THE UNIVERSITY OF TURKISH AERONAUTICAL ASSOCIATION

INSTITUE OF SCIENCE AND TECHNOLOGY

DESIGN AND IMPLEMENTATION OF A NEW CLUSTERING METHOD FOR HOMOGENEOUS WIRELESS SENSOR NETWORK

MASTER THESIS

HAITHAM SHIAIBTH CHASIB CHASIB

THE DEPARTMENT OF INFORMATION TECHNOLOGY

THE PROGRAM OF INFORMATION TECHNOLOGY

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THE UNIVERSITY OF TURKISH AERONAUTICAL ASSOCIATION

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I hereby declare that this thesis, submitted to Turk Hava Kurumu universities as the fulfillment of requirements for the degree of Master of Information Technology, entitled: Design and Implementation of A New Clustering Method for Homogeneous Wireless Sensor Network, it has not been submitted as an exercise for a similar degree at any other university. I also certify that the work described here is entirely my own except for excerpts and summaries whose sources are appropriately cited in the references.

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28.07.2017

HAITHAM CHASIB

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Thanks to the most compassionate, gracious and merciful. May Allah's blessings and peace be upon our prophet Mohammed who protects us from the depths of darkness and leads us forth into light, and his house hold.

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July 2017 **HAITHAM CHASIB**

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LIST OF ABBRIVIATION

WSN	Wireless Sensor Network
CH	Cluster Head node
MN	Member Node
LEACH	Low Energy Adaptive Clustering Hierarchy
MANET	Mobile Ad-Hoc Network
TDMA	Time Division Multiple Access
DVB-T	Digital Video Broadcasting-Terrestrial
GBRR	Gradient-Based Routing Reliable
ISO	International Standards Organization
OSI	Open Systems Interconnection
SEP	Stable Election Protocol
MEMS	Micro-Electro Mechanical Systems
FFT	Fast Fourier Transform
PANs	Personal Area Networks
DOS	Denial-Of-Service
GUI	Graphical User Interface
NS2	Network Simulator 2

ABSTRACT

DESIGN AND IMPLEMENTATION OF A NEW CLUSTERING METHOD FOR HOMOGENEOUS WIRELESS SENSOR NETWORK

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In this thesis, we implemented new scenario for saving the energy in wireless sensor network. We used 100 sensor in 100 (m) *100 (m) area [1]. All sensors have the same energy, and the value of energy for each sensor is 0.5 Jule. Actually, we used homogeneous sensors. The base station is setup in center of area. All sensors have the same information. We deployed all sensors in a square area with the 10,000m^2. All sensors are deployed as randomly distributed to this area. We setup base station at the center of the area by default. Also, we compared the result with low energy adaptive clustering hierarchy (LEACH) and the stable election protocol (SEP). These two methods have homogeneous and heterogeneous sensors. Actually, in this thesis, we divided the all area as 3 regions. These regions have a different type of communication, and the transferring of the data uses different methods for transferring. As shown in the result the proposed method has good performance than the other methods.

Keywords: Wireless Sensor Network, a Clustering method, LEACH, SEP.

ÖZET

KABLOSUZ SENSÖR AĞI İÇİN YENİ BİR KOMPLE YÖNTEMİN TASARIMI VE UYGULANMASI

HAITHAM SHIAIBTH CHASIB CHASIB

Yüksek Lisans, Bilişim Teknolojileri Anabilim Dalı

Tez Danışmanı: Yrd. Doç. Dr. Yuriy ALYEKSYEYENKOV

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Bu tezde, kablosuz sensör ağında enerji tasarrufu için yeni senaryo uyguladık. 100 (m) * 100 (m) alanda 100 sensör kullandık [1]. Tüm sensörlerin enerjileri aynıdır ve her sensör için enerji değeri 0.5 Jule'dur. Aslında, homojen sensörler kullandık. Baz istasyonu, merkezin ortasında kurulmuştur. Tüm sensörler aynı bilgiye sahiptir. Tüm sensörü 10.000 m2'lik kare alana yerleştirdik. Tüm sensörler bu bölgeye rastgele dağıtılan olarak konuşlandırılır. Varsayılan olarak alanın merkezinde baz istasyonu kuruyoruz. Ayrıca, sonuçları düşük enerji uyarlamalı kümeleme hiyerarşisi (LEACH) ve istikrarlı seçim protokolü (SEP) ile karşılaştırdık. Bu iki yöntem homojen ve heterojen sensörlere sahiptir. Aslında bu tezde tüm alanı 3 bölge olarak bölmüştük. Bu bölgeler farklı iletişim türüne sahiptir ve verilerin aktarılması, aktarım için farklı yöntemler kullanmaktadır. Sonuçta gösterildiği gibi, önerilen yöntemin diğer yöntemlerden daha iyi performansı vardır.

Anahtar Kelimeler: Kablosuz Algılayıcı Ağı, Kümeleme yöntemi, LEACH, SEP.

CHAPTER 1

INTRODUCTION

1.1. Background

A distributed sensor network consists of hundreds to several thousands of sensor nodes distributed over a field of application [2]. They monitor their environment by means of sensors and provide the measurement results to the user. They communicate wirelessly among themselves. Each node can be involved in both communication and data collection and processing. Each node can be involved in both communication and data collection and processing.

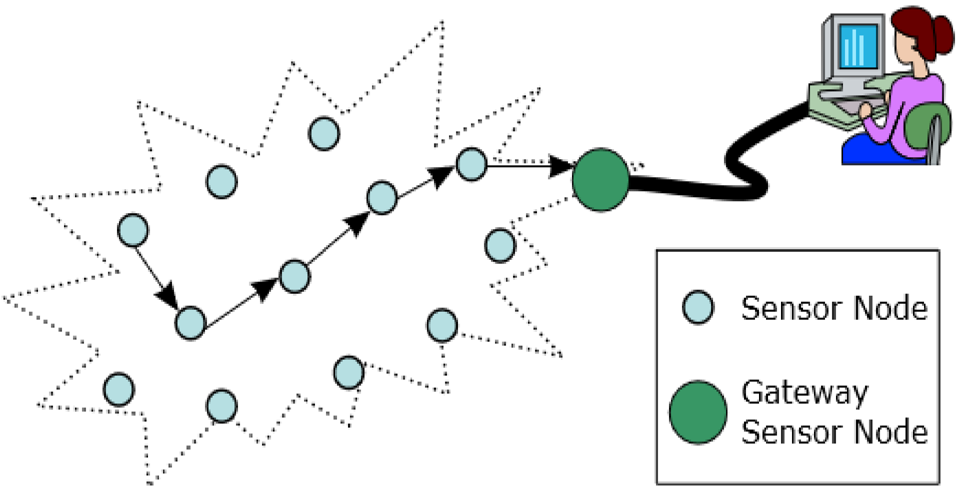

Figure 1.1: Structure of a Simple Sensor Network [3]

Figure 1.1 shows the typical structure of a simple sensor network. The user can access the sensor nodes via a central "gateway". Of particular importance in the case of sensor networks is energy consumption. Since the sensor nodes are usually battery-driven and are often located in difficult-to-access locations, they have only a limited amount of energy available. This existing energy must be used intelligently in order to fulfill the task of the sensor network as best as possible. For this, it is necessary to observe both the requirements of a single sensor node and the interplay of all nodes in the sensor network.

To meet these and other requirements, classical techniques are not sufficient for the establishment and operation of ad-hoc networks. Therefore, specialized protocols are used that take into account the special properties of wireless sensor networks.

A wireless sensor network is a computer network of sensor nodes, tiny ("dust particles") to relatively large ("shoe box") radio communicating computers, either in an infrastructure-based (base stations) or in itself organizing ad hoc network to interrogate their environment by means of sensors and to forward the information [4].

With the rapid increase in the micro-electromechanical systems (MEMS), wireless communication, as well as digital electronics, the usage of wireless sensor networks (WSNs), has immensely increased in today's world. WSN are successfully being used in many areas such as military, health, home, and nature photography, environmental, nuclear and other commercial applications. Wireless sensor networks are used to generate preliminary data for monitoring, tracking and decision support systems in many areas [5]. Due to its efficient and accurate processing, WSNs can play a vital role in military applications.

The common principal between wireless sensor networks and ad-hoc networks is the usage of multiple-hops. They both use wireless communication technology. However, there are important distinctions between them which can be found [6]. The topology constantly changes because ad-hoc networks have constant mobility. Mobility in sensor networks is very rare. However, the topology changes constantly due to the sensors that complete the life cycle. Compared to an ad-hoc network, a WSN has a higher number of nodes within the network. The hardware in the nodes of the ad-hoc networks is higher than the WSNs. In a WSN there are no user nodes, unlike an ad-hoc network. Due to its ability of being complex as well as which processing, a WSN has a base station which has a higher computing capacity than an ad-hoc network. Considering these differences the security of WSN systems is more complex than ad-hoc network systems.

Sensor networks have been designed as a military early warning system for monitoring pipelines and national boundaries. However, modern research also sees them as a substitute for costly sensor arrangements in vehicle construction, warehouse managers in warehouses and monitoring of natural areas for pollutants, forest fires and animal migration; the conceivable applications are as diverse as the available sensors. Sensor networks are always at the stage of further development; practical applications are available for experimental and demonstration purposes. Commonly used sensor networks are available for professional applications. The most famous sensor network is that of the weather stations of different suppliers, but the networking takes place through conventional telecommunication networks. Comparable networks of actuators are not known since the required energies for actuators, and the protection against malfunctions place considerably higher demands on the network and the nodes.

The smallest existing sensor node has a diameter of one millimetre (as of 2007) [4,7], the largest sensor array covering a surface area of 1300 to 300 meters with about 1000 sensor counts.

1.2. Hardware

As only a part of a large network, a single sensor node is characterized by the constraint on what is necessary. In order to minimize energy consumption and costs, a sensor node should only contain the necessary components to perform data collection, communication, and application-specific tasks.

A sensor node consists at least of the four main components shown in Figure 1.2, the very different sensors, the computing unit that takes control, a transceiver for communication with other nodes, and a source of energy that can supply the whole system with current provided.

Depending on the application, additional components can be added which, for example, allows the localization of the node in the application area or provide for mobility.

<table>
<tr><td>Sensor unit</td><td>Computing unit</td><td>Transceiver</td><td>Application-specific components</td></tr>
<tr><td colspan="4">Energy source</td></tr>
</table>

Figure 1.2: The Main Components of a Sensor Core

1.3.Computing unit

Microcontrollers are usually used to control the sensor node. These combine a processor and memory on one chip.

With regard to the protocol design, the main thing to note is that the computing power as well as the available memory of the microcontrollers is extremely limited.

Furthermore, it can be seen that several energy consumption values are indicated. Modern microcontrollers offer various operating modes that differ greatly in energy consumption [1, 2, 8]. By means of "Dynamic

Voltage Scaling" or switching off components which are not needed at the moment, this can be significantly reduced.

1.4. Transceiver

Communication between the nodes of a sensor network typically takes place wirelessly. A transceiver is used for this, is similar to the operating modes of the computing unit, the transceiver can also be switched off when not in use. During the transmission (Tx) of data, a lot of energy is consumed. Therefore, a goal of the sensor network design is to activate the transceiver as rarely and briefly as possible. Therefore, most of the time, the transceiver should either be in receive mode (Rx) or be disabled.

The range of the wireless connection is essential for the selection of the transceiver, antenna and network construction. The energy required for a transfer is exponentially dependent on the distance d between the nodes [2,8]. While the theoretical minimum is still d2, the actual energy consumption in practice is often even d3 to d4. For this reason, it is important to pay attention to the smallest possible distance between the nodes communicating with one another in network construction and the choice of the network topology to be used. The energy consumption of a transceiver can be further subdivided. This is shown in [9] using the example of receiving a DVB-T transmission.

The following skin users are identified: The analog part consumes about 10% of the total energy and includes various filters as well as the analog-to-digital conversion. At 60%, the bulk of the energy consumption is spent on digital demodulation. In particular, the required fast Fourier transform (FFT), which alone accounts for 30% of the energy consumption, is to be emphasized. The remaining energy is distributed by 20% to the "channel decoder" and by 10% to other consumers.

1.5.Energy source

Since sensor nodes are often difficult to access and spread over a large area, it is usually not possible to supply these cables with current. Therefore, an essential component of each sensor node is its respective power supply. The time that a sensor node can work depends on the energy available and the energy consumption. The capacitance of the energy source thus decisively influences the lifetime of the sensor node. The simplest and most commonly used energy source is the battery. With one charge, sensor nodes can work for several years until they need to be replaced. However, a battery has only a fixed capacitance.

In order to achieve a longer running time, energy harvesting from the surroundings of the sensor node can be used by means of "energy harvesting". A sensor node can, for example, be equipped with a solar cell and thus recharge an accumulator during the day. Important is the availability of the energy source, the necessary size to generate enough current and the cost of the application. "Energy harvesting" is more energy than the sensor is required for operation. Since the efficiency of some energy recovery processes depends on the day and season, these characteristics must also be taken into account in the protocols used. Thus, it is conceivable to activate solar-powered sensor counts preferably during high solar irradiation.

1.6. Operating Modes

Since not all combinations of the energy saving modes of the individual components are useful, only a few combinations are often selected for this purpose.

In general, it is the task of the operating system to switch between the operating modes as required. However, a transition into a more economical mode of operation also entails costs: each mode change requires a certain time to be carried out and thus consumes energy itself. As a result, the operating system must have as much information as possible in order to be able to decide when to switch to a more economical mode.

The network protocol used also plays an important role in communication. In order to minimize power consumption, the transceiver should often be switched off completely. For this purpose, it must be ensured that the node does not have to receive packets for a certain time. In order to implement such optimizations, it is necessary to observe all aspects of a sensor network.

1.7. Problem definition

There are different types of network clustering algorithms in the literature, and these algorithms usually differ with the aim of the algorithm. Many of the algorithms are improved depending on the requirements of the related application. In this study, the region will divide to 3 regions, and in each region, a different method will implement.

1.8. Proposal work

In this thesis, we will use 100 sensors in 100 (m) *100 (m) area. The base station is setup in center of area. All sensors have the same information. We will use homogeneity sensors. In our thesis, we assume that the nodes are deployed to a square area with the size of 100 (m) by 100 (m). 100 sensors are deployed uniformly random distributed to this area. We will place the base station at the center of the area by default. We have made a test with other positions of the sink inside or near the boundaries of the area.

1.9. Aims

The aim of this thesis is to provide an efficient clustering algorithm for saving of the energy in wireless sensor networks. Since our aim is to optimize the energy consumption the best clustering algorithm that fits our aim is LEACH (Low Energy Adaptive Clustering Hierarchy) and SEP

(Stable Election Protocol) algorithm. The aim of this thesis is placed on analyzing and determination of drawbacks of LEACH and provide solutions to overcome the difficulties and prevent the occurrence of undesired cases in LEACH.

Finally, the proposed method is compared with LEACH (Low Energy Adaptive Clustering Hierarchy) and also the SEP (Stable Election Protocol). We show that the performance of proposed method system is overcome the LEACH and SEP protocols.

1.10. Contribution

In this thesis, the 10,000 m^2 area is selected to employing the 100 sensors for transmitting the information to base station. This area is divided as 3 regions. These regions have a different type of communication, and the sensors use different methods for transferring the data.

The first region which includes the sensors that they are in between far sensors and near sensors to base station sends their information to rechargeable nodes. This rechargeable node has not limited energy, and every time the energy of this sensor is charging. This sensor collects the information from region 1 and sends to the base station.

The second region which includes the far sensors sends their information to cluster head. These cluster heads collect the information from sensors and send to the base station. The number of cluster head is not fixed and in each round is changing. But the number of cluster head and their clusters are limited. The last region is the third region, and in this region, sensors send their information directly to base station. With this method, we saved a lot of energy and the life time of all network is longer than the other famous methods.

1.11. Organization of the Thesis

Chapter 2 includes the literature review, in this chapter, we will discuss the literature which authors worked in wireless sensor network energy consumptions. In chapter 3 the methodology will be present. The in chapter 4 the simulation result will be discussed, and the result will be compared with other classical methods. Finally, in chapter 5 we will finish our thesis with the conclusion.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTS OF WSN

2.1. Background

Ad hoc network of wireless sensors networks with a large number of micro sensor nodes that are able to collect and transmit environmental data in an independent way. The position of the nodes is not necessarily determined. They can be randomly scattered in a geographic area, called "catchment" area of interest for the phenomenon [10].

2.2. How it works

Information captured by the nodes by a multi-hop routing to a node as a "collection point", known as a root node considered. It can be used to network users (via the Internet, satellite or another system) is connected.

Joint advances in microelectronics, microtechnology, wireless transmission technologies and software applications have made it possible to produce micro-sensors of a few cubic millimeters of volume, capable of operating in networks at a reasonable cost. It includes:

A collection unit is responsible for sensing physical quantities (heat, humidity, vibrations, radiation, etc.) and converting them into digital quantities, a computer processing and data storage unit and a wireless transmission module.

These micro-sensors are therefore truly embedded systems. The deployment of several of them, in order to collect and transmit environmental data to one or more collection points, in a stand-alone way, forms a network of wireless sensors [11].

2.3. History

Until the 1990s, except for some radio beacons for data transmission to a central control sensor, expensive and cumbersome cabling was required. New sensor networks emerged in the 1990s, particularly in the areas of environment and industry, the recent developments in wireless technologies made possible. Today, thanks to recent advances in wireless technology, new products using wireless sensor network used to retrieve the data from the environment.

2.4. Challenges

For MIT's Technology Review Magazine, the wireless sensor network is one of the ten new technologies that will revolutionize the world and how we live and work. It responds to the emergence in recent decades of supply and an increased need for observation and control of physical and biological phenomena in different areas:

- Industrial, technical and scientific (monitoring of temperature, pressure, hygrometry, brightness).
- Ecology and environment (monitoring of ultraviolet radiation, radioactivity, pollutants such as PAHs, heavy metals, ozone or NO 2 or CO 2 and other greenhouse gases).
- Health (patient follow-up, eco-epidemiological and epidemiological surveillance.
- Security.
- Transport: urban road traffic control, accident prevention, various optimizations.
- The automation of building automation.
- Etc.

2.5. Applications

Reducing the size and cost of micro-sensors, expanding the range of available sensors (heat, light, vibration, etc.) and the development of wireless communication media, network. They are part of other systems such as control and automation assembly lines. They collect, and process complex information environment is enabled.

Some prospective scientists believe that sensor networks could revolutionize the way in which complex physical systems are understood and built, particularly in the military, environmental, domestic, health, and security fields.

2.5.1. Military Applications

As in the case of several technologies, the military domain was an initial engine for the development of sensor networks. Rapid deployment, low cost, self-organization and fault tolerance of sensor networks are characteristics that make this type of network a valuable tool in this field.

A network of sensors deployed in a strategic sector or difficult to access, for example, allows to monitor all the movements (friends or enemies), or to analyze the ground before sending troops there (detection of chemical agents, Biological or radiation). Successful tests have already been carried out by the US military in the California desert.

2.5.2. Applications to security

The structures of aircraft, ships, automobiles, metros, etc. could be followed in real time by networks of sensors, as well as networks of circulation or distribution of energy. Structural alterations to a building, road, wharf, railway, bridge or hydroelectric dam (as a result of an earthquake or aging) could be detected by sensors previously integrated in the walls or the concrete, without power supply nor wired connections. Some sensors that are activated only periodically can work for years or even decades. A network of motion sensors can constitute a distributed alarm system that will be used to detect intrusions across a wide area. Disconnecting the system would no longer be as simple since there is no critical point. Monitoring of roads or railways to prevent accidents with human beings or between several vehicles is one of the envisaged applications of sensor networks [12,13].

According to their promoters, these sensor networks could reduce certain security systems and security mechanisms, while reducing their cost. Others also fear security or totalitarian drift if the use of these networks is not subject to serious ethical safeguards.

2.5.3. Environmental Applications

A wireless sensor network has been tested in Spain (in the laboratory and then in a river in eastern Spain) for the continuous monitoring of the nitrate level of a watercourse. It is associated with an expert system. A triple redundant modular sensor allows each sensor to improve the reliability of the system, without major changes in cost or energy consumption. In the future, this type of network could detect, quantify, date, map the nitrogen pollution of water and identify its geographical source, for example within the framework of the Nitrate directive, particularly in the vulnerable zone [12].

Thermo-sensors can be dispersed from airplanes, balloons, ships and report environmental problems in the catchment area (fire, pollution, epidemics, meteorological hazard, etc.) to improve knowledge of the environment and the effectiveness of the means of control.

Sensors could be seeded with seeds by farmers to detect plant water stress or soil nutrient levels to optimize water and nutrient inputs or drainage and irrigation.

In industrial sites, nuclear power plants or oil tankers, the sensor can be used in a network to detect leakage of toxic products (gas, chemicals, radioactive substances, oil, etc.) and to notify users and help them more quickly, based active intervention is effective.

A large number of micro-sensors could be deployed in forests or protected areas to collect information on the state of natural habitats and the behavior of wildlife, flora, and fauna (displacement, activity, state of health). The University of Pisa (Italy) has made sensor networks for the control of natural parks (fires, animals). Sensors swallowed by animals or placed under their skin are sometimes used). In this way, it is possible to "observe biodiversity ", without disturbing, animal species vulnerable to disturbance or difficult to study in their natural environment and to propose more effective solutions for wildlife conservation.

The possible consequences of mass distribution in the micro-sensors have a few concerns. In fact, this has micro batteries containing harmful metals equipped. Establishment of a million cubic millimeter sensor 1 which represents the volume of one liter, with varying environmental impacts depending on the material used [12].

2.5.4. Medical and Veterinary Applications

Surveillance of the vital functions of a living organism may in future be facilitated by micro-sensors swallowed or implanted under the skin. Multi-sensor capsules or micro-cameras that can be swallowed already exist, which can transmit images of the interior of a human body (with a 24-hour autonomy) without surgery. A recent study shows sensors working in the human body that could treat certain diseases. One project is to create an artificial retina composed of 100 micro-sensors to correct the view. Other ambitious biomedical applications are also presented, such as blood glucose monitoring, vital organ monitoring or early detection of cancers. Sensor networks would theoretically allow continuous patient monitoring and the possibility of collecting better physiological information, thus facilitating the diagnosis of some diseases [13].

Wireless sensor networks are also applied in agriculture, for example, to monitor the progression of the stem of a plant.

2.5.5. Commercial applications

Sensor nodes could improve the storage and delivery process (to guarantee the cold chain in particular). The network thus formed may be used to determine the position, condition, and direction of a package or cargo. A client waiting for a packet can then have a delivery notice in real time and know the position of the packet. Manufacturers, via sensor networks, could follow the production process from the raw materials to the end product delivered. With sensor networks, companies could offer a better quality of service while reducing costs. End-of-life products could be better dismantled and recycled or reused if the micro sensors ensure that they are in good condition. In buildings, the home heating and air conditioning system, lighting or water distribution system could optimize its efficiency thanks to micro-sensors in floor tiles, walls, door frames, and furniture. The systems would only work where it is needed when it is needed and to the right extent. Used on a large scale, such an application would reduce global energy demand and indirectly reduce greenhouse gas emissions. In the United States alone, the economy is estimated at $ 55 billion a year, with a decrease of 35 million tonnes of carbon emissions in the air [13].

The economic world could thus reduce its environmental impacts on the climate.

2.6. Platforms

Among the most suitable standards to be exploited in networks of wireless sensors are the dual stack Bluetooth protocol / ZigBee.

Bluetooth, of which Ericsson launched the project in 1994, has been standardized under the IEEE 802.15.1 standard and aims to create and maintain Personal Area Networks (PANs). Such a network is used for the transfer of data at low bit-rate between compatible devices. Unfortunately, the big drawback of this technique is its too high energy consumption and therefore cannot be used by sensors which are powered by a battery and which ideally should work for several years.

The ZigBee combined with IEEE 802.15.4 offers features that better meet the needs of sensor networks in terms of energy savings. ZigBee offers lower data rates, but it also consumes significantly less than Bluetooth. A low data rate is not a handicap for a sensor network where the transmission frequencies are low. Manufacturers tend to use "proprietary techniques" with the advantage of being specifically optimized for precise use, but with the disadvantage of not being compatible with one another.

2.7. Literature review

There are several kinds of data aggregation method such as clustering-based approach, tree-based approach, centralized approach, In-network aggregation, etc [14].

Kacimi et al analyzed and proposed the schemes for energy consumption balancing in nodes and guarantee improving in network lifetime by balancing data traffic load as equally as possible they assumed that network lifetime is defined to be the instant when the first sensor node dies. They also studied energy balancing strategies to prolong the lifetime of the sensor network. Depending on load balancing techniques, they obtain an ideal solution and use an experimental technique that comparison with, other routing techniques like shortest-path routing [15].

Raicu et al they developed a new algorithm, with entitled Energy Efficient Distributed Dynamic Diffusion routing algorithm, and compared it with two other algorithms, i.e. random clustering, and directed communication algorithm. The purpose algorithm has been developed through the use of cost of set up with the energy efficiency analyzing and favorable sensor network lifetime. Also, they compared the purposed algorithm with the performance of optimum clustering and an optimum counterpart algorithm. This algorithm takes advantage of astronomical prohibitive synchronization costs. The comparison of the new algorithm is done in terms of the network system lifetime, power dissipation distribution, cost of synchronization and algorithm simplicity [16].

Depending on the amount of energy needed to transmit data directly proportional to the number of nodes. To balance energy costs across the network and to increase to improve the lifetime of WSN is a key issue the researchers. According to the above aspects of the epidemic WSN scale free networks in general, it is very difficult to close the study of the dynamics of the network. They developed a model based on free network WSN reduce the scale of the epidemic [17].

Kumar et al presented an overview on increasing the network lifetime in WSNs. Where the data transmission route is selected in such a way which the whole energy used along the path is reduced. For this concept of clustering, they used the cluster to helps energy usage in limited resources which prolong and improve network lifetime [18].

Rauthan defined WSNs as sensing machine next generations and structures with restricted battery energy as greatest problem of sensor nodes. For distributing the energy in the WSNs, the load of data transfer in the sensor nodes must be balanced properly. Clustering algorithms are one of the important methods for balancing the commutations load. Sometime clustering algorithms may cause in clusters that have more node members than other clusters in the sensor network and unbalance size of clusters impact adversely load balancing in the WSNs [19].

The proposed approach improves cluster algorithm to ensure load balancing in the generation of clusters. The efficiency of wireless sensor networks is measured by the aggregate distance between sensor nodes to the base station and transferred data amount. The responsible for the creating cluster and cluster nodes is cluster head and may affect the performance of cluster. They create cluster algorithm which selected master node and alternative master node for sub areas and areas. To determine master node the region is divided and they determined the midpoint of region, by this center point master node is selected. For each partitioned parts is divided once more partition if required and which depends on the master node and nodes in that divided parts.

A new technique based on reliable network routing (GBRR) is provided [20]. The achieve in [21], they improve an optimal scheduling algorithm, which orders the time slots through which packets must be transmitted by the sensor nodes. The scheduling methodology guarantees that all the packets will be sent within a defined time slot and so delay constraints are satisfied and also identical packet loss probability is provided for each node.

Zhao present a new strategy which is use sleep-scheduling. This strategy designed for wireless sensor networks with old fashioned sensor nodes. In this strategy, multiple overlap backbones are formed to work alternatively to extend the lifetime of the sensor network. The traffic is promoted only by supporting sensor nodes, and all other remaining nodes radios turn off to save battery energy. The multiple backbones turning round grantee that the energy used is balanced in all sensor nodes, which energy fully consumed and a longer network lifetime is achieved in comparison to the other existing techniques [22].

Sharmila et al presented virtual scheduling backbone technique performance by combining between local replacement and virtual scheduling graph based algorithm, so the combined algorithm is called as virtual scheduling backbone replacement algorithm technique. In which node renewal according to their battery energy plays a key role in sensor network lifetime improvement [23].

Energy strategy with the aim of a balanced transmission range for wireless sensor networks extends the life of the network is presented in

[24]. The concentric circle design-based sensor networks where the base station is placed at the center have assumed. Depending on the study, they have prepared a transmission range regulation system of all sensor nodes and determined the ideal hop size and ring thickness for sensor network lifetime maximization. The results of simulation show considerable enhancements in terms of energy consumption balance and network lifetime over existing strategies. On the other hand, before implementing the transmission model that proposed the extensive calculations is essential for defining the ideal hop size and ring thickness. Furthermore, smallest sensor node density is required in the system for implement the strategy.

An efficient sensor deployment method in wireless sensor networks have been described in [25]. The grid based node deployment is used, and is classified into three types grid - triangular, hexagonal and square. The size of the each grid is evaluating the accuracy. Smaller sizes result in more accuracy and decreasing the coverage percentage.

An extensive analysis on traffic relay node problem aware of the location of the sensor node and the base station is known in advance conducted in [26]. According to the analysis of the optimal solution is developed to deploy relay nodes with a single sensor node, both single and multiple data streams. The authors of a hybrid algorithm that can relay node optimal number and locations of their respective return successfully improved.

The effect of path loss modeling on wireless sensor networks lifetime has not been studied. Certainly, the variances between path loss values assumed by different models that indicate major differences, but, how do these differences affect sensor network lifetime is not be studied yet [27].

Advances in electronics and wireless communications have enabled the development of small, inexpensive sensor counts. The characteristics are their low energy consumption, their versatility, and the ability to communicate loosely with one another over short distances [28]. A sensor node (usually called "mote") consists of components for data acquisition, data processing and communication with other sensor nodes.

The wireless sensor network (WSN) is the combination of many sensor nodes placed close to or in the vicinity of the observed phenomena. The position of the individual sensor nodes is not necessarily known in advance, They can also be randomly distributed, for example, by being dropped from an aircraft on difficult terrain [28], which means that the network protocols and algorithms used must be able to organize themselves, typically the sensor nodes form a close-knit multi-hop network In addition, the application of the WSNs involves the cooperation of the individual sensor nodes, which can be used for local preprocessing and do not have to transfer the raw data [28], Environmental monitoring, health care, warehousing or home automation [29].

In the meantime, various hardware platforms exist which facilitate the construction of a sensor network. The purpose of this article is to provide an overview of the products currently available. In the following, the general hardware configuration of a sensor node is discussed. Subsequently, different platforms are presented and compared.

2.8. Hardware platforms

Various hardware platforms are available to set up a sensor network. As elaborated in the course of this section, these vary, among other things, in factors such as:

- Microcontroller
- Electrical engineering
- Connection of the sensors
- Availability of sensors by the platform developer
- power consumption
- Available operating systems

Differences in these properties cause some hardware platforms to be more suitable for a particular application than others. In the following, some exemplary platforms were presented, and their suitability for the field of forestry detection was investigated.

In [5], such a system was developed by means of a sensor network. The parameters detected by the sensors were:

- Brightness
- Humidity
- Temperature

These parameters are therefore used for comparison purposes. In addition, it is assumed that the sensor cords are attached at certain pre-selected locations. As a result, their position is known, and no sensors are needed, such as GPS.

Similar to the method described in [30], the sensor nodes are to be aware of different levels of danger, and when the same warning messages are sent. For example, at a time a high temperature could be measured in combination with a very low humidity. If, as a result, a darkening of the smoke of a developing fire is detected by means of the brightness sensor, a higher danger level for the area monitored by the sensor node is reached and communicated.

2.8.1. MICA2 / MICAz

The MICA platforms have emerged from the research projects of the University of California Berkeley ("UC Berkeley") and were originally marketed by Crossbow Technology [11].The product lines were taken over by Memsic at the beginning of 2010 and are marketed by this company [14] The platforms MICA2 and MICAz are identical to each other, and therefore they are considered together. A MICA2 sensor node is shown in Figure 2.1.

Figure 2.1: A MICA2 Sensor Node

- Platform features include:
- Processor: ATmega128L
- Wireless chip MICA2: ChipCon CC1000
- Wireless chip MICAz: ChipCon CC2420
- 51-pin connector for expansion cards (transfers analog inputs, digital I / O pins, SPI, I2C And UART)
- Battery holder for two AA batteries
- Dimensions without battery holder: 58_32_7mm

The ATmega128L processor used has the following characteristics:

- 8-bit RISC architecture
- Up to 8MHz process location
- 128KB flash memory
- 4KB RAM
- 4KB EEPROM
- 10-bit analog-to-digital converter (8 channels)

- 53 digital I / O pins
- UART, SPI, and I2C interfaces
- Power consumption: 8mA in operation and <15 _A in sleep mode

A comparison of the two radio chips is shown in Table 2.1.

Table 2.1: Comparison of The Radio Chips of The MICA2 and MICAz Platform

	CC 1000	CC 2420
General properties		
Frequency ranges	868 / 916MHz	2,4GHz
Data rate	38.4 kbps	250 kbps
Range (outside)	Approx. 150m	75-100m
power consumption		
Send max.	27mA	17.4Ma
Receive	10mA	19,7mA
Sleep	$<1\mu A$	$1\mu A$

There are no sensors on the MICA boards. However, Memsic offers some sensor boards that can be connected to the base board via the 51-pin connector. The sensor board MTS400CC contains a temperature, humidity, air pressure, brightness and acceleration sensor and thus covers the required parameters.

The operating system TinyOS is usually used on the MICA boards [31].

2.8.2. TelosB

TelosB (Figure 3) is a hardware platform that can be viewed as a successor to the MICA platform.

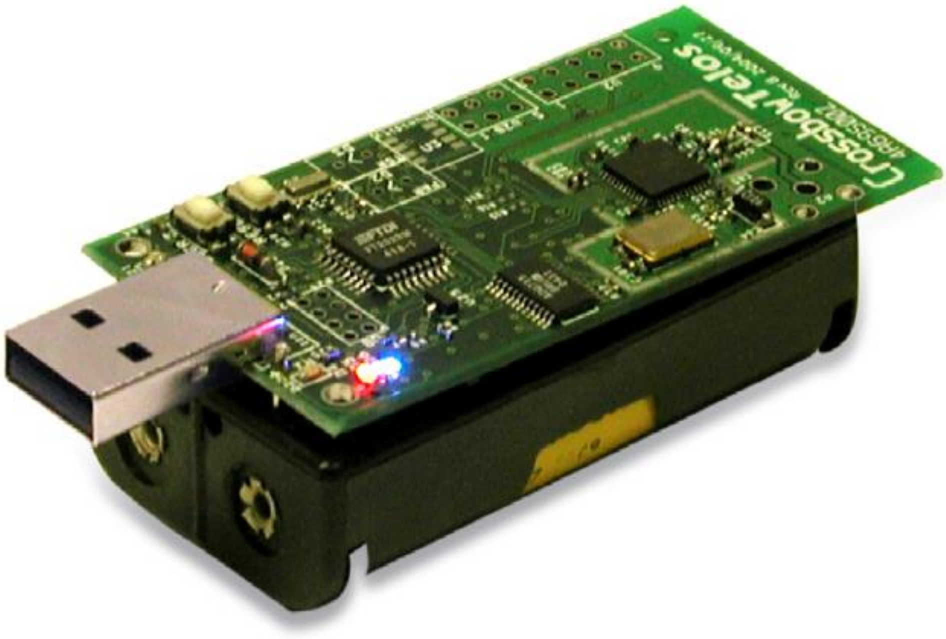

Figure 2.2: TelosB Sensor Node

It was also developed at UC Berkeley and is currently marketed by Memsic (formerly Crossbow). TelosB has the following characteristics:

- Processor: Texas Instruments (TI) MSP430F1611.
- Wireless chip: ChipCon CC2420.
- Antenna integrated on the board.
- 1 MB external flash memory for measured values/logging.
- Battery holder for two AA batteries.
- Dimensions without battery holder: 65x31x6mm.

The TI MSP430F1611 processor used [32] has these properties:

_ 16-bit RISC architecture.

_ 10KB RAM.

_ 48KB flash memory for program code.

_ 12Bit analog-to-digital converter (8 channels).

_ 48 digital I / O pins.

_ UART, SPI, and I2C interfaces.

_ Less than 6 _s required to wake up from sleep mode.

_ Power consumption: 1.8mA in operation and 5.1 in sleep mode.

There are two versions of TelosB motes: one with and one without sensors. The variant TPR2420CA contains a brightness, a humidity, and a temperature sensor. Additional sensors could in principle be connected via a 6-pin and 10-pin connection, but Memsic does not offer any related products. The available sensors make TelosB suitable for the application.

The TelosB platform is open source. As a result, there are other manufacturers that offer products based on them. Advantech [33] can serve as an example. The MTMCM5000- MSP product largely corresponds to TelosB reference design. Variations of the original design do not have the USB-A plug for space reasons and have a special interface for the connection of sensor boards. Advantech has a wide range of products on offer (see [34]). The operating system TinyOS is also used on the TelosB sensor nodes [18].

2.8.3. Scatter Web

Scatter Web is a platform developed at Freie Universität Berlin [20]. An active product of this platform is the "Modular Sensor Board MSB-430 H".

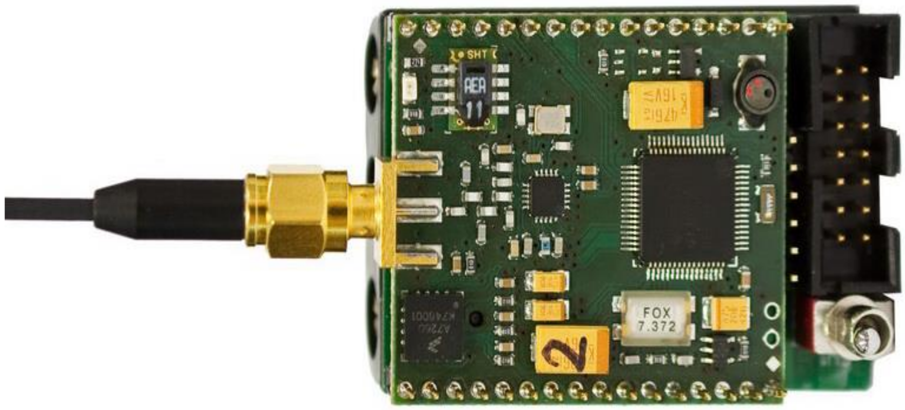

Figure 2.3: A Scatter Web MSB430-H Sensor Node

The characteristics of the MSB-430 H are:

Processor: TI MSP430F1612

Wireless chip: ChipCon CC1100

External flash memory via SD card possible

Battery holder for three AA batteries.

2.9.Security

2.9.1. Security goals

Security objectives on a wireless sensor network (WSNs) include the following primary services:

Data Privacy: It is also known as Confidentiality or Secrecy. It has to protect information against unauthorized users as adversaries [35,36]. Data privacy is considered as the highest threat in network security. Sensitive data must be protected against passive attacks to prevent eavesdropping.

Data Verification: It is also called as authentication. It allows the recipient to verify that the message arrives from the expected sender.

Data Integrity: It verifies that there is no changing on the sending data in transmission by an adversary [35,36].

Usability: Also known as availability, usability in a network system provides it with the sustenance against denial-of-service attacks (DOS) [35,36].

Non-repudiation: Non-repudiation provides valuable information regarding a source. When a packet is received in a network, it proves the source of the packet during the authentication in case the source later denies the sending.

Authorization: Authorization enables the network to deny access to an unauthorized user or source to access any kind of resources within itself.

Data Freshness: Data freshness performs the task of keeping the data recent and disallowing the repetition of a message. It also ensures that messages are replayed [9].

Reliability: Reliability is the capability to keep the functionality of the WSN even if some sensor nodes fail, many applications the WSN is a requirement to operate in uncontrolled environments.

Energy efficiency: Energy conservation is the main problem in a WSN because batteries are the only limited energy source available to power the nodes. The battery has effects on the reliability and availability of the WSN.

Forward secrecy: Forward secrecy acts as a one-way gate in the information transfer, it ensures that no sensor is able to reach or read an upcoming message once it has left the network.

Backward secrecy: Backward secrecy, just like forward secrecy takes away the ability to read a message from a sensor, but in this case, it disallows any neighboring sensor to read an old message that was transmitted previously in the network.

2.9.2. Security Challenges

Limited resources of sensors make WSN face some big security challenges. Some challenges are resolved, and many haven't been overcome yet or are understudied. The summary of WSN security challenges from [6,37] as follows:

-Conflicting between keeping the resource consumption as minimal as possible while maximizing the security level.

-Modern anti-jamming methods are useless due to its design complexity as well as it's high resource consumption.

-Most available standard security protocols cannot reach out to a large number of participants in the network.

-Additional processing, memory, and battery power are the main requirements for the encryption.

-Secure asymmetric key needs more computations.

-Although the information of a sensor's location is significant, a large number of proposals are only applicable to static WSNs.

-Most of the synchronization schemes that are available are vulnerable to several attacks.

-Their low costs impede use of expensive tamper-resistant hardware.

2.9.3. Threats and Attacks

If there is no attack by an adversary, there is no need for security. However, most security problems occur from attacks. Basically, there are two types of attacks, external attacks and internal attacks in wireless sensor networks (WSNs). External attacks consist of threats from nodes that are not a part of the WSN whereas internal attacks are the attacks carried out by nodes of a WSN that perform actions that are unintended.

External attacks can be divided into two types; passive and active. Passive external attacks involve unauthorized eavesdrop or monitor exchanged packets [6]. Active external attacks, however, occur when the data stream is modified by a node. For example, denial-of-service (DoS) attacks can break the network functionality such as its integrity and authentication.

The most important problem in internal attacks is that the node is seized by the attacker. This is called the node compromised. The attacker can get any secret information such as keys from the compromised node. The attacker can reprogram the node and send the wrong data to the network.This is called the Byzantine problem. A compromised node can inform the network that normal nodes as compromised nodes. There are many types of attacks such as HELLO flooding attacks, sink hole attacks, sniffing attack, bad mouthing attack, good mouthing attack, Sybil attack, black hole attack, worm hole attacks, or DoS attacks. These attacks can be detected because they make abnormality in the network layer. Different defense and recovery methods are developed according to the types of internal attacks such as Weighted Trust Evaluation Scheme, STL Approach, Auto regression technique, Dual Threshold [38].

2.9.4. Evaluation

Wireless sensor network security is evaluated based on some criteria. In general, these are resiliency, resistance, scalability, self-organization, flexibility, robustness, assurance and energy efficiency. Recently, especially energy efficiency has been studied because of the limited resource. New methods were applied based on cost, energy efficiency and other criteria in [39].

2.10. Attacks and defense suggestions in OSI model

The sensor network has a complex structure. Layered structure provides better analysis. At the same time, it increases security, durability, modularity and clear interfaces. Standard layered networking model of a sensor network consists of five layers which are physical layer, data link layer, network layer, transport layer, middle ware, and application layer. Each layer has its own security system. Most attacks are usually done on a single layer, but some attacks can attack multiple layers.

Security and energy efficiency are an important concern in the design of wireless sensor networks. In the system, B- Mac-based LPL WSN MAC protocol that separates the transmitter and receiver synchronization time. B-MAC protocol of the truth and no ACK receiver to listen to the sender to wait long introduction is finished. The long introduction of project-based protocols LPL energy consumption of both the sender and receiver. To solve this problem and make things better than ever, some of the design of the new system is presented. One of them, a cross-layer design of safe design integration MAC protocol and one double-layer design that can check and cut off the attack on the Czech differently. The combination of low complexity and number of parts of the Czech security process can defend against attacks and send sensor nodes to sleep as soon as possible. As a result, it can be said that the proposed system is better and more useful than existing systems because of the lower power consumption, extend the life of the network, and the use of hash chain for symmetric encryption key generation [40].

Sensors in many areas, such as security, disaster recovery, medical applications are used. Each sensor and data transmission sensory processes to sink safely. Since sensor networks can be affected by external attacks aimed at destabilizing the network. Therefore, we need to secure communications to prevent interception, analysis, and modified by an intruder who could use analytical methods to reduce the effectiveness of the sensor network. Intrusion Detection reduce complexity is provided, as would patterns of security breaches by monitoring and analyzing the activity is detected, but the problem is that the proposed system can not be directly applied to the sensor network because it must in the way of efficient energy was also due to the sensor network has its own unique characteristics and resource constraints, frequent node failure, and very distributed nature. Genetic algorithms deal with the nonlinear problem without a number of assumptions about the problem to be solved. We design security mechanism is complementary security features based on detailed analysis of the threat optimization was determined by the sink. Genetic algorithm convergences times increase exponentially if we increase the amount of nodes [41].

Integrate digital low-power micro-electro-mechanical systems, sensor data processing capabilities with intuitive circuit equipped. However, a large number of such sensors with limit sensor management create a problem. In addition, a network clustering to minimize the distance another problem is NP hard. To solve this problem, a genetic algorithm is proposed to reduce the complexity of producing the optimal number of sensors to cluster. Genetic algorithms are designed with two objectives which are: firstly to discover the optimal clusters and secondly to discover low-cost path to the sink. It is essential to mention that there tow kind of genetic algorithm which is simple genetic algorithm and multi-objective genetic algorithm. The difference is that the first one converges to a single solution and the second one is used to evolve a set of solutions towards the Pareto-optimal from where trade off analysis can be performed to select a suitable solution. We can conclude that Genetic algorithm minimizes the power consumption of the sensor system and maximize the sensor objectives (coverage and exposure) [11].

CHAPTER 3

METHODOLOGY

The classical application for a sensor network is the monitoring of physical readings. These are sent to a central “gateway”, via which the user can access the measurements. This corresponds to the case shown in Figure 1.1.

3.1. Classification

However, there are other applications for wireless sensor networks. In [42], a classification scheme for applications of sensor networks is presented which groups them according to various aspects.

3.1.1. Aim

One criterion is the goal of the sensor network. A distinction is made here between applications in which the sensor nodes carry only measurement tasks and those in which they also influence their environment by means of actuators.

One example of such a wireless sensor and actuator network is the automatic temperature control by means of additional actuator nodes. Instead of merely monitoring the air-conditioning of the application area, such a network could also actively intervene and control the ventilation. Further information on this type of sensor set can be found in [43].

If the sensor network can also react, new requirements for the network configuration and the protocols used can arise. Now some nodes must accept the task of making decisions about the behavior to be performed. To reverse these control decisions to the executing nodes, a return channel must be present.

3.1.2. Interaction patterns

This requirement leads directly to the second discrimination factor, the interaction pattern between the nodes. The classic case of a sensor network with a central “gateway” is “many-to-one”: many distributed sensor nodes send data to a “gateway”. Can be accessed over many nodes on the network instead of only via a central “gateway”, or if control nodes need to communicate with other sensor nodes, it is a “many-to-many” scenario. Here each node can communicate with each other. In rare cases, “one-to-many” sensor networks can also be found, i.e., networks in which only one node sends messages to many others.

3.1.3. Mobility

Sensor nodes can also be mobile. This is taken into account as a measure of mobilization. In contrast to static mobile sensors, their position can change during runtime.

In addition, a distinction can be made between source mobile and lower mobile applications. The data collection sensors are movable in sources mobile sensors. For these applications, the tracking and localization of the sensor nodes in the application area, as well as a regular updating of the routing tables, are necessary. In contrast, sink-mobile applications are characterized by the fact that the sink (the “gateway”) is not static and can, for example, be realized by a robot which regularly changes its position. In this case, particularly high demands are placed on the aggregation algorithms used.

Some examples of classification of different application scenarios in this classification scheme can be found in Table 3.1.

Table 3.1: Examples of Different Applications and Their Classification [42]

Application	**Target**	**Interaction**	**Mobility**	**Location**	**Time**
Glacier monitoring	"sense -only"	"many-to-one"	Static	global	periodic
Traffic control	"sense and react"	"many-to-many"	Statically	regionally	periodically
Forestry warning system	"sense only"	"many-to-one"	Statically	global	event-based
Animal Sense	"sense -only"	"many-to-one"	Mobile sources	globally	periodically

3.1.4. Location

Furthermore, the location of the processed data can be considered: While in global sensor networks, access to all nodes is necessary at the same time, it is sufficient in regional networks to access the data of some sensor nodes in a certain environment.

3.1.5. Time

Finally, data acquisition can still distinguish between periodic recording, in which measurements are carried out in one interval, and event-based sensor networks that wait and react to events.

Further classifications, as well as more detailed information on this topic, are described in [42].

3.2. Lifetime

Due to the limited available energy quantity, a sensor node can usually only operate for a certain time without maintenance. In [44] applications are classified according to the required lifetime of the sensor network. The typically required lifetime until battery replacement for some applications is shown in Table 3.2. This can move in a wide range: while in clinical applications it is easy to replace the battery by nurses, the often distant locations of an earthquake detection system should be used for a long time without costly intervention to work.

Table 3.2: Areas of Application by Lifetime [44]

Application	**Lifetime**	**Measuring frequency**
Weather monitoring	Years	Very low
Earthquake Detection	Decades	Low-Medium
Heart rate monitoring	Daily	Means
Goods monitoring	Months	Low
Vibration monitoring	Months	High

For this purpose, various aspects of the lifetime of a sensor network are identified in [45]: usually, the lifetime is indicated by the number of active sensor nodes. A sensor network is then functional if more than n nodes are lukewarm. However, this simple metric ignores some functional aspects.

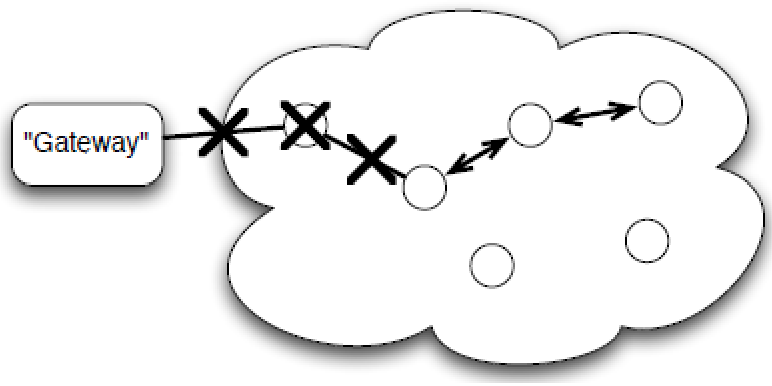

Figure 3.1: Failure of a Central Node

Alternatively, the life time can also be specified by the remaining sensor nodes via the coverage of the application area or the accessibility of the “gateway”.

These definitions already include the functionality of the sensor network. In particular, not every failure is weighted equally: If a node that had previously assumed central routing tasks is more serious than the failure of a boundary node. Figure 3 shows such a possible extreme case. Since the entire sensor network could only communicate with the “gateway” via a node, the failure of this one node already leads to the sensor network being unable to fulfill its task. Finally, a good metric is the specification of a lifetime based on the “quality of service” requirements: The lifetime of a network is the time when the network continuously meets the requirements of the application.

3.3. Topologies

The network topology of a sensor network indicates how the nodes communicate with each other.

3.3.1. Star

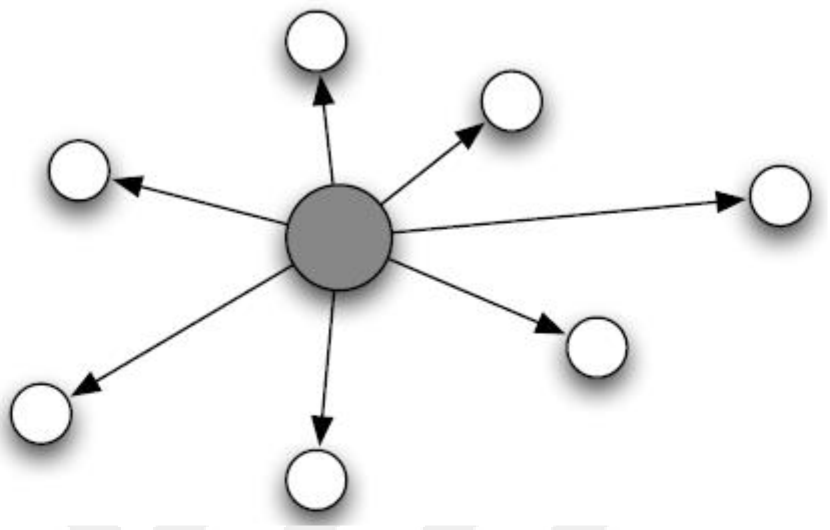

Figure 3.2: Star Topology

The simplest topology is the star. All communication via a single base station [46] takes place. Only this can communicate with the other nodes; direct communication between other nodes is not permissible in a star-shaped network. By this structure, the communication is very simple since each node can be reached by each node with a maximum of two hops. In the case of larger networks, however, some problems arise. In particular, the range of wireless communication limits the possible applications. The limitation to a single base station is also a weak point with regard to the reliability of the network. If this is the case, communication is no longer possible in the entire network.

3.3.2. Tree

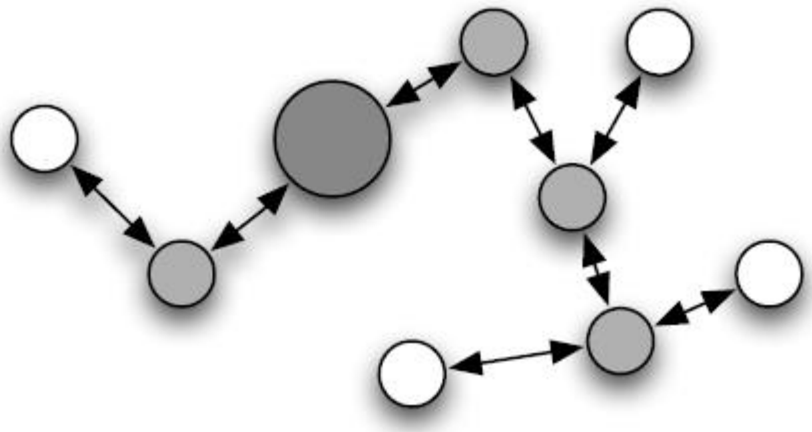

Figure 3.3: Tree Topology

An extension of the star topology is the tree structure. Additional network stations can also be used with larger base stations for greater spatial expansion.

Therefore, the energy consumption of the sensor nodes can be differentiated according to the position in the network. This is an important point for protocol design. Thus, it would be possible to provide more redundancy in these highly stressed nodes, so that if a routing node fails, the replacement is available. However, in order to achieve this, the corresponding support, e.g. for updating the routing information in the log pack.

3.4.Protocol Design

3.4.1. Conditions

From the consideration of the hardware used as well as the application cases, some specific requirements arise for the protocol design. In [47] these and other objectives and challenges are presented. The most important ones should be briefly summarized here.

3.4.2. Hardware

Sensor nodes should be as cheap as possible and have to do with a limited amount of energy. Therefore, little computing power and memory are available.

3.4.3. Transceiver

Sensor networks usually communicate wirelessly. In protocol design, therefore, the higher bit error rates, latencies, and fluctuating bandwidth must be taken into account. It is also necessary to react robustly to very unusual nodes. In order to keep the energy consumption low, the distances between nodes which communicate directly with one another should be minimized.

3.4.4. Applications

The versatile applications for sensor networks are just as varied as the protocols used. These network quality requirements are adhered to in the Quality of Service requirements of the application and must be adhered to by the protocol stack.

The gateway is intended to integrate the sensor network with other networks such as the Internet.

3.4.5. Network construction

Sensor networks consist of a large number of nodes, which can be mobile and must be easily interchangeable. For this, the network should be able to organize itself and be very flexible.

The network must be robust against interference. This includes fault tolerance as well as security against attacks. As wireless communication is easy to cut, important information should be encrypted. Furthermore, the right timing is critical for many sensor functions. Therefore, the network should provide a time synchronization mechanism. This is required, for example, for some safety mechanisms as well as for exact time measurement of events.

3.4.6. Differences to classic ad-hoc networks

Some of these requirements are already met by general protocols for ad-hoc wireless networks. There are however some serious differences between wireless sensor networks and ad-hoc networks [28].

Because of the lower costs, much more nodes can be used in sensor networks than in traditional ad-hoc networks. Therefore, the techniques used must scale well. From the power supply problems, the failure of a sensor node is no exception, and the network must respond accordingly. Not only due to failures but also due to node mobility or manual intervention, the topology of the sensor network can also change frequently.

Finally, the interaction is to be considered. As already presented in previous sections, the most commonly used form of communication is the broadcast of measurement data to the “gateway”. This is in contrast to the most commonly used point-to-point communication in traditional computer networks.

3.5.Log staple

In order to meet the special requirements of wireless sensor networks, the classic protocol stack based on the ISO / OSI layer model is extended in [28]. As shown in Figure 3.4, additional layers are relevant to sensor networks.

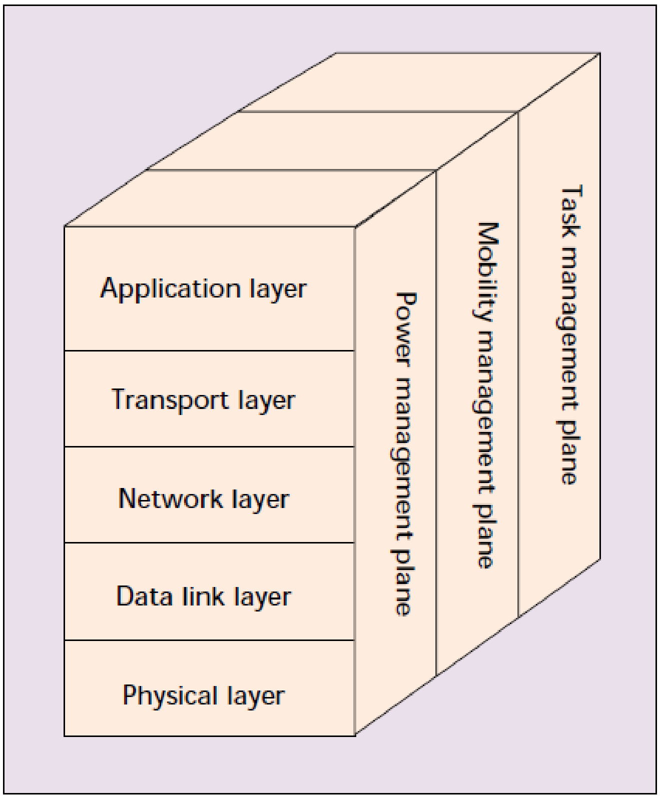

Figure 3.4: Protocol Stack for Sensor Networks

In order to take account of the energy shortage, the "Power Management Plan" is introduced. It regulates the energy consumption of the sensor nodes and the goal of increasing the lifetime of the sensor network. This can be done, for example, by minimizing the routing functionality of nodes with little remaining runtime and using the remaining energy only for measurements.

The "Mobility Management Plane" tracks the movements of the nodes and can thereby better control energy consumption and task distribution.

The distribution of tasks to available sensor nodes is regulated by the "Task Management Plan". Figure 3.4 shows an application for this. A measurement is to be carried out in each of the four sectors of the application area. However, in some cases significantly more than required sensor nodes are available.

Therefore, the task must now be divided into the sensor nodes. By temporarily deactivating unnecessary nodes, energy can be saved and the lifetime of the entire system can be increased.

A possible division is shown with filled nodes for active and empty nodes for deactivated nodes in Figure 3.5.

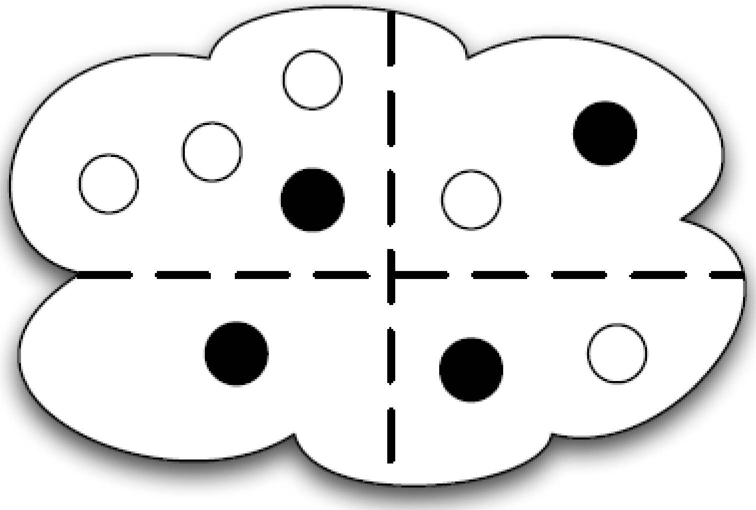

Figure 3.5: Energy Saving by Switching off Nodes

Depending on the ratio of active to deactivate nodes, this results in different life times for the entire system. It is even conceivable to adjust the ratio dynamically as required. This would allow more accurate measurement data to be available when they are needed, and energy is saved in the remaining time.

Even with this simple example, it becomes clear that a good protocol has to consider many properties of a sensor network in order to work efficiently.

3.6. Cross-Layer Design

In architectures such as the ISO / OSI layer model, network design is divided into hierarchical layers that offer specific services. Direct communication between non-adjacent layers is not permitted [48].

With regard to sensor networks, “cross-layer design” primarily refers to the softening of this strict layer separation. For this purpose, mechanisms are introduced to exchange information over several layers. This means that the available resources can be used more efficiently, especially in the case of wireless communication. This is particularly useful for cross-layer optimization.

CHAPTER 4

SIMULATION RESULT AND DISCUSSION

4.1. Proposed Method

The schematic of proposed method is shown in the following figure. As shown in this figure the close sensor will send their information to base station directly. The far sensor (between square and circle sensors) will send their information to rechargeable node, and then the rechargeable node sends the information to base station. The far sensors (outside of the square) they send their information to cluster heads and then this cluster heads send to base station. This scenario will save a lot of energy and the number of alive sensors will be dead after more round time.

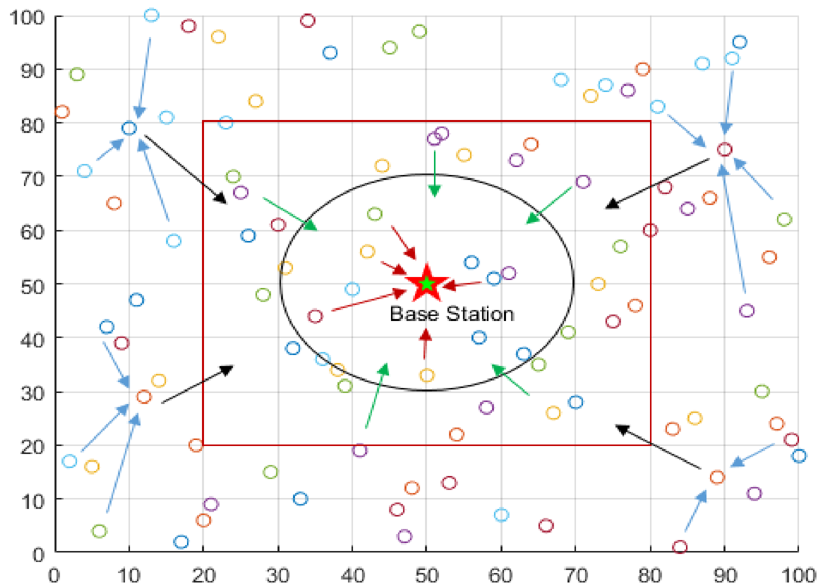

Figure 4.1: The Schematic of Proposed Method

The regions and the different sensors are shown in figure 4.2.

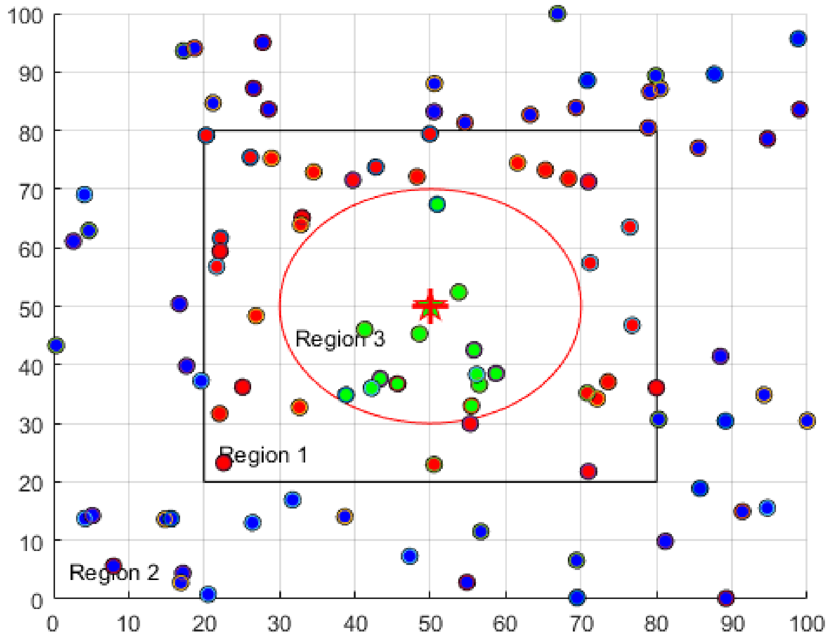

Figure 4.2: The Regions of The Sensor in Proposed Method

As shown in this figure, we have 3 regions. The region 3 has direct communication with base station, and the sensors send their information directly to base station. These sensors are shown in green color. The region 1 sends their information to the rechargeable node, and this rechargeable node sends all information to base station. These sensors are shown in red color.

Finally, there are far sensors which shown in blue color. These sensors send their information to the cluster head, and these cluster heads send the information to base station. The probability of the sensor which selects the cluster head is described in equation (4.1).

$$T(n) = \begin{cases} \dfrac{P}{1 - P[r * \bmod(1/P)]} & \text{if } n \in G \\ 0 & otherwise, \end{cases} \qquad (4.1)$$

4.2.Radio energy dissipation model

For transferring of the information its need the radio model. Figure 4.3 shows the radio model which we used in this thesis.

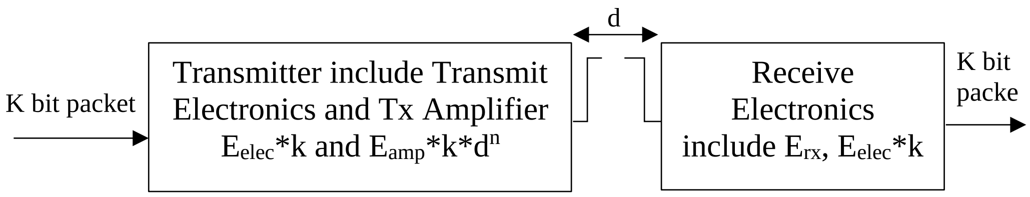

Figure 4.3: Radio Model

In this model, the ***d*** is the distance between each sensor. ***k*** is the length of the packet. $\boldsymbol{E_{elec}}$ is the energy of the each sensor and $\boldsymbol{E_{amp}}$ is the energy of the amplifier. N is the constant that depends on the distance between sensors. If the distance between sensor is long that time this value will be 4. When the distance between sensors is short that time this value will be 2.

The energy of transmission is shown in Equation 4.1 [1].

$$E_{Tx}(k,d) = \begin{cases} kE_{elec} + k\varepsilon_{fs}d^2 & if\ d \le d_0 \\ kE_{elec} + k\varepsilon_{fs}d^4 & if\ d > d_0 \end{cases} \tag{4.1}$$

The energy of receiver is shown in Equation 4.2.

$$E_{Rx}(k,d) = kE_{elec} \tag{4.2}$$

If the distance between sensors is small, then the energy of amplifier and energy of free space will be the same. This situation is shown in 4.3.

$$\varepsilon_{amp} = \varepsilon_{fs}, \quad n = 2 \tag{4.3}$$

If the distance between sensors is long, then the energy of amplifier will be as energy of multipath. This situation is shown in 4.4 .

$$\varepsilon_{amp} = \varepsilon_{mp}\,, \quad n = 4 \tag{4.4}$$

The value of n is depended on the threshold value. This threshold value is shown in 4.5.

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \tag{4.5}$$

In this equation, d_0 is a threshold value, ε_{fs} is the free space energy and ε_{mp} is the energy of amplifier. The parameter which used in this thesis is shown in table 4.1.

Table 4.1: Parameter That Used in Our Thesis [1]

Parameter	**Value**
n (number of nodes)	100
X	[0 100] m
Y	[0 100] m
BS position	[50, 50]
Initial energy of each sensor	0.5 J
E_{elec}	5 nJ/bit
ε_{fs}	10 pJ/bit
ε_{mp}	0.0013 pJ/bit

4.3. Setup phase

In this phase, each sensor chooses a random number m between 0 and 1.

If m <T (n) for node n, cluster head node at which equation (4.1) has to be converted.

In this equation, P is the percentage of cluster heads. R is the number of rounds. G set of nodes to the cluster during the last 1 / P are not far away. Around the cluster nodes decide to join the signal strength of the message.

Cluster heads assign a time division multiple access (TDMA) schedule for their members. The TDMA is a technique access control medium for transmitting multiple streams of traffic on a single channel or single frequency band. It uses a time division of the bandwidth, the principle of which is to distribute the available time between the different users. By this means, frequency (carrier) or a wavelength can be allocated, in turn (almost simultaneously), to several subscribers. This technology is used, for example, in the GSM standard, where each carrier supports 8-time slots allocated to 8 simultaneous communications. In the military field, the communication uses this technology for the secure exchange of data. TDMA also designates a mobile phone standard based on this technology [49].

A disadvantage of this technique is that it is necessary to transmit a synchronization (clock) which is the best possible so that each user can recover his received data and transmit without interfering with the other subscribers.

In this thesis, we used MATLAB 2016a for implementation of the proposed method. We compared our method with LEACH and SEP method. The results are shown in figure 4.4 and figure 4.5. The number of alive nodes vs. of rounds is shown in figure 4.4.

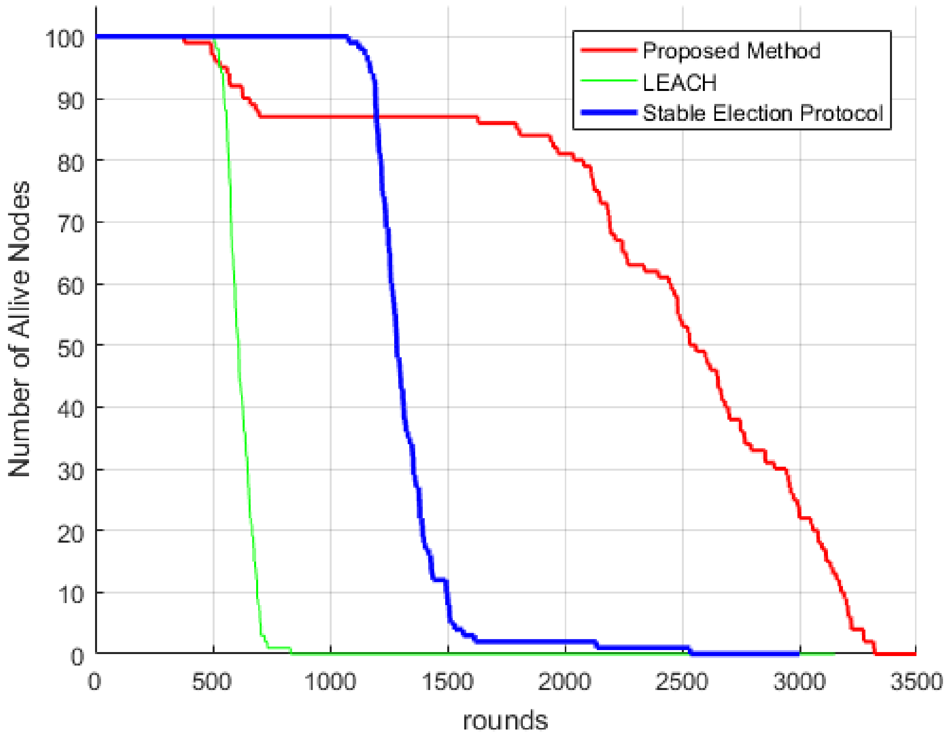

Figure 4.4: Number of Alive Nodes vs. Rounds

As shown in this figure the proposed method has a high number of the round which the sensors are dead. As this result, LEACH protocol has low performance than the other ones.

The result for the number of packets received at BS is shown in figure 4.5.

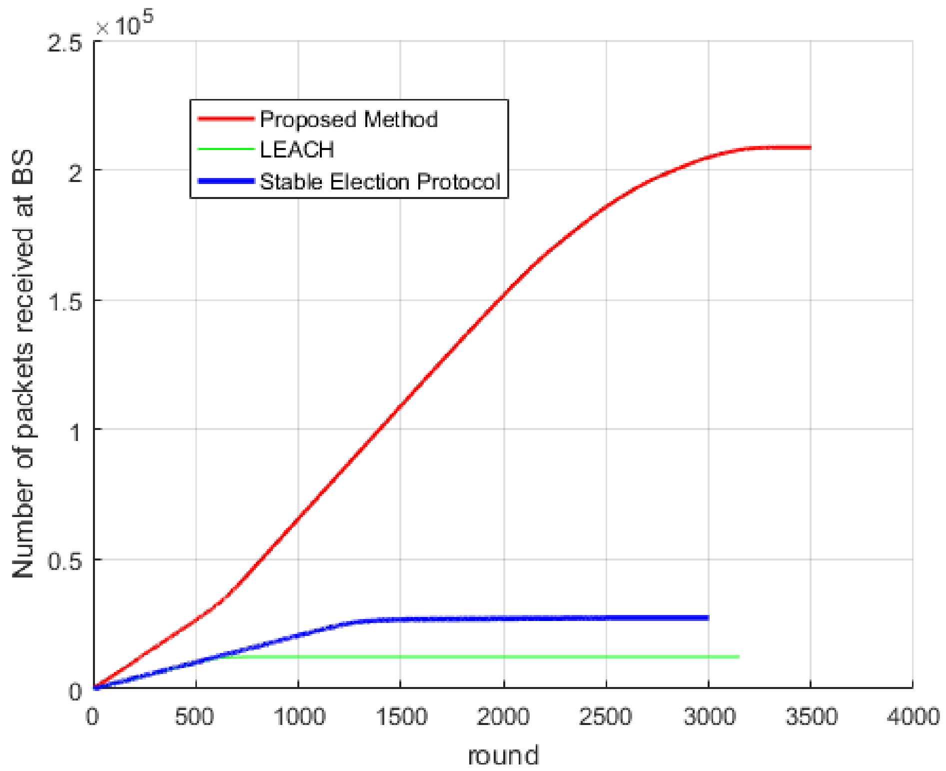

Figure 4.5: Number of Packets Received at BS

As shown in this figure the proposed method has the highest value in received packet at BS. The highest value 209006 packets are received at BS after 3000 round. This value for SEP is 27206 and for LEACH is 12404 packets.

In Table 4.2 the comparison of maximum packets which received at BS between proposed method and other methods is illustrated.

Table 4.2: The Comparison Between LEACH, SEP and Proposed Method

Method	Maximum packets which received at BS
LEACH	12404-bit packet
SEP	27206-bit packet
Proposed method	209006-bit packet

The processing time of these methods is shown in Table 4.3.

Table 4.3: Processing Time for Three Methods

Method	Process Time
LEACH	4.03 second
SEP	104.68 second
Proposed method	5.14 second

Also in this thesis, we created the graphical user interface (GUI) with Matlab. The GUI of proposed method is shown in figure 4.6.

In this GUI we select the 5 screen axis. The first screen shows the sensor deployment. The second screen shows the alive nodes vs. round. The third screen shows the dead nodes vs. round, and the fourth screen shows the number of packets which received in BS. Finally, we used the screen five for showing the sending of the information from BS to CH and sensor nodes.

Figure 4.6: The GUI of The Proposed Method

In this GUI we used 8 pushbuttons. This scenario is shown in figure 4.7. The Load Data pushbutton is loaded the sensors location and the region 1, 2 and 3.

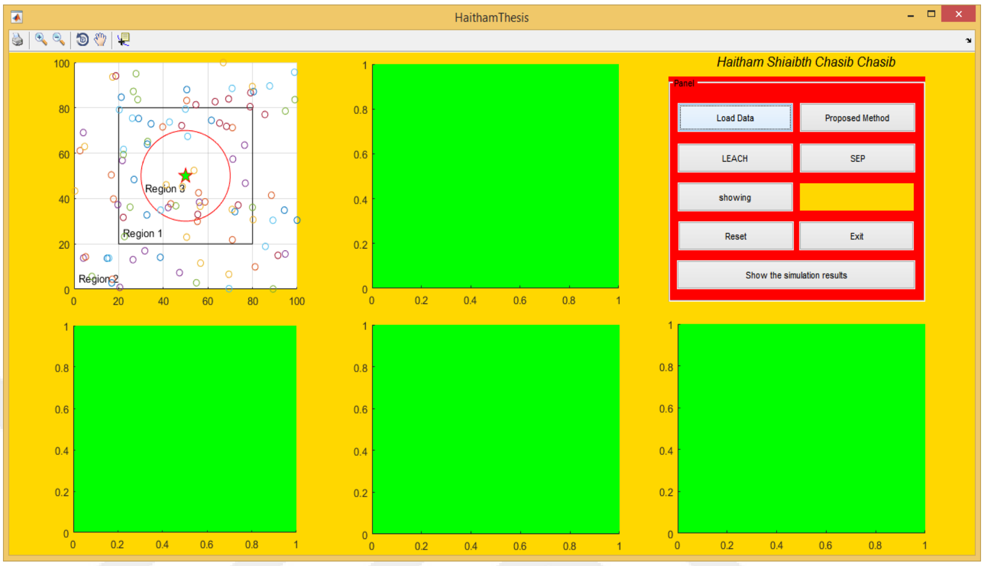

Figure 4.7: Scenario of The Pushbutton

The proposed method pushbutton is calculated and run the proposed method and show in the screen 2, 3 and 4. This scenario is shown in figure 4.8.

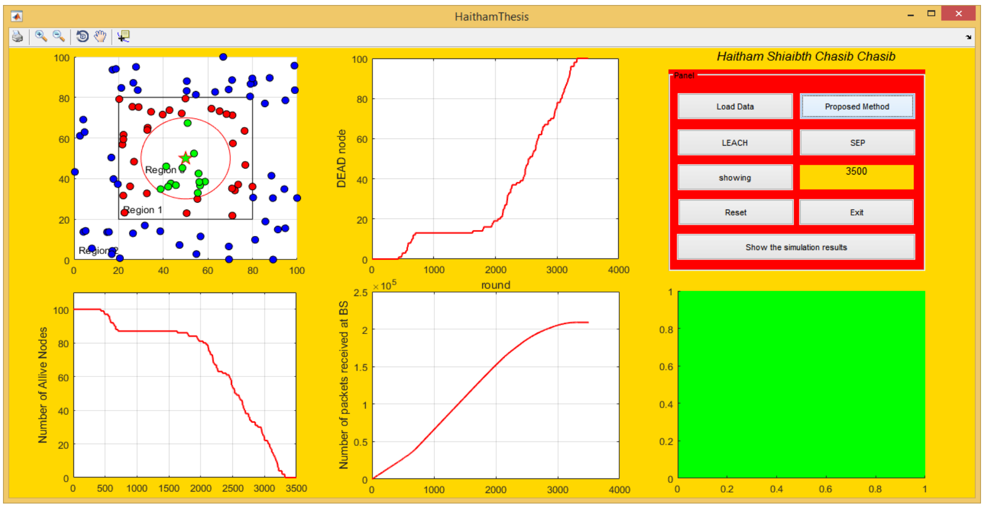

Figure 4.8: Scenario for Proposed Method Push Button

The LEACH pushbutton is calculated and run the LEACH method. This scenario is illustrated in figure 4.9. Also when we click on the LEACH pushbutton, the previous result holds, and the result of the LEACH will save in the same figure.

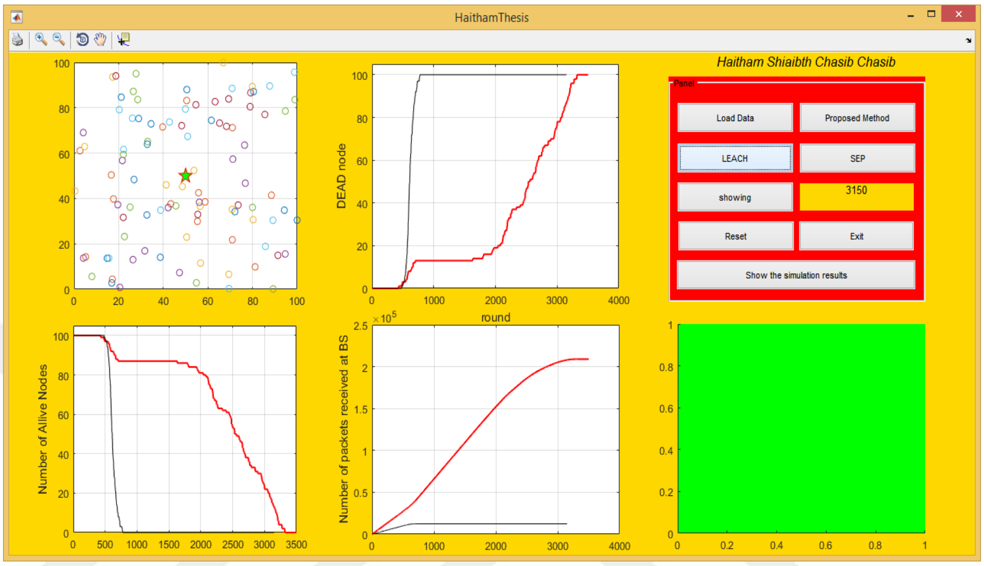

Figure 4.9: Scenario for LEACH Push Button

The SEP pushbutton is calculated and run the SEP method. This scenario is illustrated in figure 4.10. Also when we click on the SEP pushbutton, the previous result holds, and the result of the SEP will save in the same figure. The previous result means the result of the SEP and LEACH.

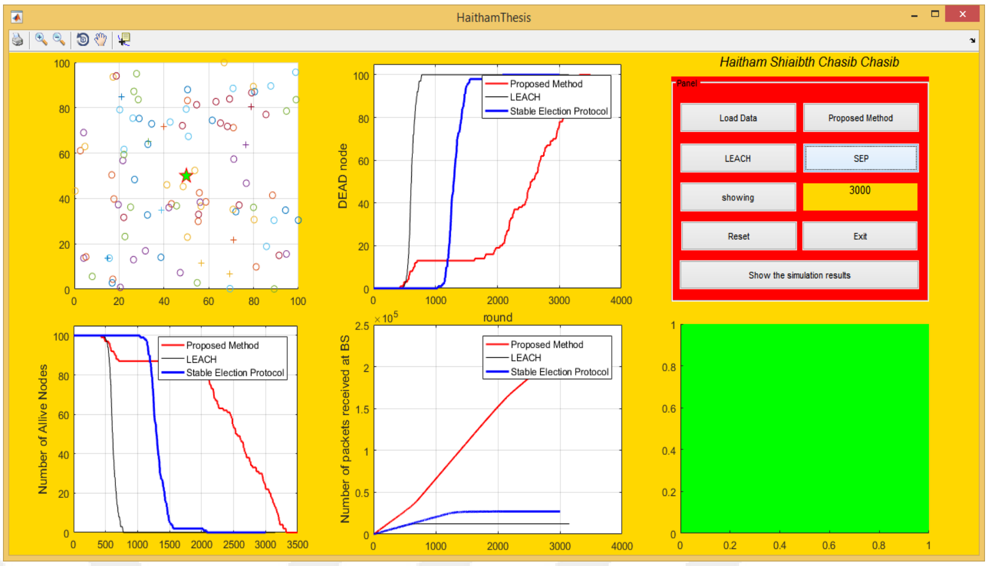

Figure 4.10: Scenario for SEP Push Button

The showing pushbutton is calculated and run the treatment of the sensors and BS and Ch for sending and receiving information. This scenario is illustrated in figure 4.11.

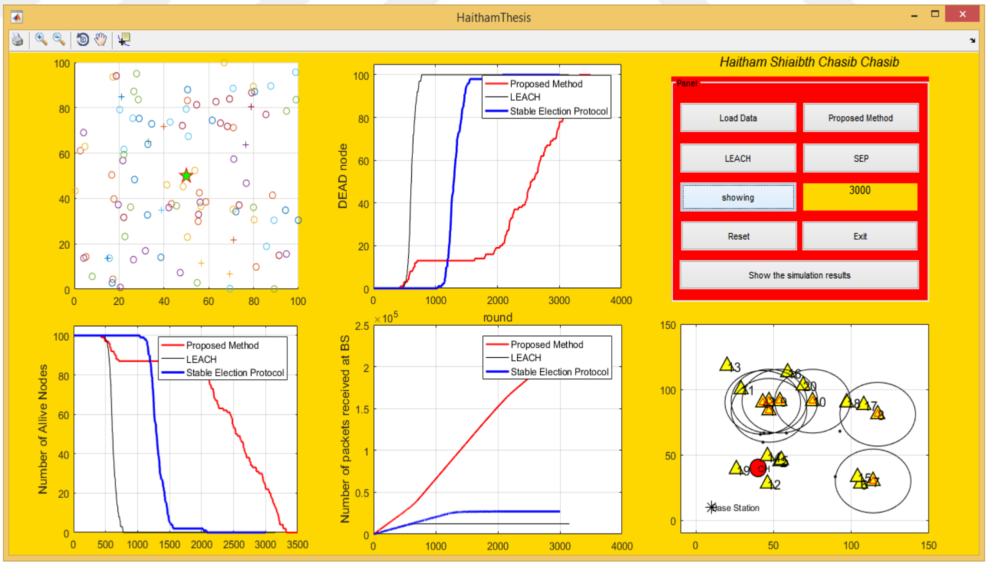

Figure 4.11: Sending and Receiving Data for BS, CH and Sensors.

The performance of the methods for first dead node and last dead node is shown in table 4.4 and figure 4.12.

Table 4.4: Performance of The Methods for First and Last Dead Node

Method	First dead node	Last dead node
Leach [1]	540	793
Sep	1013	2241
Proposed method	375	3321

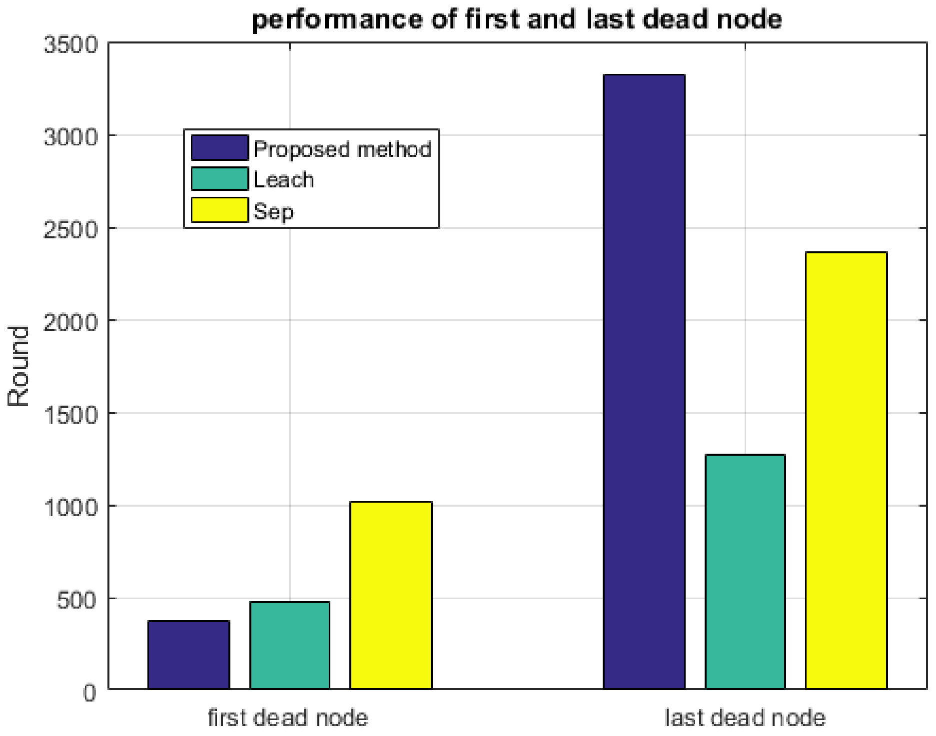

Figure 4.12: Performance of The Methods for First and Last Dead Node

As shown in this figure the proposed method has the highest value than the other methods for the last nodes. This means in the proposed method the sensor has more energy in a lifetime.

Figure 4.13 shows the percentage of the first dead node for each method.

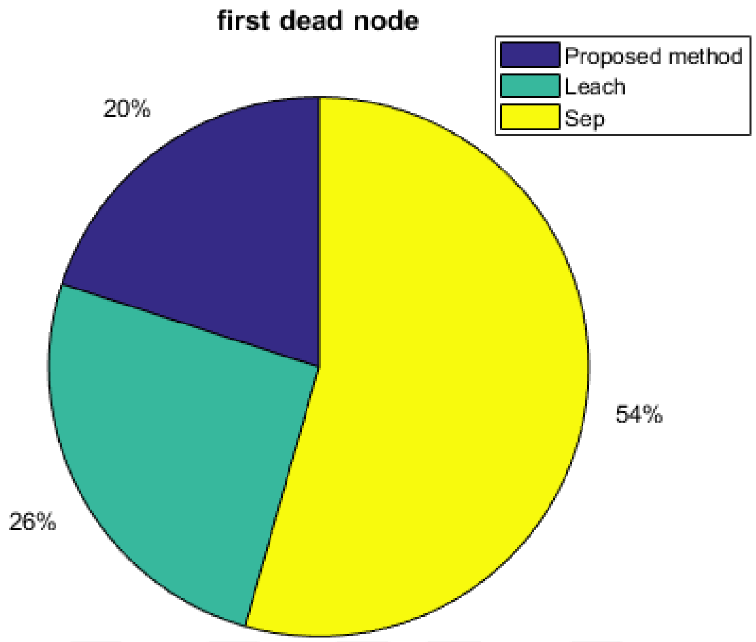

Figure 4.13: Percentage of The First Dead Node for Each Method

The percentage of the last dead node for each method is illustrated in figure 4.14.

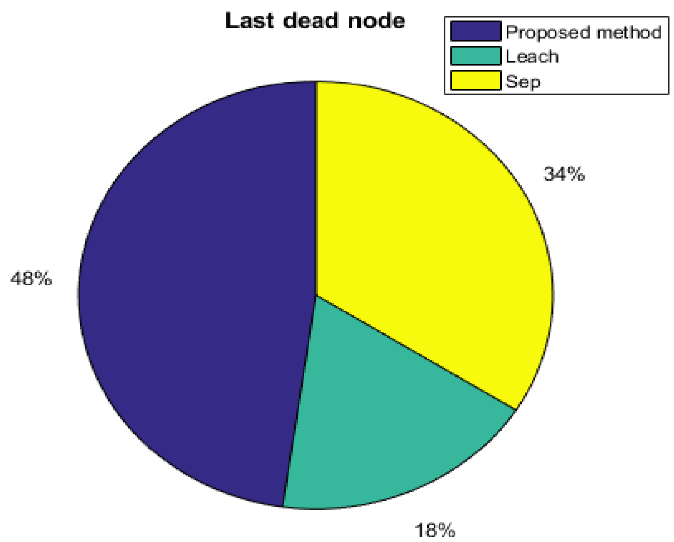

Figure 4.14: Percentage of The Last Dead Node for Each Method

CHAPTER 5

CONCLUSION

Wireless sensor network is a network of small computers ("nodes"), equipped with sensors, which work together in a partnership. Sensor networks are a relatively new concept in data acquisition and processing with multiple applications in various fields including industrial environments, home automation, military environments, and environmental detection. This type of networks by its ease of deployment and the automatically adjustable, capable of converting all the time emitter identified, receiver, providing routing services between nodes without direct vision, as well as to record data with reference to the sensor location each node. The idea of a random network node in a great land, which the nodes observe until it exhausted its energy resources to distribute. Features of "small", "cheap" and "independent" made the concept known as smart dust.

In this thesis, we provided an efficient clustering algorithm for saving of the energy in wireless sensor networks. We used the new scenario for optimizing the energy consumption which was the best clustering algorithm that fits our aim is LEACH (Low Energy Adaptive Clustering Hierarchy) and SEP (Stable Election Protocol) algorithm. The aim of this thesis is placed on analyzing and determination of drawbacks of LEACH and provide solutions to overcome the difficulties and prevent the occurrence of undesired cases in LEACH. The performance of proposed system was overcome the LEACH and SEP protocols. Finally, it can be stated that a large number of dependencies exist between the application, the hardware used and the protocol design. The design of the sensor network is the central application. From this, the hardware and the protocols used can be defined first. The application also specifies which of these dependencies are relevant for a concrete deployment. Depending on the application, the focus can be on various aspects. In any case, it is essential to consider the sensor network as a whole when planning. Only in this way can an efficient protocol and thus a well-functioning sensor network be developed.

Future Work

This algorithm which presented in the previous chapter can be implemented on the devices. In future, we can use the NS2 for modeling and simulation. As results, this proposed method can use in the industry like the controlling the 10 km square.

The results of this thesis and future studies in the direction of contributions are as follows:

1. Artificial intelligence techniques can be used to optimize the designed routing protocol.

2. The designed routing protocol works with Medium Access Control. Performance can be improved by making use of the information provided by the physical layer in taking routing decisions.

3. The designed protocol can operate without the need for additional equipment on modern wireless sensor nodes. For this reason, it can be implemented physically on commercial sensor nodes.

4. The designed protocol can work on the assumption that the wireless sensor nodes are aware of their location.

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