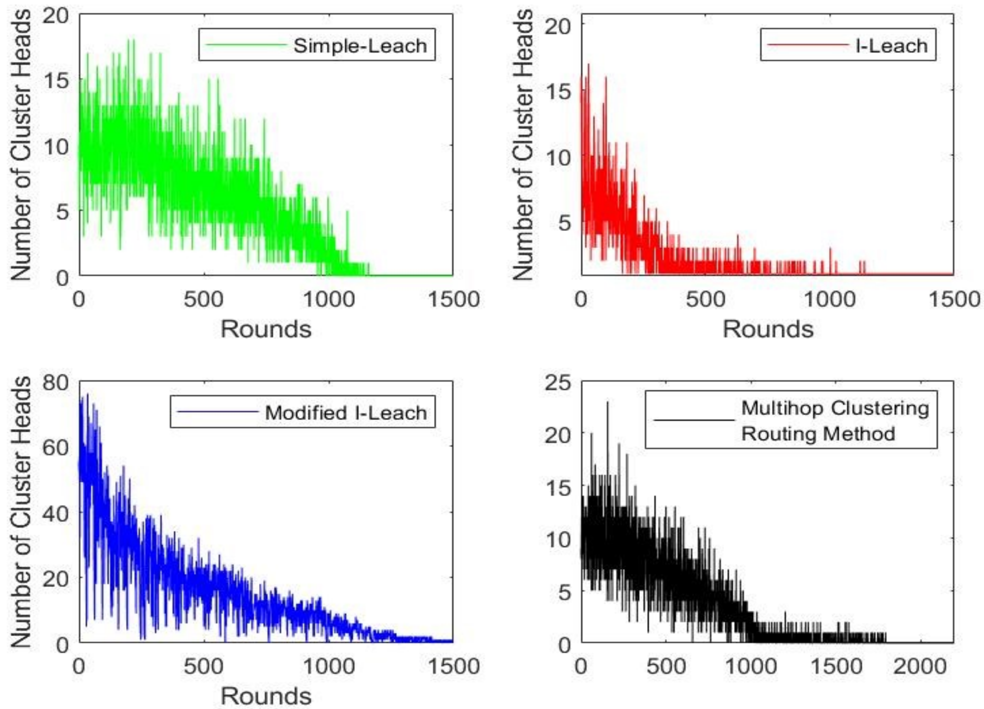


Fig 10. Cluster Counts in Simple Leach, I-Leach, Modified I-Leach and Multi-hop Clustering Routing Method in Leach

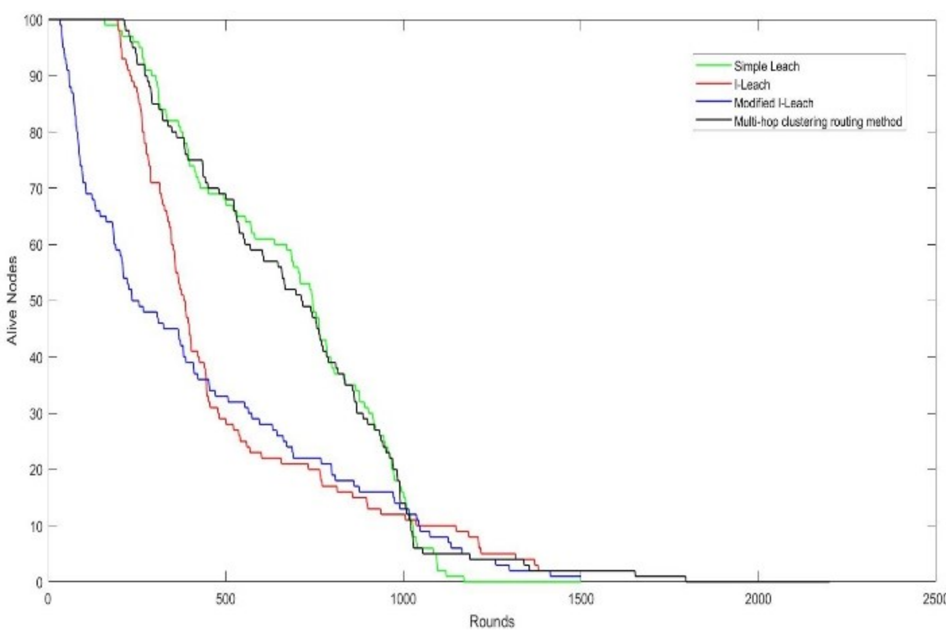


Fig 11. Life Metrices: Alive Nodes

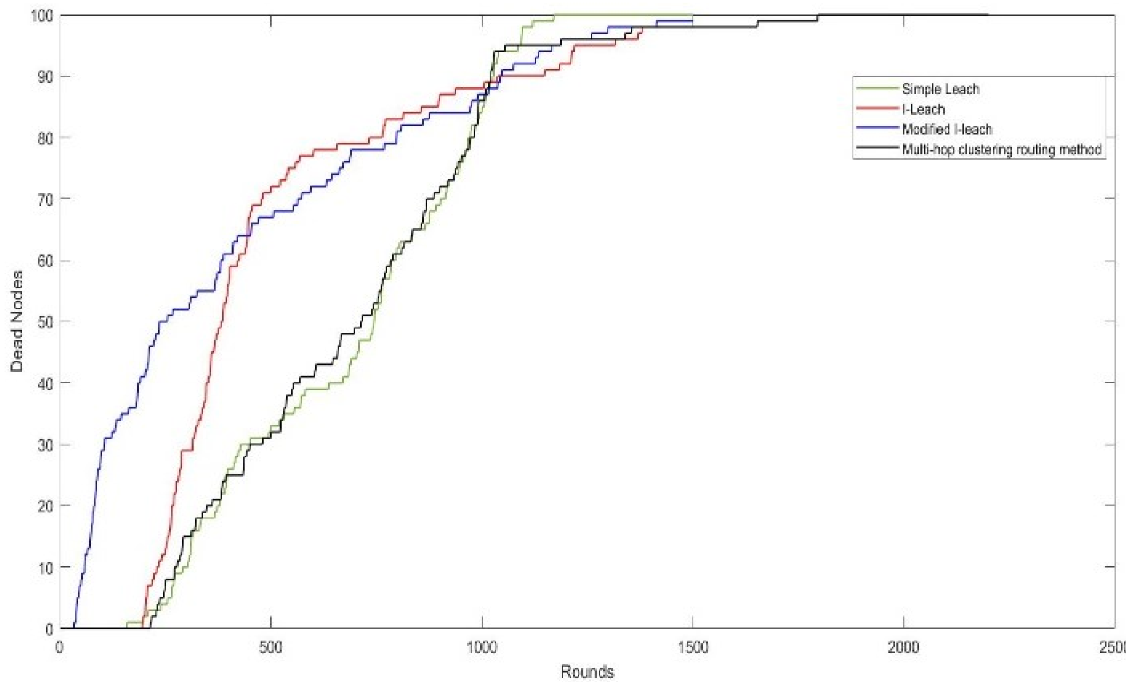


Fig 12. Life Metrices: Dead Nodes

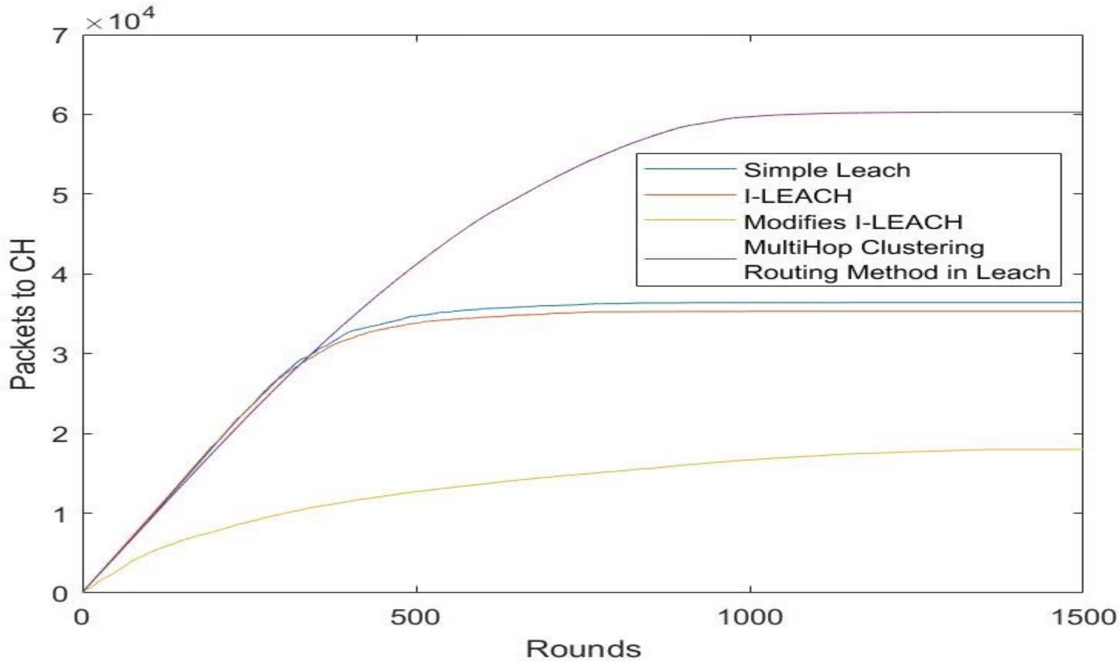


Fig 13. Packets Communicated to CH

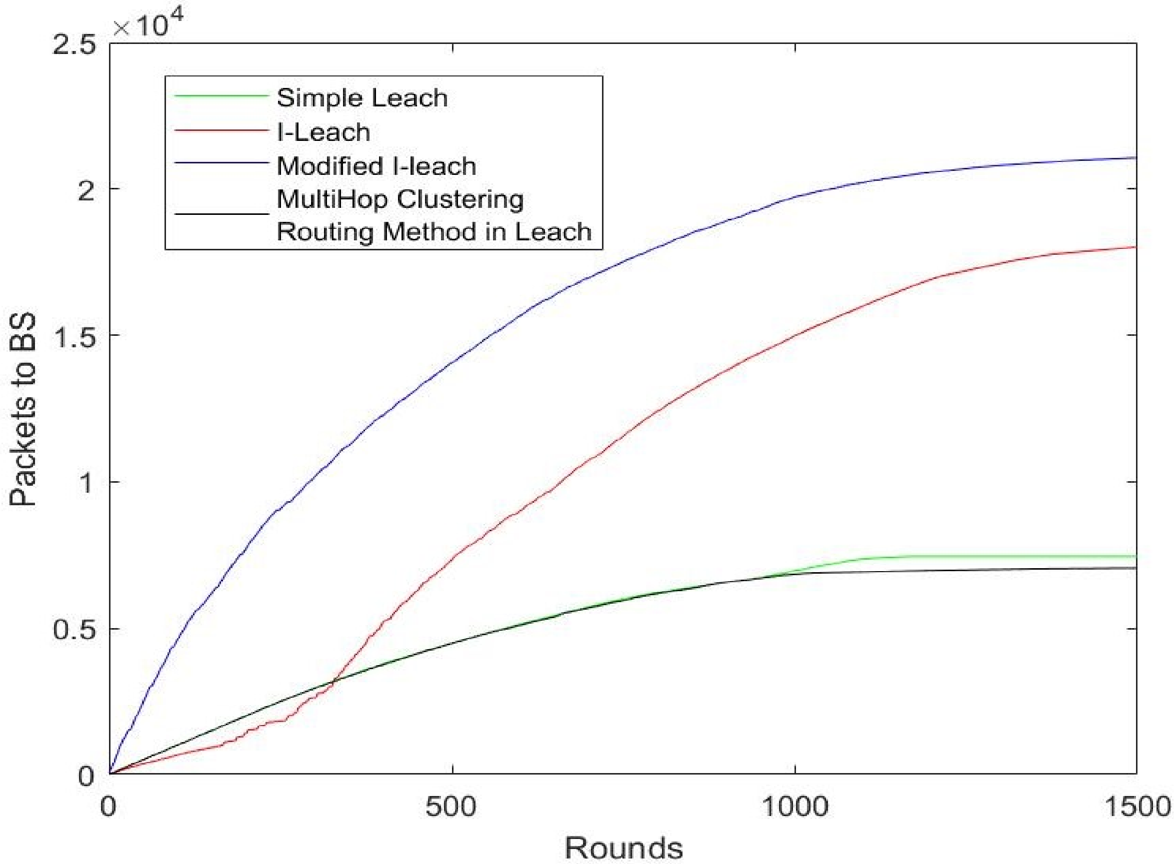


Fig 14. Packets Communicated to BS

The sensor node's energy depletes as number of the rounds rises, until it dies. Quantity of the alive as well as dead nodes, respectively, represent the network lifespan in Fig 11. and fig 12. The number of active nodes drops to zero after about 750 rounds, but with I-LEACH, some nodes can stay active for up to 1500 rounds. In our suggested strategy, the multi-hop clustering routing mechanism in Leach keeps a large number of nodes alive until 1900 rounds. As a result, a complete scene to maximise longevity of the network emerges, including allocating various power levels for several types of network communication.

On comparing all the techniques, it is found that the proposed technique which is Multi-Hop Clustering Routing technique works better in terms of the network lifetime, as well as stability period. The protocol has been improved to allow for the switching of multiple power levels at the same time as well as efficient CH selection.

The protocol increases network's life due to consumption of the energy decrease in a dispersed method. When associated with the different techniques of the low-energy, the suggested protocol was found to be the best fit for a variety of applications with varying quantity of nodes, energy as well as area. We can even expand the study to look at various routing protocols and see what results they produce

5.2 REFERENCES

[1] Lee I, Lee K (2015) The internet of things (IoT): applications, investments, and challenges for enterprises. Bus Horizons 58(4):431–440

[2] Qiu T, Han M, Li M, Zhang Y (2017) SRTS: a self-recoverable time synchronization for sensor networks of healthcare IoT. Comput Netw 129:481–492

[3] Lazarescu MT (2013) Design of a WSN platform for long-term environmental monitoring for IoT applications. IEEE J Emerg Select Topics Circuit Syst 3(1):45–54

[4] Ghayvat H, Mukhopadhyay S, Gui X, Suryadevara N, Ghayvat H, Mukhopadhyay S, Gui X, Suryadevara N (2015) WSNand

[5] IOT-based smart homes and their extension to smart buildings. Sensors 15(5):10350–10379

[6] Bhende M, Wagh SJ, Utpat A (2014) A quick survey on wireless sensor networks. In: 2014 fourth international conference on communication systems and network technologies. pp 160–167

[7] Trupti Mayee Behera, Umesh Chandra Samal, Sushanta Kumar Mohapatra, "Energy-efficient modified LEACH protocol for IoT application", The Institution of Engineering and Technology 2018, ISSN 2043-6386, May. 2018, doi: 10.1049/iet-wss.2017.0099.

[8] Hana Rhim, Karim Tamine, Ryma Abassi, Damien Sauveron and Sihem Guemara, "A multi-hop graph-based approach for an energy-efficient routing protocol in wireless sensor networks", Rhim et al. Hum. Cent. Comput. Inf. Sci. (2018) 8:30

[9] Yick, J., Mukherjee, B., Ghosal, D.: 'Wireless sensor network survey', Comput. Netw., 2008, 52, (12), pp. 2292–2330

[10] Kim, D.S., Chung, Y.J.: 'Self-organization routing protocol supporting mobile nodes for wireless sensor network'. First Int. Multi-Symp. on Computer and Computational Sciences, IMSCCS '06, Hanzhou, Zhejiang, China, 2006, vol. 2, pp. 622–626

[11] Akyildiz, I.F., Su, W., Sankarasubramaniam, Y., et al.: 'Wireless sensor networks: a survey', Comput. Netw., 2002, 38, (4), pp. 393–422

[12] Kumar, V., Jain, S., Tiwari, S., et al.: ‘Energy efficient clustering algorithms in wireless sensor networks: a survey’, Int. J. Comput. Sci. Issues, 2011, 8, (5), pp. 814–1694

[13] Zorzi, M., Gluhak, A., Lange, S., et al.: ‘From today's intranet of things to a future internet of things: a wireless-and mobility-related view’, IEEE Wirel. Commun., 2010, 17, (6), pp. 44–51

[14] Mahapatra, R.P., Yadav, R.K.: ‘Descendant of LEACH based routing protocols in wireless sensor networks’, Procedia Comput. Sci., 2015, 57, pp. 1005–1014

[15] Wu, W., Xiong, N., Wu, C.: ‘Improved clustering algorithm based on energy consumption in wireless sensor networks’, IET Netw., 2017, 6, (3), pp. 47–53

[16] Rasheed, M.B., Javaid, N., Khan, Z.A., et al.: ‘E-HORM: An energy-efficient hole removing mechanism in wireless sensor networks’. 2013 26th Annual IEEE Canadian Conf. on Electrical and Computer Engineering (CCECE), Regina, SK, Canada, 2013, pp. 1–4

[17] Li, J., Mohapatra, P.: ‘An analytical model for the energy hole problem in many-to-one sensor networks’. IEEE Vehicular Technology Conf., Dallas, TX, USA, 1999, 2005, vol. 62, p. 2721

[18] Elbhiri, B., Saadane, R., Aboutajdine, D., et al.: ‘Developed distributed energy-efficient clustering (DDEEC) for heterogeneous wireless sensor networks’. 2010 5th Int. Symp. on I/V Communications and Mobile Network (ISVC), Rabat, Morocco, 2010, pp. 1–4

[19] Perera, C., Zaslavsky, A., Christen, P., et al.: ‘Sensing as a service model for smart cities supported by internet of things’, Trans. Emerg. Telecommun. Technol., 2014, 25, (1), pp. 81–93.

[20] Gaba, Gurjot & Monga, Himanshu & Kansal, Lavish & Miglani, Rajan. (2016). I-LEACH Protocol for Wireless Sensor Networks. International Journal of Multimedia and Ubiquitous Engineering. 11. 279-292.

[21] Nahar, Khalid & Ra, N.A. & Al-Khatib, Ra'ed M. & Barhoush, Malek & Abdul Halin, Alfian. (2019). MPF-LEACH: modified probability function for cluster head election

in LEACH protocol. International Journal of Computer Applications in Technology. 60. 267. 10.1504/IJCAT.2019.100295.

[22] Trupti Mayee Behera, Umesh Chandra Samal, Sushanta Kumar Mohapatra. Energy-efficient modified LEACH protocol for IoT application". The Institution of Engineering and Technology 2018.

LIST OF PUBLICATIONS

[1] Vivek Kumar, Dr. Ruchika Malhotra, "Energy Efficient Modified LEACH Protocol for Wireless Sensor Networks (WSN)". Submitted and accepted at the **Defense Science Journal (DSJ).**

Indexed by Science Citation Index Expanded (SCIE)

Paper Id: 18187

Abstract- Numerous researches have been done for minimization of the consumption of energy on wireless sensor networks (WSNs). The reason behind such research is because of a large number of applications in this field. We have proposed a method for the same in our paper. We have implemented various approaches to minimize the energy consumption and based on various results which are calculation of cluster count, Communication between the packets and lifetime matrices which are number of alive and dead node. The techniques implemented in the system are simple leach, I-leach, modified I-Leach and the Multi-Hop Clustering Routing method in Leach. On comparing all the techniques, it is found how the suggested technique performs which is Multi-Hop Clustering Routing is better in network lifetime as well as in terms of stability period.