AN EFFICIENT ENERGY SCHEME FOR HYBRID CLUSTERING WIRELESS SENSOR NETWORKS

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AN EFFICIENT ENERGY SCHEME FOR HYBRID CLUSTERING WIRELESS SENSOR NETWORKS

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ABSTRACT

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Wireless network clustering is one of the major methods which have been used in many applications for energy optimization. As there are many nodes in networks, our aim is to provide adaptive energy consumption with clustering methods. LEACH is a famous algorithm for clustering, which depends on random clustering method. In this algorithm, there are two different types of node, namely the cluster head and cluster members. Communication is provided via these cluster heads. Therefore, the LEACH algorithm achieves its main purpose by providing dynamic clustering and adaptive energy consumption. In this thesis, a new hybrid clustering algorithm is introduced, analyzed and implemented in a network area. The energy performance of the proposed method is compared with LEACH (Low Energy Adaptive Clustering Hierarchy) and SEP (Stable Elections Protocol). Cluster head selection with different constraints and methods achieves better results in cases of energy consumption.

Keywords: Wireless Sensor Network, Cluster Head, Distance, Energy Level, Power Consumption.

ÖZ

HİBRİT KÜMELENME KABLOSUZ ALGILAYICI AĞLARI İÇİN VERİMLİ ENERJİ PROGRAMI

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Kablosuz algılayıcı ağlarda kümeleme, enerji optimizasyonu için birçok uygulamalarda kullanılmakta olan önemli yöntemlerden biridir. Ağlarda birçok düğüm olduğundan, kümeleme yöntemleri ile uyarlanabilir enerji tüketimini sağlamak amaçlanmaktadır. LEACH rastgele kümelenme metoduna dayanan en popüler kümeleme algoritmalarından biridir. Bu algoritmada küme başı ve küme üyeleri olmak üzere iki farklı düğüm tipi bulunmaktadır. İletişim bu küme başları ile sağlanır. Bu nedenle LEACH algoritması, dinamik kümeleme ve uyarlanabilir enerji tüketimi sağlayarak ana amacına ulaşır. Bu tezde yeni bir melez kümeleme algoritması ağ alanında tanıtılmış, analiz edilmiş ve uygulanmıştır. Önerilen yöntemin enerji performansı LEACH (Düşük Enerji Uyarlanabilir Kümelenme Hiyerarşi) ve SEP (Stabil Seçim Protokolü) ile karşılaştırılmıştır. Farklı kısıtlamaları ve yöntemleri ile küme baş seçimi enerji tüketimi konusunda daha iyi sonuçlar ortaya çıkartır.

Anahtar Kelimeler: Kablosuz Algılayıcı Ağ, Küme Baş, Mesafe, Enerji Sınıfı, Güç Tüketimi.

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LIST OF ABBREVIATIONS

ACH	Associate Cluster Head
BS	Base Station
CH	Cluster Head
CN	Candidate Node
EC	Energy Consumption
MNs	Member Nodes
OS	Operating System
PIM	Reply Information Message
QIM	Request Information Message
SN	Sensor Node
WSN	Wireless Sensor Network

CHAPTER 1

INTRODUCTION

1.1 Overview

Techniques for remote sensing and control now have the ability to progress significantly in many areas, for example, in health, agriculture, science, manufacturing and engineering, because of the impact of effective management and improvements and increases in production and reduction of costs. Moreover, it can intervene in the framework of monitoring and control, for example, traffic control and security roads. This evolution in remote sensing techniques has had much impact clearly in the creation of a new generation of amenities such as wireless sensors. We will focus on the idea of network devices and the application of wireless technology.

1.2 Wireless Sensor Networks (WSNs) Concepts

A WSN consists of a set of sensors deployed in a particular environment to control and monitor environmental and physical conditions. For example, one may need to monitor and detect environmental changes in certain places. Sensors consist of a set of nodes that are spread and distributed independently to detect conditions, such as those that cause disasters; therefore, sensors are placed to avoid the occurrence of disasters and take necessary measures to prevent such disasters, such as for earthquakes, where sensors that cooperate with each other send those emergency changes by sensor to the main base. Networks can also be wireless sensors found in many diverse areas such as medicine, science, industry, engineering, agriculture, and military battlefield surveillance and monitoring of enemy movements and the organization of traffic and road safety. The goal of the development of this type of networking is the large number of uses in our daily lives [1].

The cost and size of SNs vary and depend on the corresponding limitations of resources, including energy, computational speed, memory size and bandwidth, according to the design and complexity of the SN [1] in Figure 1.

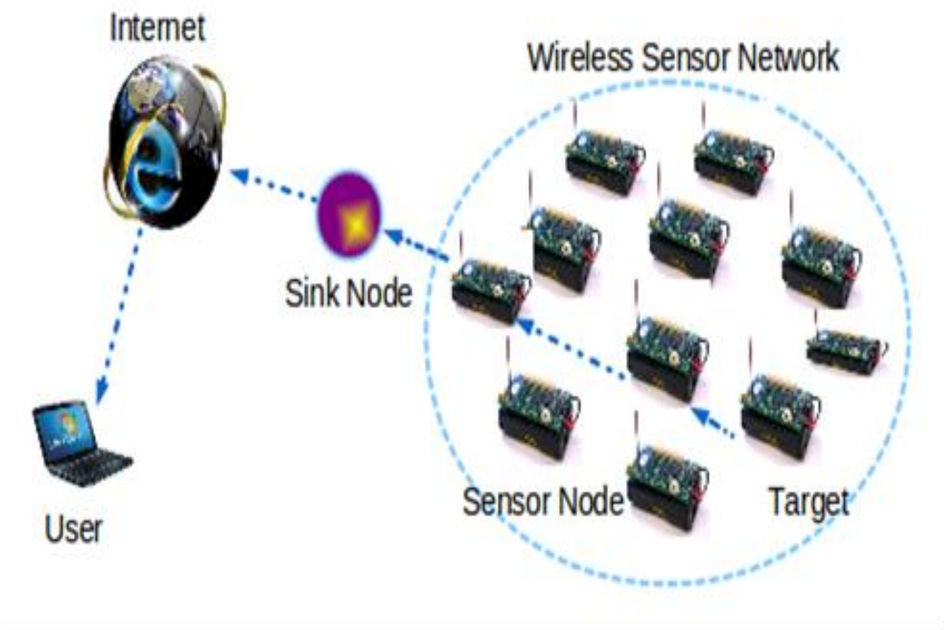


Figure 1: Overview of the sensor network

1.3 WSN Components

WSN components have the ability to wirelessly connect between nodes within a network. A sensor network contains of a set of sensors deployed within a particular environment, which in turn secures wireless connections within the network and to the BS. Examples include the spread of sensors to monitor roads and detect contaminants, as well as to monitor battlefields and monitor enemy movements. Sensors also have the possibility of collecting data, analyzing data and then sending it to the BS, which in turn takes appropriate action to avoid accidents and disasters [2].

SNs are deployed in a special area called a sensing field. SN distributions usually have the ability to collect and analyze data, and the way to them (designated) point sink. Figure 2 depicts a typical arrangement of a WSN [2]. A WSN consists of the following parts:

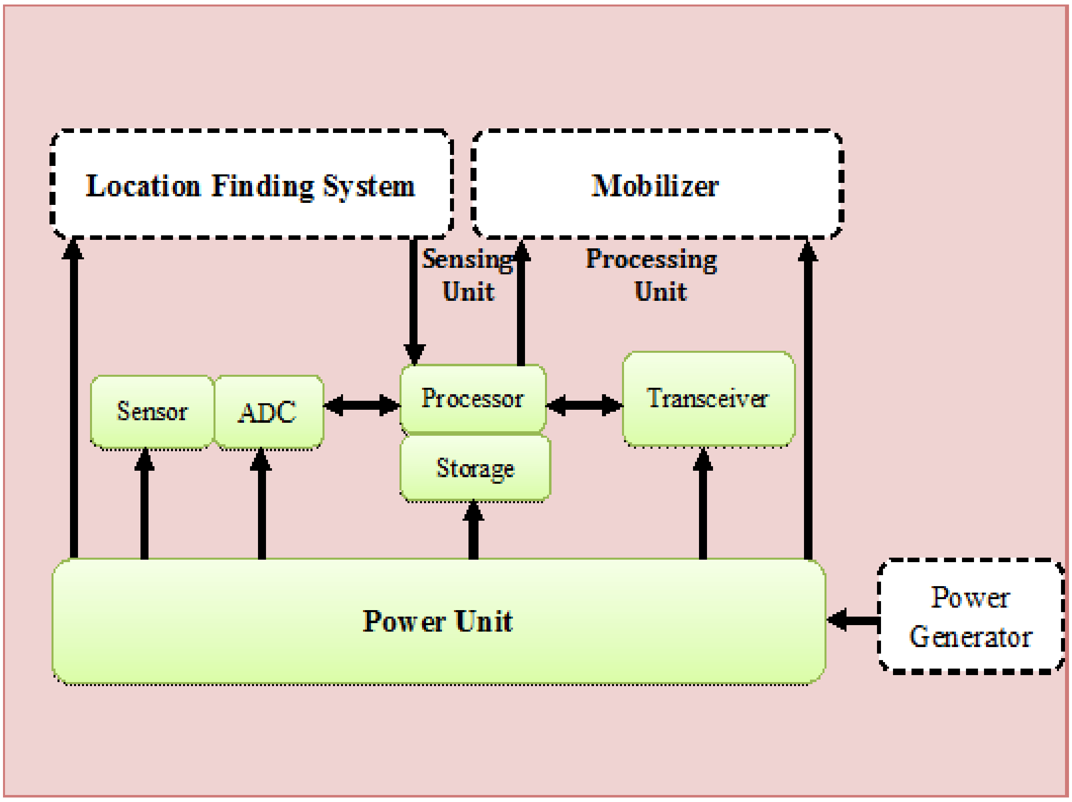


Figure 2: Configuration sensor node [3]

1.3.1 Sensor Node (SN)

An SN is a device placed in a particular environment to control and monitor events. It has the ability to detect and respond to any type of input according to the design of the SN. Inputs are light, heat, motion, humidity, pressure or any other type of environmental phenomena that needs to be controlled and monitored. This sensor sends a signal that is converted to a display that humans can read. The sensor is in the location and takes the appropriate measures to avoid disasters and environmental accidents [1, 2].

Any SN usually consist of four main components, as illustrated in Figure 2: sensing units as this unit contains a sensor and (ADCs) Analog to-Digital Converters, where the sensing unit has the ability to sense any particular phenomenon on contact. After analog signals are converted to digital via (ADC) and introduced into the processing unit, a second component of the components SN, the processing unit associated with the embedded operating system and has a small portion of the volume. The processing unit implements a wide range of specific application tasks. The transceiver unit is the third component of the SN, which binds to the sensor network node. The transceiver module is responsible for the transmission and reception of data from any node to any other or to the BS. The fourth component of the SN is a power unit, which is responsible for energy delivery to each part of work [3].

There are various types of hardware implementation of SN, one of which is shown in Figure 3.

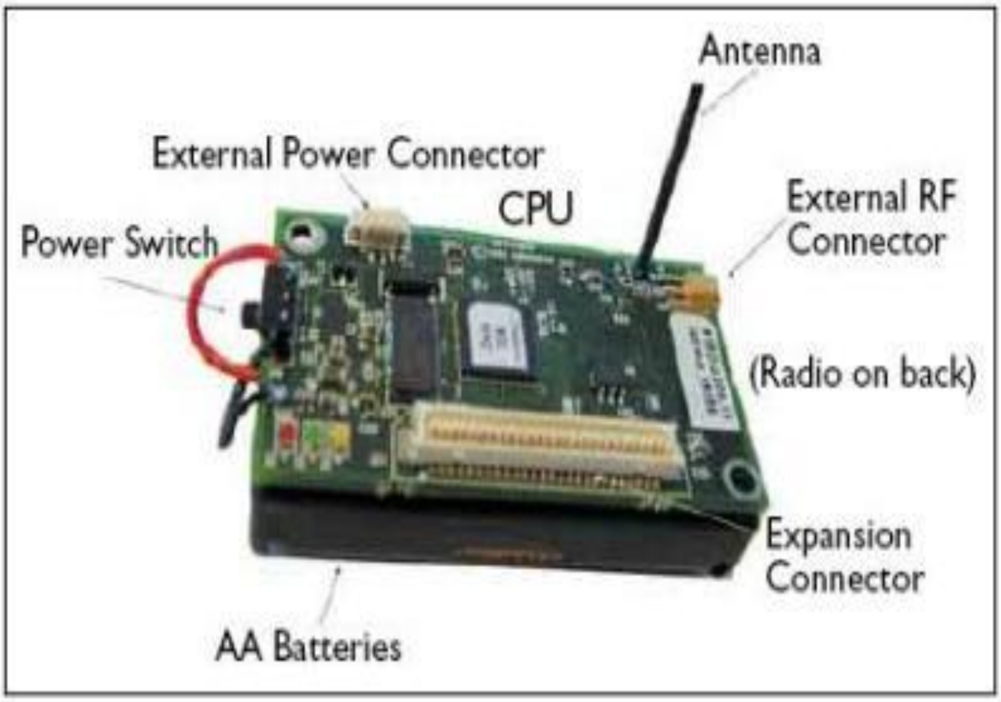


Figure 3: Example of sensor node, MICAz 2.4 GHz Mote module

1.3.2 WSN Operating System (OS)

The OS in WSNs is a slightly different design than that of traditional OSs because of limited characteristics such as limited power supply and high dynamics that cannot be accessed. The main functions of the OS do not appear as low-level details of the SN by providing the interface for more clarification to the outside world. These low-level details offered by the OS include the processor and memory management, device management, and policy and scheduling. The OS has threading and multiple tasks. In addition, it also provides services. The selection and design of a suitable OS WSN according to the requirements of the application that is selected to design the ideal OS. The OS of the WSN must be designed to take into account the challenges imposed on it during the design; for example, energy management and the application programming interface (API), dynamic loading and unloading of modules and appropriate synchronization mechanisms. A WSN works on two levels; firstly in linking and routing, and the characteristics of the channel of communication protocols and others. The second level node includes radio, CPU, sensors and limited energy also in addition to relating to the management of limited resources, energy management and memory. These issues should be taken into consideration when designing the level of the OS in the WSN [4, 5].

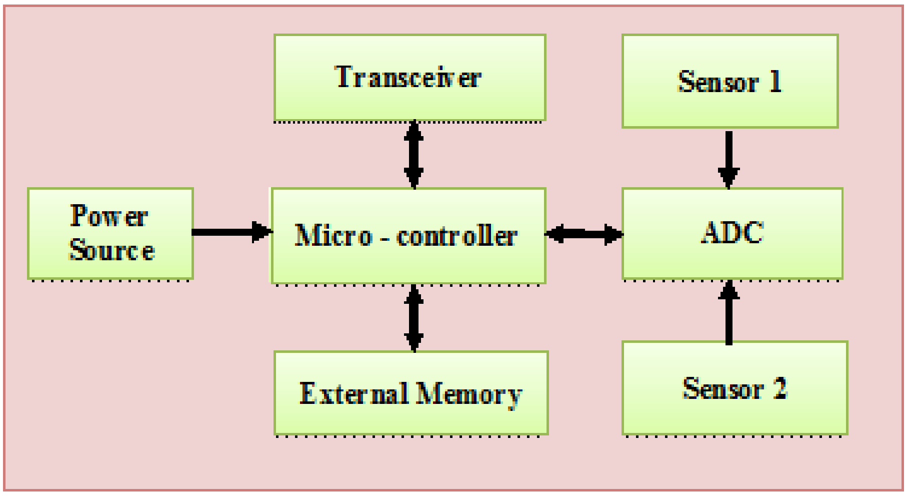


Figure 4: Sensor node architecture[4]

1.4 Usage of WSN

1.4.1 Disaster/Crime prevention and military applications

In 2001, when the terrorist attacks raised fears about safety, research related to sensor networks to detect crime and security problems and the prevention of terrorism was published. Moreover, we saw the intervention of sensor network applications in many areas where they, for example, can be placed at intersections of main roads to detect terrorist attacks and other events of concern regarding safety and security in the world [4].

1.4.2 Environmental applications

WSNs used in the field of environmental applications are large. For example, they are used to monitor environmental changes in the oceans, monitor floods, plains and the level of precision in agriculture. An example is the Glass Web, which is used to monitor glaciers in order to monitor changes. Furthermore, they use sensors to monitor and follow wild animals [4].

1.4.3 Health applications

Sensor applications are found in the field of health and medicine where medical surveillance, remote from physiological data and control of doctors and patients in the hospital, can also be used as sensors to monitor a wide range of patients continuously at all times. Remote medical surveillance enables doctors to diagnose patients quickly and accurately and give them proper treatment [4].

1.4.4 Smart spaces

Home automation and smart environments are designed to create the intellectual space with a large number of networked sensors. Smart is a research project, which uses sensors in the goods that we use in everyday life. Instead of bar codes, where human interaction is necessary, the creation of autonomous sensor networks allows for the position and quality of goods to be detected in order to achieve automatic control. Monitoring inventory management, vehicle tracking and interactive museums are in this category [4].

1.5 Challenges and Design Issues

One of the important issues to be taken into account when the OS for WSN design level, where it is working two levels, the network and the node. The level of importance of the network is linking and routing and the characteristics of communication protocols and the other channel. The importance of the level of the nodes are devices, radio, CPU, sensors and limited power. Important issues associated with the level of the nodes are limited resources management, in addition to dealing with synchronization, power management and memory management [5].

1.5.1 Restricted resources

The SN model, as in Figure 4, of the resources available restricts the limited energy, memory, processing capacity and bandwidth. These resources must be taken into consideration during the design because these are important and necessary issues. We review the restricted resources with an explanation for each, as in the following [5].

1.5.1.1 Battery power

EC is necessary and important in life-based WSN applications. More applications in WSN prolong life that ranges from days and years. Therefore, a typical node with limited energy supplies needs to last mostly for months or years. Conventional systems do not need a power supply, or they are not taken into consideration, as in WSN. When we are building a system, WSN must be taken into complete consideration as the source of energy such that the power source is a battery that must be maintained to reduce energy consumption. This is the only source for the survival of the node sensor; therefore, one must conserve energy and presented more scenarios regarding the reduction of energy exchange because of its impact on the continuation of the life of the network. More EC during a connection is compared with the account and remote sensing.

The cost of energy to transfer data through the RF channel is nearly equivalent to the implementation of thousands of instruction; for example, the reading, writing and storing of these processes consume a large amount of energy. Therefore, the operating environment overheads that consume energy during the loading and unloading of the memory modules should be taken into account. For this reason, the OS must provide the mechanics of preparing for the consumption of energy in the best way to extend the life of the network. A periodically sleeping SN is considered as a means to help save energy and reduce consumption [5].

1.5.1.2 Processing power

SN has a processing power for which one must determine the true account of the dates of intensive operations. Otherwise, high-priority tasks are delayed Calculation models, such as event-driven ones, follow to complete the form. The processor takes longer if the task is turned for a long time and this leads to preventing other functions from waiting for a longer period, regardless of priority. The OS must have a proper processor scheduling and be and in accordance with the priority of jobs [5].

1.5.1.3 Memory

One of the important resources in the sensors and controllers in small devices includes mica, in addition to some of the micro-controller units such as (nymph, EYES, etc.). Memory may vary in size and capacity. Memory is one of the major constraints faced by WSNs and is developed to allow for OS harmony with this memory. The system software must fall within this memory use and be used optimally, beginning from the lowest level, which is the OS. The SN mechanism has non-volatile external data storage [5].

1.5.1.4 Bandwidth

A channel model RF is used for communication among nodes within the network and there are several criteria to determine communications. For example, ZigBee is a standard for the identification of an emerging communications protocol stacked on the basis of a physical-layer and linking the current data. The wireless standard rarely used in WSN has been IEEE 802.11 (Wi-Fi), at a data rate of nearly 54 Mbps. PAN consumes low energy and is now used on a large scale in the SN. It works in various media in order to preserve energy. The Bluetooth RF transceiver consumes more energy to switch between the two modes [5]. Table 1 shows the available standards for wireless communications in WSNs.

Table 1 Wireless standards

Range	Data rate	Standard
300 m	**39 kbps**	**CC1000**
100 m	**256 kbps**	**802.15.4 (PAN)**
1m to 100 m	**up to 3 Mbps**	**Bluetooth**
45 m to 90 m	**54 Mbps**	**802.11 (Wi-Fi)**

1.6 The Purpose of the Study

There are numerous studies on, and many ways one may discuss how to reduce energy consumption in a WSN. Since batteries are the only power in a WSN, the power source is of limited capacity. The battery is the main source of the SN, which faces the WSN. It is impossible to re-charge the battery or replace it. Therefore, more research and studies had been made during the previous period in order to conserve energy and use energy more efficiently so that the network can prolong its life for as long as possible. One must develop new algorithms for energy saving and efficiency. Here , we offer a new algorithm and use a new method to conserve energy and reduce consumption, and thus prolong the lifetime of the network.

1.6.1 Scope of the study

We have a BS, and hundreds or thousands of nodes spread randomly. These nodes may contain groups called clusters. Each cluster includes a group of the nodes in accordance with an algorithm. Each cluster selects a "node" called the CH which is responsible for data collection and data compression from the remaining nodes, after which it is sent to the BS.

1.7 Problem Definition

The energy used in a WSN is not yet efficient. There are many studies that are attempting to formulate an algorithm that includes better usage or savings of battery energy of the nodes.

Therefore, we are going to apply a new algorithm for the clustering of the WSN to optimize the efficiency of the use of battery power.

1.8 Expected Results

We expect good results through the creation of a new algorithm designed to lower the EC and extend the lifetime of the network compared with some previous algorithms.

1.9 Research Question

We proposed the following scheme to obtain more efficient energy usage:

1- Limiting the number of nodes in each cluster, which results in a better node distribution in each cluster as well as decreasing the load on the CH of the cluster.

2- Nodes that are close to the BS are directly connected with it without imposing them onto any cluster. This will decrease the load on a CH.

3- Select the head node within the cluster depending on several parameters, not only one parameter as found in previous work. Parameters may include energy level, position in the cluster, etc. Moreover, we are going to use between nodes an algorithm which has the same average of the required parameter to be the head node.

4- Select a subset of the wireless sensor nodes as CNs. This depends on three parameters: neighborhood, energy level and distance. As a result, we have determined the CN and this node can be exchanged with the CH in the event of low battery and this helps to extend the lifetime the network.

In this work, we propose to be able to achieve:

- An increase of the long-life of the CH by specifying the number of nodes which belong to it.
- An increase in the efficiency of the cluster WSN.

1.10 The Aim of This Thesis

The aim of the thesis is to find the best way to lower battery consumption and extend the lifetime the network by using a simulation, thereby representing how to calculate, study, read and analyze the results.

1.11 Organization of the Thesis

This thesis contains five chapters that discuss WSNs. Moreover, it discusses some of the challenges and issues facing sensor networks and all the necessary information about efficient energy to prolong the lifetime network, which will be listed in the thesis and according the chapters:

Chapter 1 presents a review the about WSNs and the concept in general, their usage, contents and the challenges of operating system design issues. Additionally, it presents the scope and purpose of the study, an identification of the problem and the aim of the thesis.

Chapter 2 reviews the protocols used in WSNs and the protocols that are based on the network and study with examples and a review of previous studies that are relevant to the topic of the thesis.

Chapter 3 discusses the design protocol, i.e., the new algorithm that we have proposed. This chapter is the core of our research, where a full description of the proposed new algorithm is given.

Chapter 4 discusses the proposed method of the network model with a presentation of the results and compares them with previous algorithms.

Chapter 5 presents the conclusion.

CHAPTER 2

THEORETICAL BACKGROUND

2.1 WSNs Routing Protocol

WSNs consist of a small number of the nodes which sense, calculate and have the ability of a wireless connection. Routing, power management and dissemination of data protocols include the design specifications for a WSN in order to know the energy of the fundamental issues and the importance of the design [6].

In this chapter, we review the study of routing techniques and also the design of routing protocol challenges in WSN. Routing protocols differ from, and depend on, applications and network architecture [6, 8].

In general, routing protocols can be divided in WSN according to the structure of the network, which in turn is classified into three categories: flat, hierarchical and location-based, all of which depend on the system architecture in the network. This will be touched upon in detail later with examples of each type. The second division is protocol operation, which can be divided into five sections: Negotiations, Multipath, Query, QoS and Coherent [6, 9], as in Figure 5.

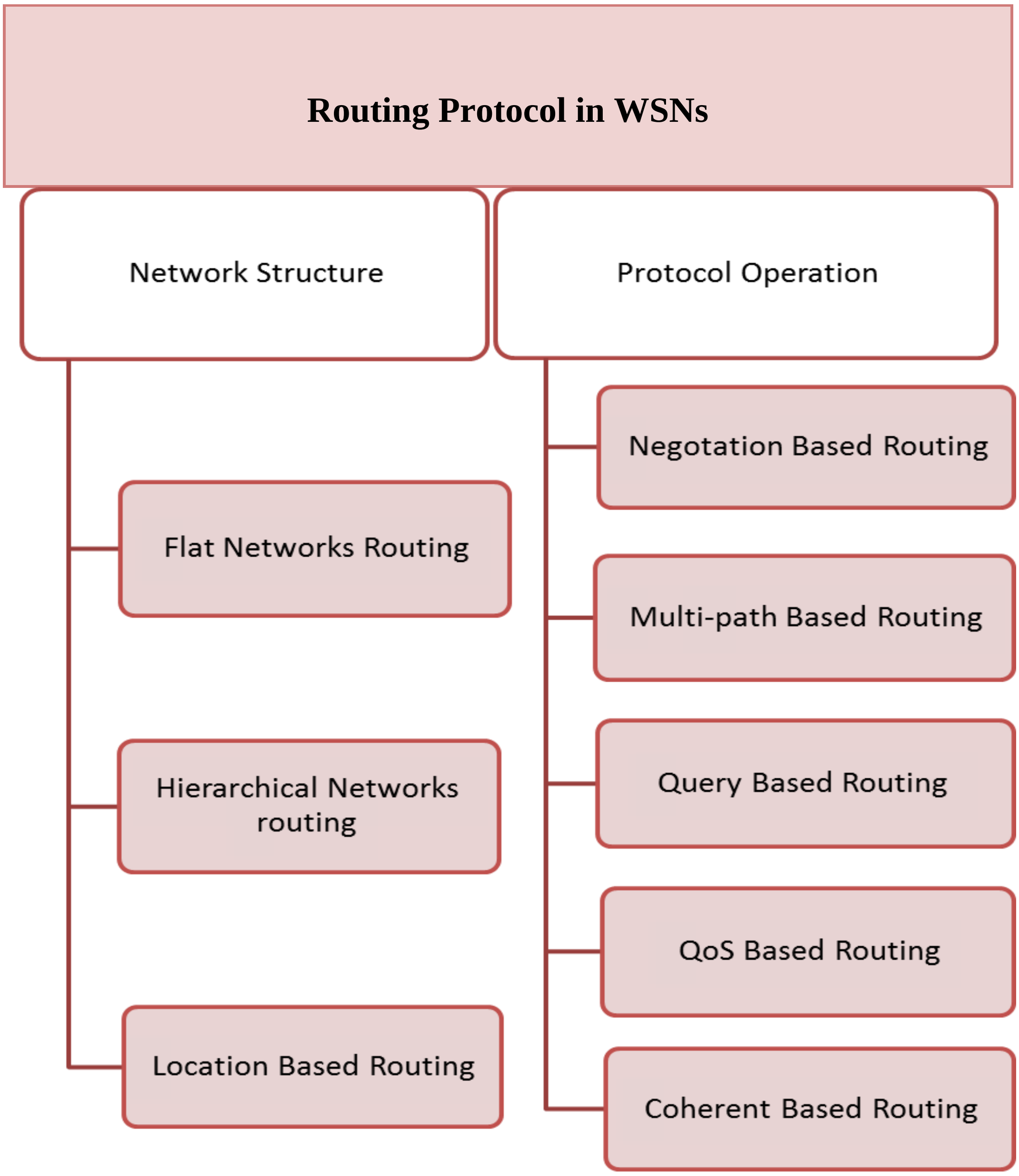


Figure 5: Routing protocols in WSN[6]

2.2 Applications of Multiple Routing Protocols

WSN is used in various applications in military, civilian and industrial fields. Researchers are trying to adopt sensor network technology to problems that are hard to solve with conventional wireless networking [18, 19].

Some examples include the following:

1. Environment monitoring including monitoring remote terrain, air, soil, water and detecting hazards. Sensors are deployed to analyze the motion of tornados as well as fire detection in a forest in remote locations.

2. Military applications including tracking battlefield surveillance, intrusion detection, target fields and imaging. Sensor networks detect locate or track enemy movements.

3. Civilian applications include environment and habitat monitoring and tracking, such as health applications, home automation and traffic control [20].

2.3 Network Structure Based Routing Protocols

Routing protocols have an impact on, and are highly effective, in sensor networks. Network construction based on the protocols of job issues and challenges in the design of WSN prolong network lifetimes and download energy balance among most sensors in the network. These challenges include deployment nodes, data collection, coverage, dynamic network, etc.. Therefore, protocols must be able to process the challenges of network traffic, including node mobility and node failures. Additionally, the design of an energy efficient protocol must balance the energy load to prolong the life of the network [10].

2.3.1 Flat Routing

This is one of the multi-hop routing protocols where every node within the network has an important role in the implementation of the task of sensing through its participation with other nodes. This protocol adopts a data-centric approach because it contains many of the nodes that are not appropriate to set a universal identity for each node. Therefore, the BS sends a query to some areas and waits for data from the sensors in the determined areas. Where data are requested by inquiries and name based on the essential feature to determine data attributes, we can find a wide range of protocols [6]. All the nodes in a network of sensors have equal roles in the collection of information and the same information.

Examples of this type include Directed Diffusion, Spin, Rumor routing, Minimum Cost Forwarding Algorithm, Gradient-Based, Cougar, and Acquire. We will study two examples: the flat Protocols SPIN and SEER [7].

2.3.1.1 SPIN (Sensor Protocol for Information via Negotiation)

The SPIN protocol was suggested by Heinzelman and others. This is the use of data and resources and negotiating technique of adaptive algorithms. Information is disseminated on each node in the network, where it is assumed that every node in the network may be from a type of wireless sensor, such as BSs.

This protocol allows the user to request access to information from any node in the network as every node has the same information, thereby enabling the user to obtain the information required since every node has the same neighboring data [7].

2.3.1.2 SEER (Simple Energy Efficient Routing)

The SEER routing protocol is energy efficient for sensor networks and for the efficient use of energy in WSNs. This protocol achieves efficiency by reducing EC. This protocol depends on a number of hops in the routing based on the distance to the BS, where the BS is in the center of the network with the nodes uniformly distributed around the BS. This proposed protocol achieves efficiency in reducing EC [7].

2.3.1.3 Problem associated with flat routing protocols

This protocol carries out actions that consume energy of a wireless node's battery such as, network setup and detecting neighbors, transmitting new data, shipping data and updating energy and maintenance of the network. Challenges to and issues of this process include calculating the energies using a radio model according to the distance between nodes and removing dead neighbor nodes from the table. During network maintenance, every node in a network should maintain the information of the entire network [7].

2.3.2 Location Based Routing Protocols

This is one of the routing protocols based on sensor locations in addition to processing sensor locations by the distance between adjacent nodes on the basis of the signal strength recipients [6]. One may obtain the required information or the exchange of information from the neighbors [11, 12, 14]. The node locations can be identified by satellite using GPS, which is used to determine those locations and contact it [13].

This protocol is based on location, and in order to reduce EC, the node must go to sleep in the case of any activity according to the sleep period tables for each node in a localized manner. This can be obtained by reducing EC and by increasing the number of nodes that go to sleep in the network [13]. We study two examples of location based routing protocols: GAF and GEAR.

2.3.2.1 GAF (Geographic Adaptive Fidelity)

This algorithm or protocol is based on location and is designed mainly for mobile networks. Additionally, it can enter sensor networks in order to determine the SN location that uses the GAF protocol for GPS. This protocol includes three cases: discovery, activity and sleeping. The Protocol forms a virtual network and divides the network area into fixed locations within each place. The nodes play different roles and cooperate with each other. Moreover, an SN is selected to be awake for a given period of time, while the other nodes sleep. The selected node is responsible for monitoring and reporting the data to the BS on account other nodes in the region [13].

2.3.2.2 GEAR (Geographical and Energy Aware Routing)

This protocol is one the routing protocols that is based on location and uses geographic information during the deployment of queries for the allocation of regions because data queries include geographic features [6]. The main concept is to reduce the number of interests in direct diffusion expressions except through the appointment of a particular area of interest and sends them instead of sending them to the entire network. Thus, this protocol can save more energy in the directed diffusion.

2.3.3 Hierarchical Routing

Hierarchical routing depends on the cluster and has special advantages in WSNs and the efficiency of communications. In this way, the idea of hierarchical routing is used for routing efficiency in energy use in WSNs, which thus extends the life of the network [16]. Hierarchical routing in reducing EC is used by forming groups within the network.

Hierarchical routing depends on the formation of groups leading to a reduction of EC in the network by reducing the number of emissions and by transferring data and messages from the nodes to the BS. The network is divided into groups in which each cluster is elected CH of the clusters. Building clusters and groups in sensor networks leads to extending the network lifetime and efficiency in the EC. Hierarchical routing is based on two levels: the first determines the CH and the second level is used for routing [17].

2.3.3.1 Hierarchical clustering

Hierarchical cluster divides the network hierarchically into levels within the network. The network is divided into groups, and the goal of the network division is to reduce EC and to extend network lifetime by forming clusters, where each cluster includes a group of nodes. Each cluster elects a suitable node to become the CH, which is responsible for data collection from nodes within the cluster. The CH compresses and sends a packet to the BS. In this chapter, we reconsider a set of hierarchical routing protocols in WSNs. For example, we take a model of hierarchical algorithm as the LEACH protocol [24]. Figure 6 shows the cluster-based hierarchical model.

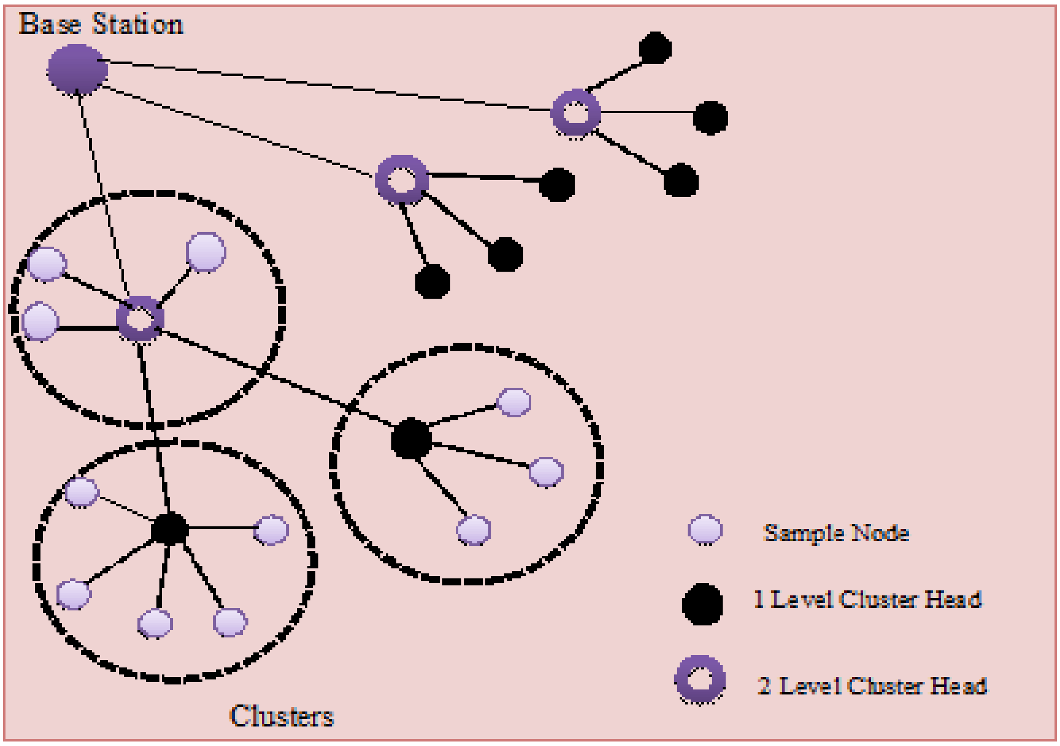


Figure 6: Cluster-based hierarchical model [8]

2.3.3.2 Challenges of clustering

There are significant challenges facing designers of WSNs which must be taken into account when being designed particularly for WSNs. These challenges [8] include:

• Cost clustering.

• Choosing the CH from clusters.

• Processing in real time.

• Synchronization.

• Data collection.

• Repair mechanisms.

• QoS.

2.3.3.3 LEACH (Low Energy Adaptive Clustering Hierarchy)

The LEACH algorithm, which depends on clusters, was discovered by Heinzelman and is one of the important algorithms known in the field of hierarchies in WSN. The LEACH protocol works to reduce EC in the WSN to a large extent compared to previous protocols through the use of clusters in the reduction of energy between the SNs that are evenly distributed so that every node allows for the possibility of prolonging the lifetime of the network. This algorithm depends on the deployment of SNs in a particular area. LEACH divides the network into groups called clusters. Each cluster selects one node representing the chief role and known as a CH. The remaining nodes within the cluster linked to the CH. The CH is determined through random selection and rotation so that in each round determines the CH again. The CH is responsible for collecting data and information from the remaining nodes within the cluster. Not every node can send or receive data only by CH. A CH compresses data, information and sends it as a package to the BS. After processing the data from the BS and before being returned to the CH, it recreates the data to a node within the cluster [24]. The following equation is used in many papers.

$$T(i) = \begin{cases} \frac{p}{1 - p \times \left(r \bmod \left(\frac{1}{p} \right) \right)} & \text{if } i \in G \\ 0 & \text{otherwise} \end{cases}$$

Each sensor has the probability value to be a CH. Each node determines a random number within a period of (0,1) and compares the value with the value of the equation. Through the above equation, it can be determined CH [24,36].

Since sensors in networks are energy constrained, the lifetime of these networks has become a major concern. In order to prolong the lifetime of networks, CHs should be richer in resources than other simple nodes. Therefore, intra cluster communication costs will also decrease due to richer CHs [24, 36]. LEACH is divided into two phases:-

2.3.3.3.1 Setup phase

When this phase begins, each node in the network will elect itself to become the CH. After identifying itself as the CH, the other nodes begin to organize themselves to link to the best CH or to the closest (usually the closest CH) [24].

2.3.3.3.2 Steady state phase

This phase is responsible for data collection and transfer to the BS [24], as seen in Figure 7.

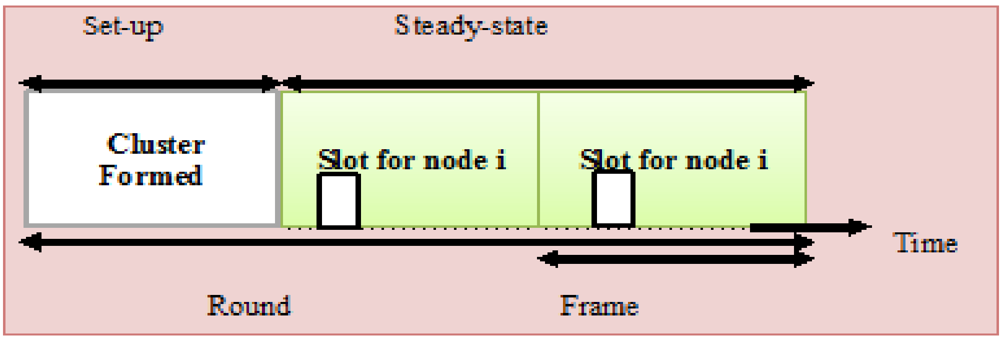


Figure 7: LEACH operation [17]

2.3.3.3.3 Advertisement phase

During this phase, each node within the network elects itself to become the CH for the next round. Each node sends information about itself to the CH team randomly for the current round where the CH elected in the current round cannot become CH for the next round because of the current round message announcement broadcast that it became CH. The remaining nodes, after hearing the announcement, organize themselves to the nearest CH and connect to it and rely on the strength of the announcement contained as a reference. The node that is not the CH must keep their receivers until the announcement of the set up phase. It uses an energy transfer announcement message transfer using an energy fixed Carrier Sense Multiple Access (CSMA) MAC protocol. Figure 8 shows the selected CH [24].

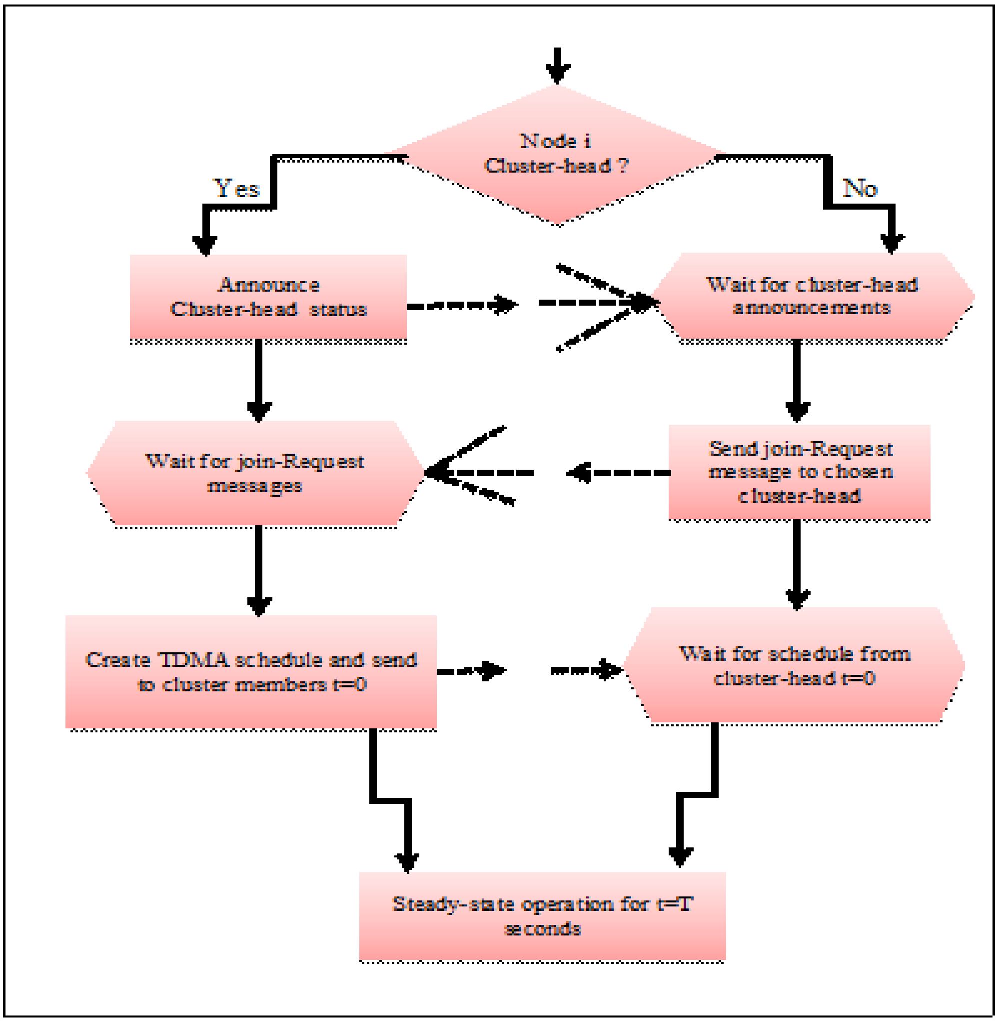


Figure 8: Algorithm cluster scheme formation distributed LEACH [25]

2.3.3.3.4 Cluster setup phase

After selecting the CH, the remaining nodes begin to organize themselves within clusters such that each group of nodes chooses the best CH, and this node becomes a member within the cluster. Each node transfers information using a CSMA MAC protocol to the CH [24].

2.3.3.3.5 Schedule creation

The CH is responsible for the creation of the schedule (TDMA), which receives data and information from the remaining nodes to prevent collision. The CH broadcasts the schedule to every node within a cluster to determine when each node has the right to send data and information [24].

2.3.3.3.6 Data transmission

The CH creates a schedule within each cluster for the transfer of data (TDMA), where the node itself begins accession to the nearest CH belonging to it. Any node within each cluster would be unable to transmit data or information without the consent of the CH. The CH configures the schedule by which a node is able to send data or information by sequencing within the schedule. Where time is allocated for each node through this time, it can send data and information to the CH. The transmitter inside cluster one between the nodes and the CH needs a very small amount of energy, thereby leading to reducing power dissipation in this node. The CH collects data, compresses them and sends them as a package to the BS [24].

2.4 Energy Consumption (EC) Reduction WSN Routing Protocol

Reducing the EC is one of the important and necessary challenges facing WSNs and is a great challenge for designers of networks. SNs have a single source of energy, a limited battery power, and they cannot recharge the battery or be replaced, especially in hostile environments; therefore, they must execute protocols to ensure the largest possible reduction of the EC of the battery as much as possible. Therefore, the designers of networks should take this into consideration to reduce EC guarantee good performance [18].

2.4.1 Importance of EC with benefits

The development and growth of wireless communications technology, where it has become small-scale, low-cost and low energy, has led to it playing an important role in multiple functions [22, 23]. Routing protocols in WSNs and limited requests have led to the development of a variety of protocols [20]. WSNs consist of a set of SNs that have limited energy. The battery is considered the only source of energy, and it is impossible to be replaced or re-shipped especially when deployed in hostile environments. Limited energy batteries, deploying data and bandwidth are considered some of the challenges to routing protocols in WSNs. Therefore, it must reduce EC in a sensor, which leads to an extended lifetime in the network for as long as possible [18].

2.4.2 Evaluation metrics of EC routing protocol

We propose the following to obtain a more efficient energy usage scheme by limiting the number of nodes in each cluster, which results in better node distribution in each cluster as well as decreasing the load on the head node of the cluster. This make the neighbor nodes of the BS connect directly to BS without imposing them onto any cluster, thereby decreasing the load on a CH. Selecting the CH within the cluster depends on several parameters, not only one parameter as seen in previous work, including parameters such as energy level, distance. Moreover, we will use the algorithm between nodes, which have the same average of the required parameter to be a CH. This is determined by a subset of the wireless sensor nodes as candidate nodes. They depend on three parameters: neighborhood, energy level, distance. We have determined the candidate node and this node can be exchanged with the CH in the event of low battery CH and in this way, it helps to extend the lifetime of the network.

2.5 Literature Survey

2.5.1 LEACH-C (Low Energy Adaptive Clustering Hierarchy Centralized)

The author [25] proposes LEACH-C to improve LEACH by choosing the best cluster based on a central node to identify a cluster where every node sends information about itself to the BS. The information required includes location and energy level for each node. After arrival of the information, the BS distributes the power load evenly among all the nodes. The BS computes the average energy and then compares energy levels. If the level is below average, the node cannot become a CH. This algorithm yields the best results from LEACH [26].

2.5.2 PEGASIS (Power Efficient Gathering in Sensor Information Systems)

In [27], the author proposes PEGASIS to improve LEACH. PEGASIS is formed through a series of SNs where they are transferred to every node which is received from one of the neighbors which selects only one node from the series through which it sends data to the BS. Data traffic is collected from one node and is then sent to the BS. The construction of the series in a way greed. The protocol uses multi-hop routing through the formation of chains. The PEGASIS protocol increases energy saving when compared with LEACH.

2.5.3 TEEN (Threshold Sensitive Energy Efficient Sensor Network)

In [28], the TEEN algorithm uses the mechanism of a central database. After a cluster is configured based on the thresholds where it includes hard and soft thresholds, the CH broadcasts threshold values to each node, which can change the values and be tuned so as to control the number of transfer packets. The transmission of data from the node to the CH requires access to a threshold value, and this leads to a reduction of the number of transmissions. Therefore, it is considered inefficient because it cannot send reports periodically and continuously and thus cannot obtain the required data as there are thresholds that reduce the number of transmissions [29].

2.5.4 APTEEN (AdaptiveThreshold Sensitive Energy Efficient Sensor Network)

This is a prolongation of the TEEN algorithm. The aim is to capture all of the data and the periodic reaction to the events critical to time collection. The architecture is identical to TEEN. When the BS forms into clusters, the CHs are responsible for the broadcast properties, schedule the threshold values and determine who will send them to every node and perform data collection. This algorithm supports three different types of query: analysis of previous data values, taking an overview of the network, and continuing to monitor this event for a while [29,30].

2.5.5 HEED (Hybrid Energy Efficient Distributed)

The author suggested the HEED algorithm to prolong the life of the network. Selecting the CH is carried out through the use of criteria measurements. The first measurement depends on the residual energy and the second measurement is based on communication cost. In the HEED protocol, each node decides whether the node will elect to become a CH or join the cluster by calling the clustering process [31].

2.5.6 SEP (Stable Elections Protocol)

In [32], the stable election of a sensor model was used. In this model, the nodes become CHs. The node analyzes and aggregates the information and sends it to cluster members followed by transmitting this data to the BS. In their model, sensors are heterogeneous and the population of nodes is changed with the energy of sources thereby saving much energy.

CHAPTER 3

PROTOCOL DESIGN

3.1 Description Of Proposed Algorithm

In this thesis, we suggest a Hybrid Structures for Efficient Energy Management (HSEEM) algorithm. HSEEM is based on rounds where in each round contains a setup phase, which we call the (deployment phase) and a steady-state phase, which we call the (sensing phase).

3.1.1 Deployment phase

In the deployment phase, the wireless sensor node is grouped into clusters or connected directly to the BS depending on their positions and energy levels.

1- Neighbor nodes of the BS which are within its range are designed to be connected to the BS directly without involving them in clusters. The benefit is a decrease of the load on the CH in a cluster.

2- Selecting a subset of the wireless sensor nodes as CN depends on three parameters: neighborhood, energy level and distance.

3- Logic clustering is the logical grouping of the wireless sensor nodes.

After selecting the CH, the BS decides on which CH the remaining nodes would be connected depending on the average distance between the CH and MNs.

To select a CH following steps are followed:

i. Placing the sensor node

ii. Selecting the ACH

iii. Selecting the CH

iv. Clustering process

v. Remaining nodes selected as MNs

vi. Sensing information from the MNs and sending to the corresponding CH

vii. Transferring information to the BS from the CH.

Pseudo code 1: The main HSEEM algorithm

```
1   SETUP ( )
2   SNs send information :
    its current location (physical group, distance, energy level, number of hops) to
    BS.
3   Determining CN
4   Determining CH
5   Determining flat nodes
6   Determining good clusters
    unicast the information to the nodes to inform them which are the
     - Cluster Head CH
     - Candidate Nodes CN
     - Member Nodes MNs
     - CN is subset of MNs
7   MNs send data to CH (transmission uses a minimal energy)
8   END
9   CH performs data aggregation
10  aggregated data is sent to BS (transmission takes high energy)
11  IF (all CN residual energy < the threshold value)
12  new rounds without re-clustering (Logical grouping)
    just select (CH and CN) for same MN using HSEEM.
13  END
```

3.1.1.1 Wireless sensor nodes mobility

When a node is joined to the network or to a cluster, it first sends a hello message to discover its neighbors. When the BS is within its coverage area, it connects directly to it. Otherwise, it should connect to the CH by using wireless Ad-Hoc style. In the next round, the new node is taken into account to calculate whether it should be CH, CN or MN.

Pseudo code 2: The mobility algorithm

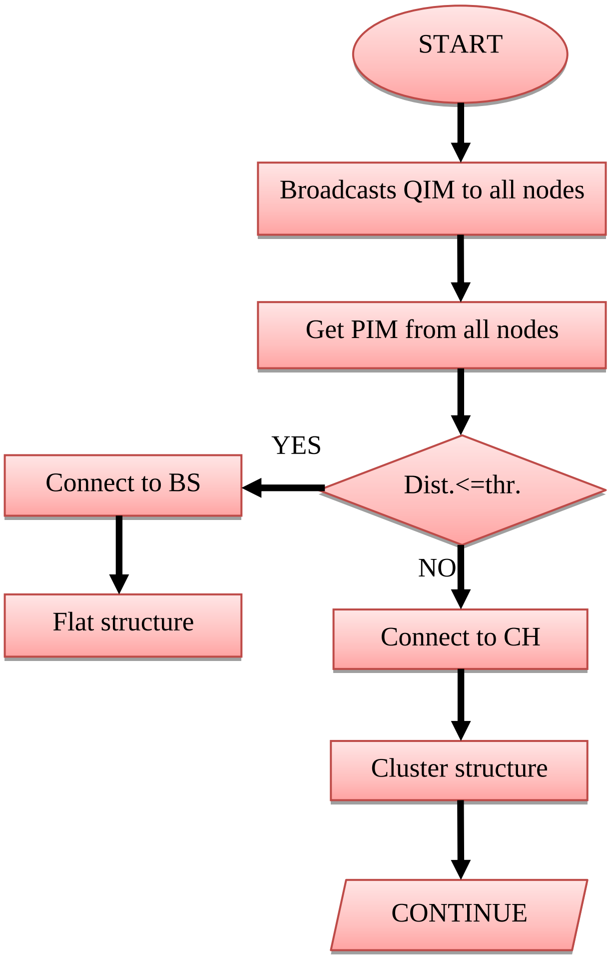
```
SETUP ( )
new SN arrived to the network
hello messages exchange,  neighbors nodes discovering.
new SNs send information about itself.
   IF get reply from the BS
       {
           send request message to the CH
           connect is done
       }
   ELSE
       {
           send request message to the CH
           get the path to the CH
           joined to the cluster.
           new around
           send its information to the BS Its current location (physical group,
           distance, energy level, number of hops) to the BS.
           selected as CH, CN, or MN
       }

END
```

3.1.1.2 Determining flat / cluster nodes

Any node in a wireless network periodically sends a hello message to discover its neighbors. Each node replying to the hello message means they are neighbors. Therefore, when the BS receives a hello message, it will deal with it as it is a flat structured node without involving it in a cluster.

Pseudo code 3: nodes structuring algorithm and the flowchart

```
1  SETUP ( )
2  node changed its position
3  neighbour discovering send hello message
       IF
          4 BS received the msg.
             {
                5 connect to the BS
             }
       ELSE
             {
                6 connect to the CH
             }
7  END
```



3.1.1.3 Determining CH and CN

HSEEM applies a selection algorithm to the CH in the deployment phase, where it leads to separate the entire network into a number of clusters each with one CH and a set of CNs. The selection of the CNs leads to determining the CH, which has the best value to compare with the other nodes in the CNs. We used multiple parameters that calculate the best node to be the CH as it plays an important role in balancing the energy load of the CH, thereby extending the life of the WSN. The parameter is used to calculate the CH which is based on energy levels, distance and the neighborhood.
We are going to study each parameter separately as will be mentioned later and we will see how the every parameter is interacting. The parameters to be used are:

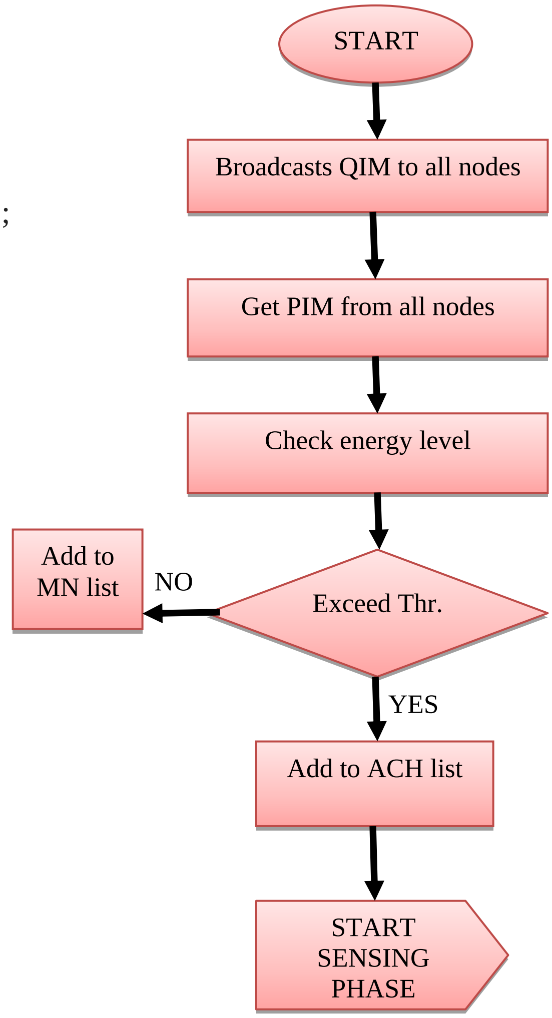
3.1.1.3.1 Energy parameter

At the beginning of each deployment around the BS, the BS broadcasts a QIM to the every sensor node in the region around the BS. Every node receives the QIM, which will immediately reply by sending a PIM. The PIM includes the required information for each node, including energy levels, IDs and paths to the BS.
The node sends its residual energy level via PIM when the residual energy exceeds the threshold of minimum energy which allows the node to be a CH. In this case, it will be added to the ACH list; otherwise, it will be added to the MNs list.

Pseudo code: ACH node algorithm and the flowchart

```
SETUP (threshold)
BS broadcast QIM
ACH_LIST is empty
MN_LIST is empty
i number of nodes in the network
FOR (i=0, i<n, i++)
    {   reply  PIM;
```

```
    {
        IF
            {
                residual energy > or = energy threshold
                ACH_LIST ++;
            }
        ELSE
            {

                MN_LIST++;
            }
    }
}
CONTINUE
```



3.1.1.3.2 Distance parameter

There are two ways to correspond the node distance. The first way is by considering the number of hops between two nodes. If we consider that every hop has the same weight or cost; this calculation would, specifically, be in the network layer. The second way is to calculate the distance to a node by measuring the strength of its received signal, whereas the radiated original signal strength of the nodes is known;

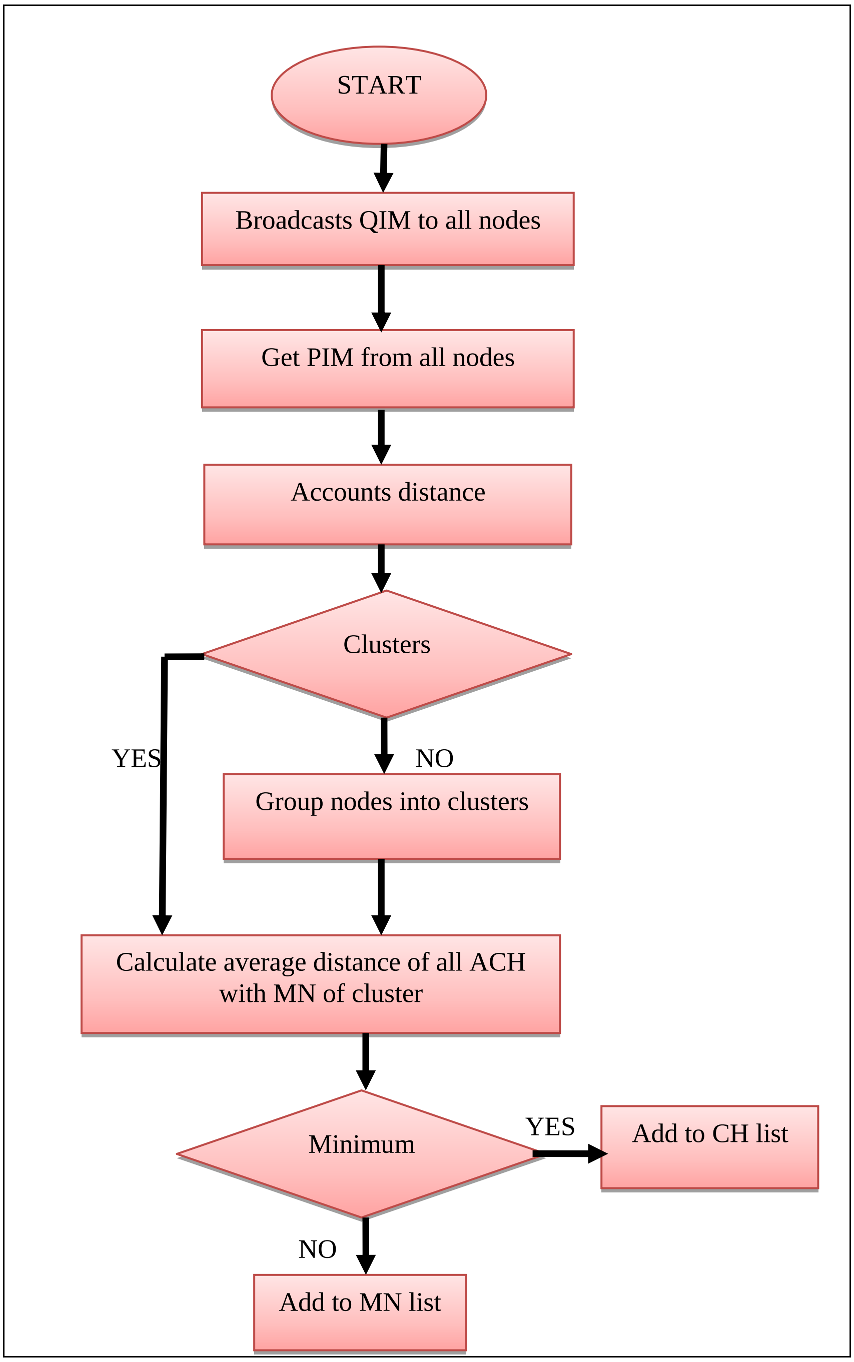
this method is carried out in the MAC layer. We have considered the fact that the distance is the first method as mentioned above. The cost of each hop is equal to one. Each node sends PIM messages to its neighbor to be forwarded to the BS. Whenever a node forwards the message, it includes the full path to the BS if it is available; otherwise, it will broadcast the PIM to its neighbors and add the next node in the path table of the packet header of PIM.

In this way, the BS knows the path for each node belonging to its network, namely the number of hops corresponding to the distance in our approach.

Pseudo code; Distance Algorithm

```
1  SETUP ( )
2    IF
         3 CH_LIST is empty
            network divided for two phase
            {
               4 set ACH = nearest sensor to CH values;
               5 divides WSN into groups;
            }
         6 MN = all cluster nodes
         7 BS broadcast QIM to MNs;
     ELSE
            {
               8 BS unicast QIM to CH && to flat node;
               9 CH broadcast QIM to its MNs;
            }
10 FOR (c=0, c< number of cluster, c++)
      {
         11 FOR (i=0, i< number of MN in each cluster, i++)
               {
                  12 MN insert path in PIM;
```

```
                13 MN reply PIM;
                14 BS receive PIM;
                15 BS extract path;
                16 BS calculate distance;
               }
      }
17 CH=0
18 FOR (c=0, c< number of cluster, c++)
     {
        19 FOR (j=0, j< ACH_LIST nodes, j++)
              {
                 20 BS calculate average distance of the ACH with the cluster nodes
                 21 select ACH node with minimum avg. distance as CH;
                    CH= average distance of the ACH of node0;
                    IF
                     {
                       22   CH >= average distance of ACH in node j;
                       23   ACH_LIST-1;
                       24   CN_LIST= ACH_LIST;
                       25   MN_LIST= MN_LIST + CN_LIST;
                     }
              }
     }
26 END
27 CONTINUE
```


START
Broadcasts QIM to all nodes
Get PIM from all nodes
Accounts distance
Clusters
YES
NO
Group nodes into clusters
Calculate average distance of all ACH with MN of cluster
Minimum
YES
Add to CH list
NO
Add to MN list

3.1.1.4 Clustering WSN nodes

In this thesis two phase is used for transferring packet to BS. First phase is near to BS and the threshold value is defined and in setup phase the nearest sensor to BS is selected. Second phase is far sensors and these sensor are far from BS. The nearest sensors to BS send packet directly to BS and far sensor has clustering algorithm for sending packet to BS. Each sensor in far from BS collect information and sent to nearest CH and then CH send their information to BS.

3.1.1.5 Exchange the CH position

After completing the deployment phase which is responsible for selecting the CH and grouping each MN in the form of clusters in the WSN, each MN announces a link to the CH by broadcasting an advertisement message. The sensing phase is started and makes the neighbor nodes, called flat nodes, link to the BS. Flat nodes transmit their data to the BS directly without clusters. The nodes which belong to the clusters are called MNs. MNs send their data to the CH, which collects data received from the MNs and sends them to the BS. After sending, the CH will decrease its energy level. Therefore, we have designed our algorithm to exchange the CH position with the best CN. The exchange occurs while the energy level of the CH is lower than the energy level of the CN.

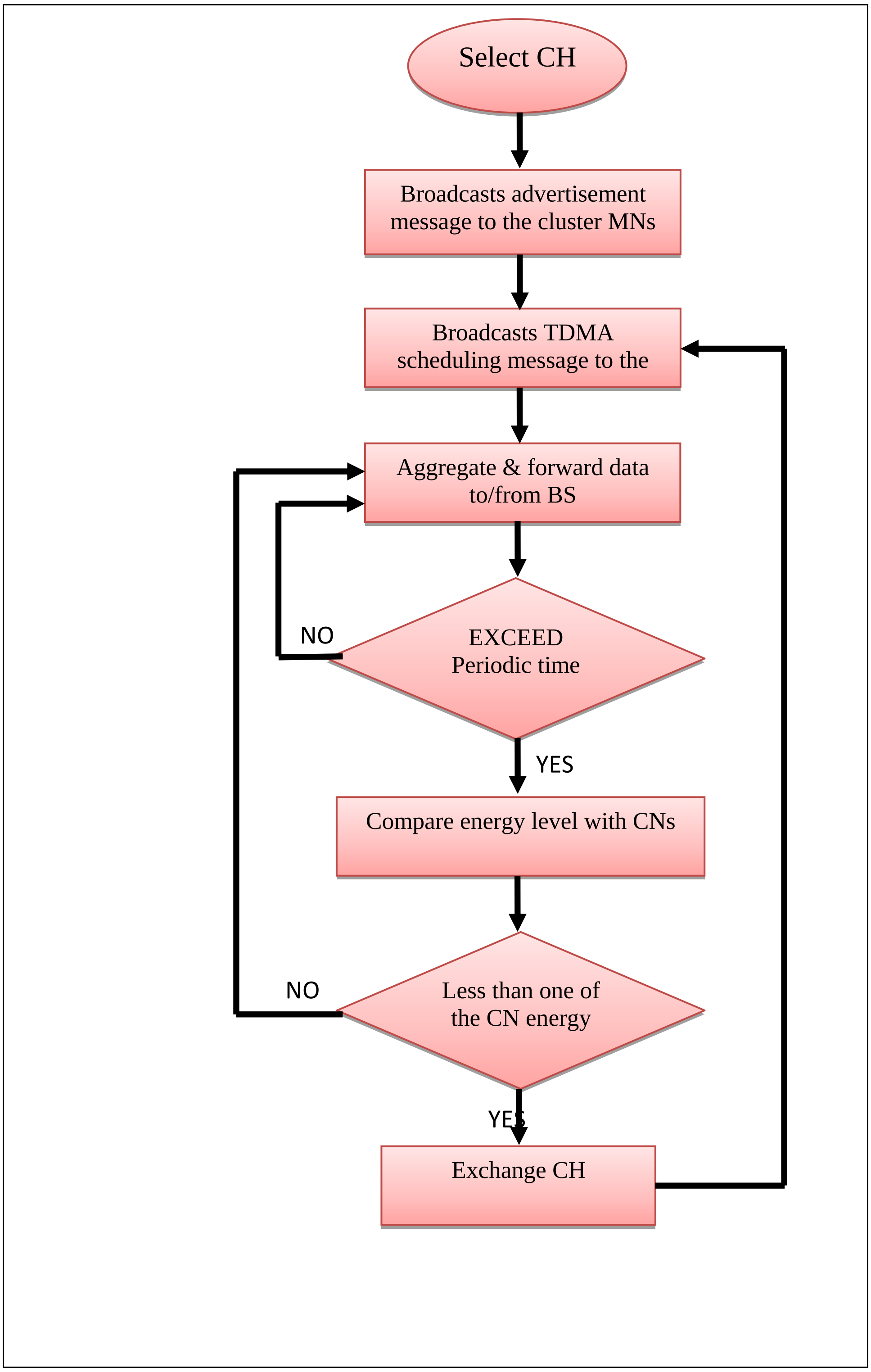
Pseudo code; Exchange CH **with** CN **Algorithm**

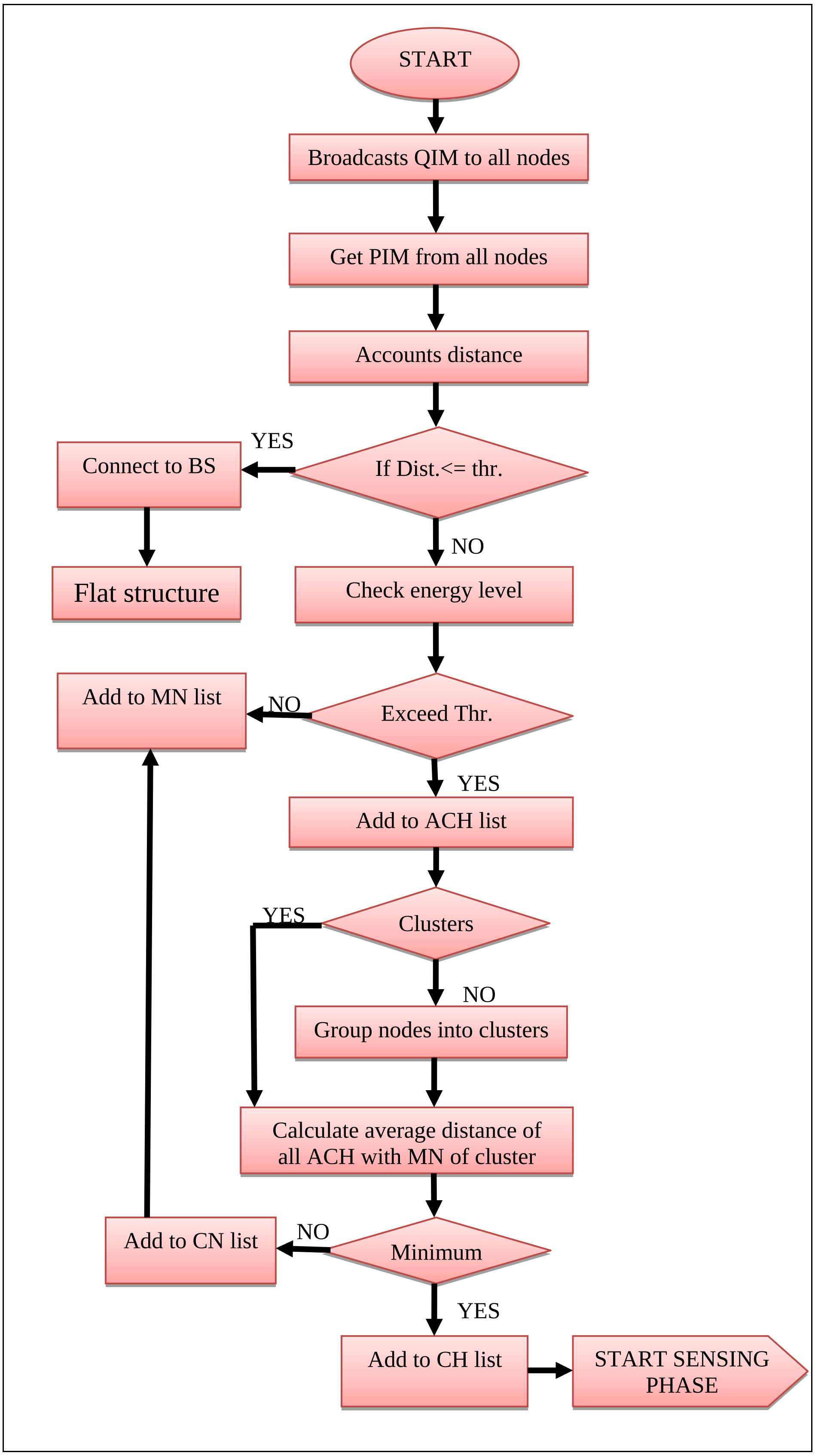
```
1  MN send to CH
2  CH forward  to BS
3  exceed the periodic time
4  FOR (i=0, i< CN_LIST, i++)
       {
            5 CH check the energy level with CN
                IF
```

```
            6 CH energy < CN energy
                {
                    7  CH add to MN_LIST;
                    8 MN_LIST;
                    9 CH = CN;
                }
    }
10 broadcast announcement to MN
11 resume the sensing phase
12 END
```

3.1.2. Sensing Phase

This phase is responsible for data collection and sending to the BS. After setting the CH in this phase, the announcement message is broadcast to the remaining nodes and the CH is selected. The CH collects data from the remaining the nodes and sends them to the BS. The CH uses Protocol (CSMA), where each CH transfers an announcement message to the remaining nodes using the same transport capacity. Other nodes that are not CH must save the receiver during the setup phase so as to hear the announcement message. Each node also sends information to the CH using Protocol (CSMA). During this phase, every CH keeps its receiver. Each CH receives a message from the nodes that wish to join it to form a cluster as the closest or most appropriate. The CH configures the schedule TDMA and this schedule is broadcast to those nodes belonging to it. After the formation of the cluster, tells CH tells each node when it must send data to it according to its role in the schedule and the allocation of the time transmitter. This process helps to reduce the consumption of energy between the nodes in one cluster. The CH combines data, pressure and sends it together in a package to the BS. This transmission requires a high energy transfer due to the large distance between the CH and the BS.


Select CH
Broadcasts advertisement message to the cluster MNs
Broadcasts TDMA scheduling message to the
Aggregate & forward data to/from BS
EXCEED Periodic time
NO
YES
Compare energy level with CNs
Less than one of the CN energy
NO
YES
Exchange CH


START
Broadcasts QIM to all nodes
Get PIM from all nodes
Accounts distance
If Dist.<= thr.
YES
Connect to BS
Flat structure
NO
Check energy level
Exceed Thr.
NO
Add to MN list
YES
Add to ACH list
Clusters
YES
NO
Group nodes into clusters
Calculate average distance of all ACH with MN of cluster
Minimum
NO
Add to CN list
YES
Add to CH list
START SENSING PHASE

CHAPTER 4

PROPOSED METHOD

4.1 Network model

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 according to the requirements of a related application. The aim of this thesis is to provide an efficient clustering algorithm for energy optimization in WSNs. Since our work is to optimize the EC, the best clustering algorithm that fits our aim is LEACH and SEP algorithm. The aim of this thesis is to analyze and determine the drawbacks of LEACH and provide solutions to overcome the difficulties and prevent the occurrence of undesired cases in LEACH. The details of the improvement of LEACH will be given in this chapter.

WSNs are usually located in larger geographical areas and can have different distributions. There are different papers in the literature about the effect of network distribution on network lifetime. The best results are achieved by locating the sensors in a controllable manner; however, this method does not seem possible in real networks. Most WSNs are randomly distributed, and due to the large geographical areas of networks, it is not possible to locate every sensor by hand.

In our work, we used 100 sensors in a 100×100 square meter area. The BS is set up in the center of the area. Each sensor has the same information. We used homogeneity sensors. Our wireless sensor model is shown in shown in Figure 9.

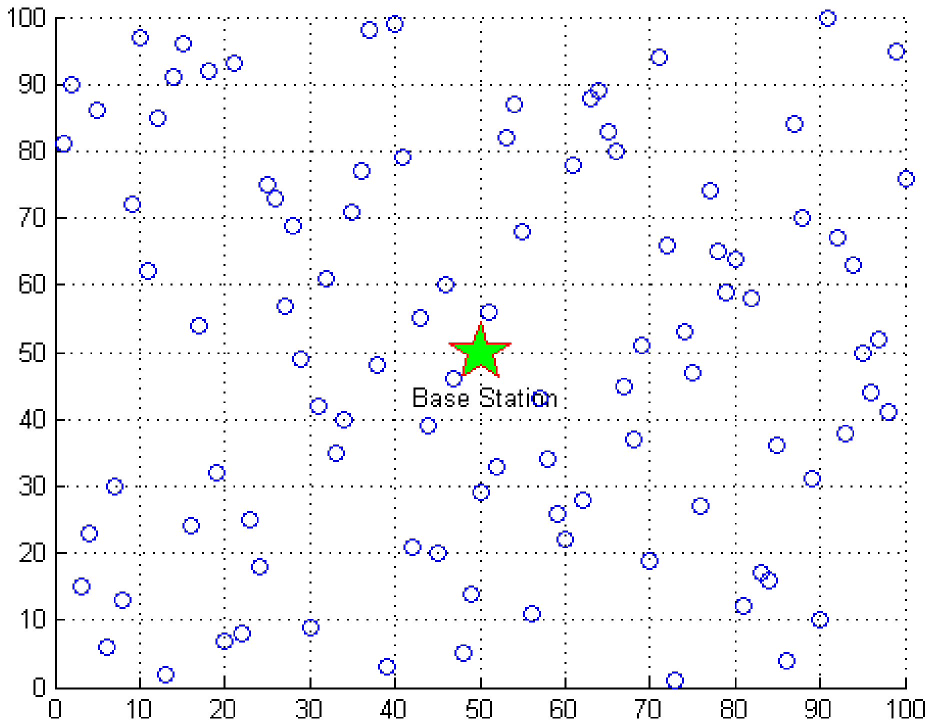


Figure 9: Architecture of proposed WSN model

In order to simulate the energy efficiency of the network, a simple model which is used in a number of previous studies is assumed [33, 34]. Figure 10 shows the radio model used in our method. It is assumed that radio dissipates an Eelec=50 nJ/bit and the transmitter amplifier is Eamp=100pJ/bit/m2.

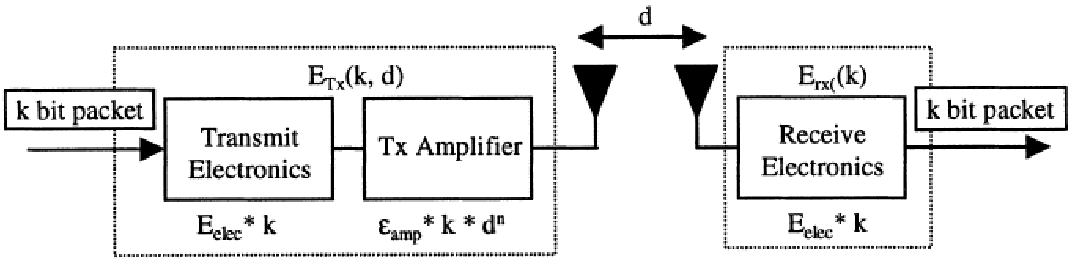


Figure 10: Radio model used in our method [25]

In order to simulate the energy efficiency of a network, it is assumed to be a simple model which has been used in previous studies. It is assumed in this model that radio dissipates and transmitters amplify. The following model is used to simulate the communication scenario:

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$
$$E_{Tx}(k,d) = E_{elec} \times k + E_{amp} \times k \times d^2 \qquad (4.1)$$

$$E_{Rx}(k) = E_{Rx-elec}(k) E_{Rx}(k) = E_{elec} \times k$$
$$E_{Rx}(k) = E_{elec} \times k \qquad (4.2)$$

In our network, we assume that the nodes are published in a square area of size 100×100. 100 sensors are deployed uniformly and randomly distributed in this area. We place the BS in the center of the area by default. We have tested other positions of the sink inside or near the boundaries of the area. The energy expended in node *i* in each unit of information transfer from node *i* to node *j* is assumed to be:

$$Et_{i,j}(k, d_{i,j}) = E_{t.elect} * k + E_{amp} * k * (d_{i,j})^{\gamma} \qquad (4.3)$$

In addition, the energy expenditure in node *j* in each unit of information received from node *i* to node *j* is assumed to be:

$$Er_i(k) = E_{r \cdot elect} * k \qquad (4.4)$$

In this thesis, we used $E_{r \cdot elect}$ = 50 nJ/bit. In the energy consumption model used in Chang et al., $E_{r \cdot elect}$ = 150 nJ/bit was used [35].

The process of transferring and receiving the message is not low cost; therefore, the number the transmissions and receptions per message needs to be limited. Since the radio channel is symmetrical, the energy consumed for the transfer of a message from node A to node B is the same amount of energy consumed in the case of sending the message in reverse.

The sensing range of the sensors (R_s) is assumed to be 10 meters and their communication range (R_c) is assumed to be 20 meters. The sink is considered to have an unlimited power supply. Events occur at a rate of, on average, one event per minute uniformly randomly distributed between zero and two events per minute at a randomly selected point in the area. The sensors that sense an event in their sensing range collect information about the event and send it to the BS. If they have no event to report, they wait until the next event occurs while they idle at waiting energy (Ew_i) of 50 nJ/min. The packets generated from event monitoring are 128 bits. Sensors forward the event information to the sink without any lag, so aggregation is not used. In our simulations, we considered both for all our algorithms. We made ten simulations for each random network setup and compared the performance of the routing algorithms in the same area with the LEACH and SEP methods.

4.2. The Proposed Method

In our method, we used sensors such that the near sensors have direct communication with the BS. The far sensors used the clustering method to send information to the BS. In the far sensors, each sensor sends information to the CH, which analyzes the information and then sends it to the BS. For the communication scenario, it is supposed that each node can transmit a message to another node, and initially each node has an equal level of energy of 0.5J.

4.2.1. Initial phase

In the initial phase, we put the value of the parameters in (4-3) and (4-4). After the creation of the nodes and simulation environment, the BS creates the first message announcement, which includes an ID message, transmitter, query and sending of a

list. After the announcement of the production of the message, the BS creates the first entry with time stamp 0.0, which is located primarily with a timestamp 0.0.
This entry contains the sender node and a list of nodes that send the message and timestamp.
The first entry is processed at the beginning of the simulation phase.

4.2.2. Setup phase

In the setup phase, sensors are placed randomly in a 100×100 network area. Additionally, the BS is inside of network area. Each sensor has the same energy. We separate the sending of information to the BS into 2 parts. Some of these sensors directly send information to the BS, while some of them have a CH and send it to CH send to the BS.

4.2.3. CH Selection

In this thesis, for the far sensor we used the clustering method for communication between the sensors and the BS. In the clustering method, we must select the CH in each round. For CH selection, we used (4.5).

$$T(i) = \begin{cases} \frac{p}{1-p\times\left(r \bmod \left(\frac{1}{p}\right)\right)} & if \;\; i \in G \\ 0 & otherwise \end{cases} \qquad (4.5)$$

This equation is used in many papers. Each sensor has the probability value to be a clustering head. Here, each node determines the number of random intervals form 0 and 1, and this value is compared with the value in (4.5). If this value is less than T(i), then this sensor is CH.

Since the sensors in the networks are energy constrained, the lifetime of these networks has become a major concern. In order to extend the life of networks, CHs should be richer in resources than other simple nodes. Therefore, intra cluster communication costs will also decrease due to the richer CHs. A new algorithm which aims to select more centralized CHs and increase efficiency of the network by decreasing the intra cluster communication costs is given in this section. As a first step, our algorithm differs from LEACH by defining a set of probable CHs. The LEACH algorithm provides an equal opportunity to all nodes to become a CH, and in this case, some undesired cases may occur, such as border nodes becoming CHs, or the nodes with no neighbors becoming CHs. In order to prevent the occurrence of these bad cases, a set of probable CHs is defined according to connectivity levels of nodes. With this limitation, it is aimed that only more centralized nodes have the probability to become CHs. Therefore, the distance between nodes and their CHs will be small enough to achieve the aim of saving energy. Topology, or neighbor discovery, in sensor networks is generally carried out by allowing nodes to send hello messages so at to signal their presence. In order to apply new connectivity algorithm, the nodes need to discover a number of their neighbors. After this process is completed, the connectivity algorithm can be applied to the network. Within the application of this algorithm, there will be a neighbor discovery process at the beginning; otherwise, a number of probable CHs will be determined after the topology discovery is completed. The nodes that do not have a sufficient degree of connectivity will not have the opportunity to become CHs and they will not need to run the CH selection algorithm in any round. The only process that will be carried out by these nodes will be to find their appropriate clusters [36, 37, 38].

4.2.4. Development generating

Development is a repetitive procedure via the definition of CH from sensors in simulation. Here, CHs are originated in the sensor slant. The CH sensor count is planned by adding CH sensor members and their member sensors up to BS.

4.2.5. Steady state phase

The decision of each node to become a CH is based on the proposed percentage in *p*. This proposed percentage shows whether or not the node becomes a CH, where all sensors *i* have become CHs according to (*r* mod (1/*p*)) of rounds, which means by *Ci* (*t*), and in the beginning of round *r*.

4.3. Evaluation of Performance

We compare our results with the results of the LEACH and SEP protocols. The results of our performance system overcome the previous works.

4.3.1. WSN parameters

In this thesis, we used the WSN parameters as illustrated in Table 1. These parameters include the number of sensors, X and Y coordinates, primary energy, electronics energy, etc.

Table 2 The parameter that used in this thesis

Parameter	Value
Number of Sensor in WSN area	100
Message Size	4000 bit
BS Position	(50, 50)
X	[0 100] m
Y	[0 100] m
E0	0.5J
Eelec	50 nJ/bit
Efs	10pJ/bit/m2
Emp	0.0013 pJ/bit/m4
Eda	5 pJ/bit

4.3.2. Simulation results and analysis

Here, we illustrate that our method has higher performance than the LEACH and SEP methods. Furthermore, we show that in our method, we saved great amounts of energy when sending information to the BS.

We compare our results with LEACH and SEP.

4.3.3. WSN Lifetime

Network life relies heavily on the power supply of sensors and these supplies are battery and solar panels. The sensor consumes energy to generate data from the targets, which it receives from other sensors and transfers them to other sensors. We adopt the communication power consumption model that was used by Heinzelman et al (2000). In the adaptive transmission power model, the energy required to transmit unit data increases with distance. In order to send the data to a sensor over longer distances, an acceptable signal to noise ratio should be achieved by consuming more energy.

In Figure 11, the alive nodes vs round is illustrated. As shown in Figure 11, it can be seen that our method is far better than the other method. In our method, the sensors die after 1500 rounds, whereas the sensors in the LEACH protocol die after 500 rounds. Moreover, in the SEP protocol, sensors were dying after 1000 rounds.

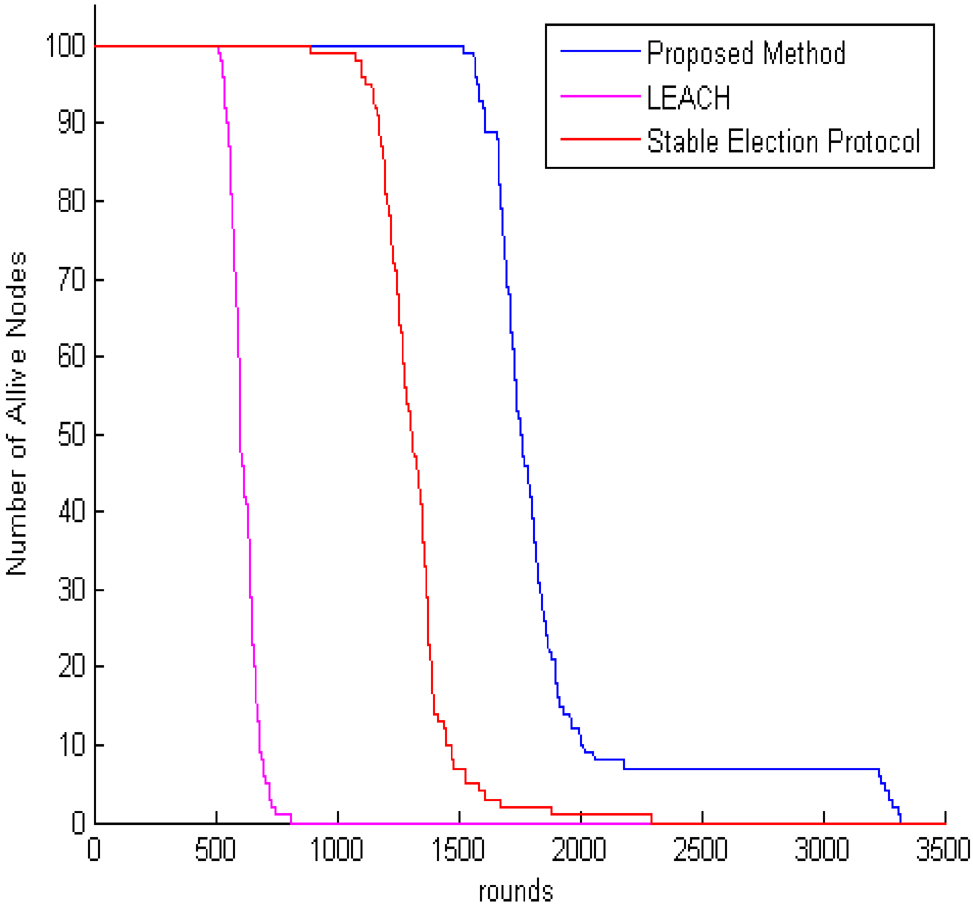


Figure 11: The simulation output result

Figure 12 shows the number of packets received in the BS vs rounds. Every sensor sends information to the BS. However, the near nodes send their information to the BS directly, whereas other sensors send information to the CH followed by the CH sending it to the BS. As shown in this figure, in our method the sensors send many packets to the BS. However, in the other methods, they send small packets to the BS.

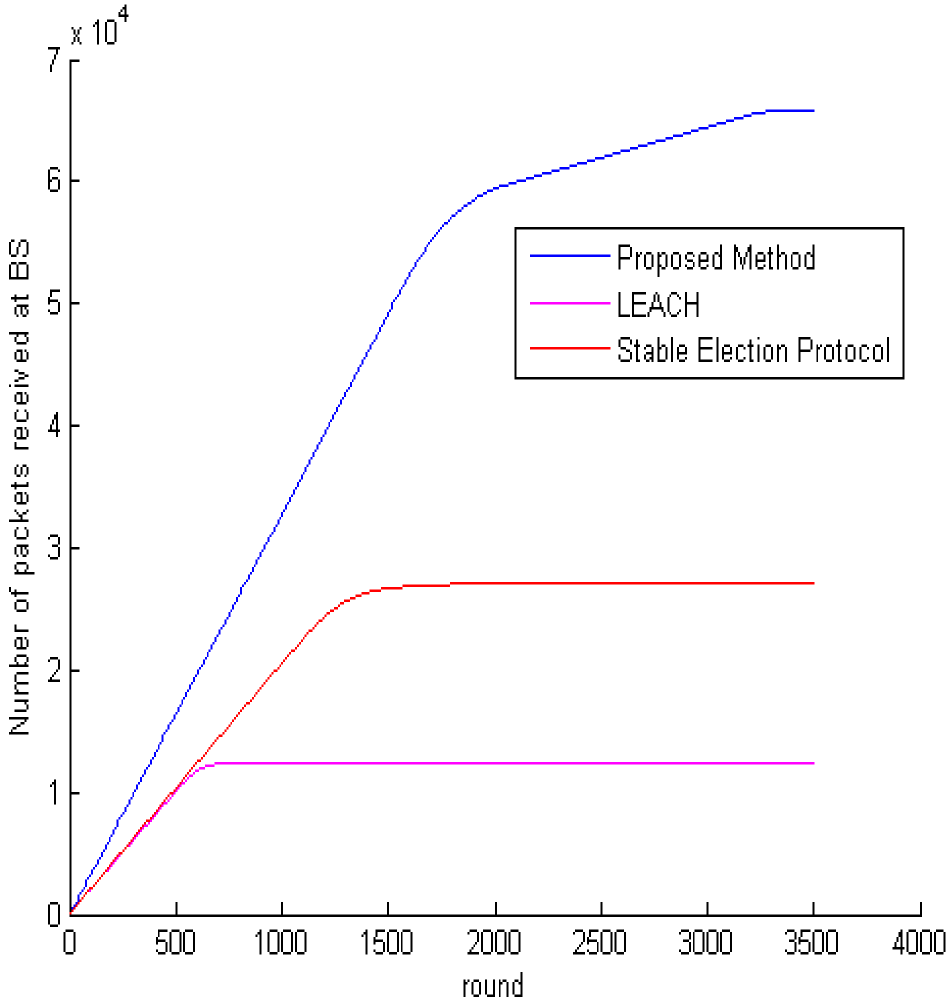


Figure 12: The number of packets that received in BS

Figure 13 shows remaining energy vs. round. As seen in this figure in the same remaining energy, we have many rounds. This means we use many rounds for the same energy. However, in the LEACH or SEP protocol, for the same energy we have little round numbers. Here, the same sensor directly communicates or freely communicates with the BS and the same sensor does not have free communication with the BS.

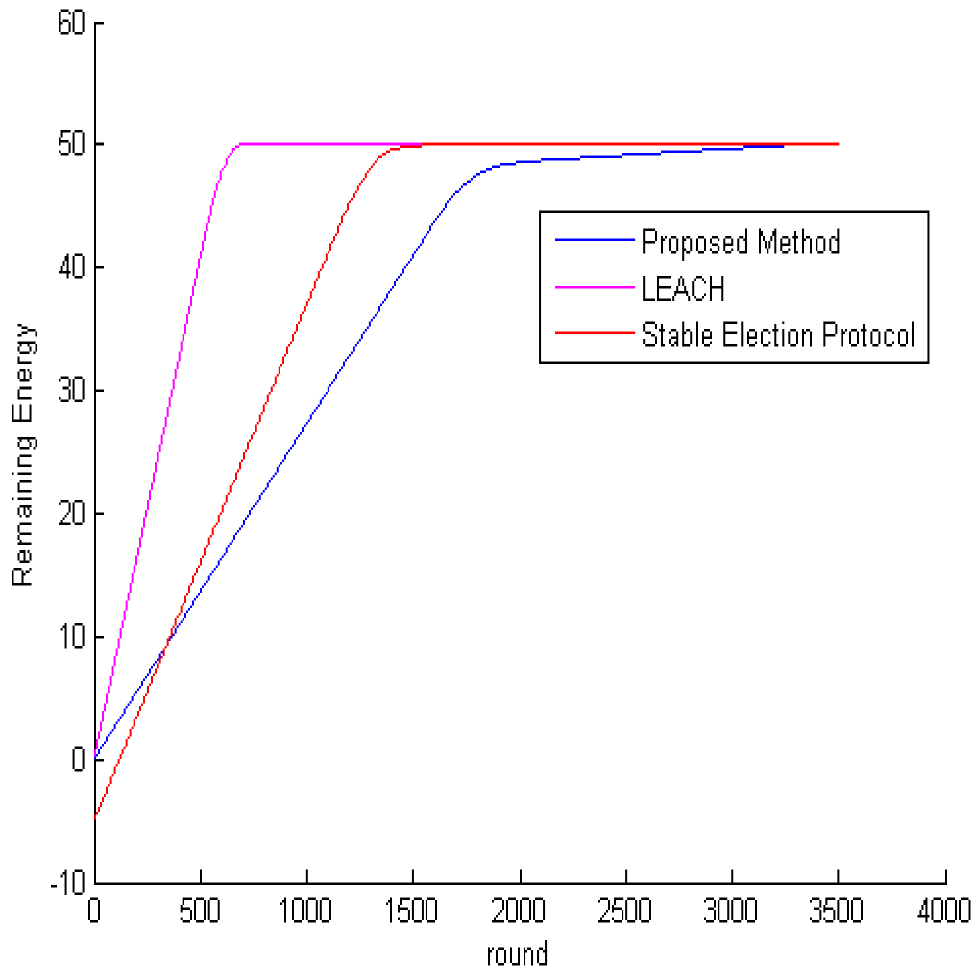


Figure13: As a result the remaining of energy simulation

CHAPTER 5

CONCLUSION

5.1 Conclusion

WSNs are the networks that contain many sensors that have different abilities, such as sensing, communicating and processing. In recent years, many applications based on these kinds of networks have materialized. Since most applications in WSNs require EC, the energy level of any one node becomes important. There are different methods in the literature which provide efficient energy consumption for WSNs.

Wireless network clustering is one of these major methods which have been used in many applications for energy optimization. As there are many nodes in the networks, it is aimed to provide an adaptive EC with clustering methods. LEACH is a famous algorithm for clustering, which depends on the random clustering method. In this algorithm, there are two different types of nodes acting as CHs and cluster members. Communication is provided via these CHs. Therefore, the LEACH algorithm achieves its main purpose by providing dynamic clustering and adaptive EC.

LEACH provides a random clustering method; nevertheless, there are some constraints that affect the clustering algorithm, such as the definition of a number of groups in each round. In LEACH-based algorithms, a p value is defined as the desired percentage of CHs being used to calculate threshold values. Therefore, it directly affects the CH selection. As a first step, the optimal value should be determined and the parameters that depend on the p value should be selected to achieve better results.

In this thesis, we used a separate area for the sensor. The first sensors were near to the BS while some were far from the BS. Those sensors near the BS were free and communicated directly with the BS. The sensors that were further way carried out cluster-based communication with the BS. In this area, each sensor had a probability value to be a CH. Each sensor sent its information to the CH and then this CH sent information to the BS. Each sensor had the same energy. In the setup, we gave the same energy to each sensor.

We compared our method with 2 famous methods: the LEACH and SEP protocols. Our result was better than the other two methods.

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APPENDICES A

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