# ADAPTIVE ENERGY CONSUMPTION METHOD FOR WIRELESS SENSOR NETWORKS USING OPTIMIZATION ALGORITHMS

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# ADAPTIVE ENERGY CONSUMPTION METHOD FOR WIRELESS SENSOR NETWORKS USING OPTIMIZATION ALGORITHMS

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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## ABSTRACT

**ADAPTIVE ENERGY CONSUMPTION METHOD FOR WIRELESS SENSOR NETWORKS USING OPTIMIZATION ALGORITHMS**

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The objective of this thesis is to save the nodes energy using optimization approach with Particle Swarm Optimization Algorithm. The network area is divided to several regions for parametric study. In the proposed method, the energy of the efficient routing is enhanced and the system used the Particle Swarm Optimization for eliminate the individual nodes in wireless sensor network. In this thesis the optimization method is used to find the best hop in wireless sensor network which use the Gravitational Search Algorithm. The proposed work compared with Low Energy Adaptive Clustering Hierarchy. In simulation result the total energy for proposed method is got 8 Joules, which the energy for the OEERP is got 10 Joules and for the LEACH the 20 Joules is got. That's mean proposed method is 20% better than the energy consumption from optimized energy efficient routing protocol and 60% better than the Low Energy Adaptive Clustering Hierarchy method is reduced. In proposed method the packet delivery ratio is high than the optimized energy efficient routing protocol and Low Energy Adaptive Clustering Hierarchy method. As result the packet delivery is 100. This values only the base value and for 4000 bit packet that time 400,000 packet will send to the base station. The packet delivery for optimized energy efficient routing protocol is 60 and for Low Energy Adaptive Clustering Hierarchy this value is 64.

**Keywords:** Wireless Sensor Network, Particle Swarm Optimization Algorithm, Clustering Method

## ÖZ

### OPTİMİZASYON ALGORİTMALARINI KULLANARAK KABLOSUZ SENSÖR AĞLARI İÇİN UYARLANABİLİR ENERJİ TÜKETİM YÖNTEMİ

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Bu tezin amacı, Parçacık Sürüsü Optimizasyon Algoritması ile optimizasyon yaklaşımı kullanarak düğümlerin enerji tasarrufu sağlamaktır. Ağ alanı, parametrik çalışma için birkaç bölgeye ayrılmıştır. Önerilen yöntemde, etkin yönlendirme enerjisi güçlendirildi ve sistem, kablosuz sensör ağındaki bağımsız düğümleri ortadan kaldırmak için Parçacık Sürüsü Optimizasyonunu kullandı. Bu tezde, Gravitational Search Algorithm kullanan kablosuz sensör ağında en iyi atlamayı bulmak için optimizasyon yöntemi kullanılmıştır. Önerilen iş, Düşük Enerji Uyarlanabilir Kümeleme Hiyerarşisi ile karşılaştırılmıştır. Simülasyon sonucunda elde edilen enerji, EERP için 10 Joules, LEACH için 20 Joules önerilen yöntem için 8 Joule'dir. Önerilen yöntem, optimize edilmiş enerji verimli yönlendirme protokolünden gelen enerji tüketiminin %20 daha iyi olduğu ve Düşük Enerji Uyarlanabilir Kümeleme Hiyerarşisi yönteminden %60'ının indirgendiği öneridir. Önerilen yöntemde paket dağıtım oranı, optimize edilmiş enerji verimli yönlendirme protokolünden ve Düşük Enerji Uyarlanabilir Kümeleme Hiyerarşisi yönteminden yüksektir. Sonuç olarak, paket teslimatı 100'tür. Bu sadece baz değerini ve 400.000 paketin ana istasyona gönderileceği 4000 bitlik pakete değer verir. En uygun enerji verimli yönlendirme protokolü için paket teslimatı 60, Düşük Enerji Uyarlanabilir Kümeleme Hiyerarşisi için bu değer 64'tür.

**Anahtar Kelimeler:** Kablosuz algılayıcı ağları, Parçacık Sürüsü Optimizasyon Algoritması, kümeleme methodu.

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## TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| **WSN** | **:** | Wireless Sensor Network |
| **LEACH** | **:** | Low Energy Adaptive Clustering Hierarchy |
| **CH** | **:** | Cluster Head node |
| **MANET** | **:** | Mobile Ad-Hoc Network |
| **RTS** | **:** | Ready to Send |
| **DSR** | **:** | Dynamic Source routing |

# CHAPTER I

# 1. INTRODUCTION

## 1.1 Background

A wireless sensor network (WSN) consists of distributed autonomous sensors, in cooperation monitor a process or an environment. A wireless sensor network is a relatively new technology that has great potential for measurement of sound, light, vibration, pressure, motion or chemical substances in the air. With such systems, it is possible to provide a two or three-dimensional situation image based on a number of simultaneous sensor measurements in contrast to conventional sensors, which provide only a point measurement. A sensor network can consist of - two to three sensor nodes - and up to several thousand depending on the application.

Today, the technology is in use in many industrial and civil areas, including process monitoring, environmental monitoring, intelligent control of house - and traffic control. Other areas of use are monitoring the spread of oil spills or forest fires. Wireless sensor nodes can be characterized as small computers with very low processing capacities, limited working memory, sensor electronics, a simple communication device (usually a simple radio circuit) and a power source (usually a battery). Further, it is usually desirable that each node is as small and cheap as possible. The main purpose of the sensor network is to collect data from all sensor nodes in a shared data hub. This is done like by nodes on transmitters (routes) data traffic on behalf of other sensor nodes.

The unique characteristics as sensor networks, make electronics, operating and data protocoled be developed with special care: Sensor node must operate with limited battery capacity, it must withstand hard impacts, the network must tolerate individual sensor nodes fails, individual nodes can be mobile, network topology can be dynamic, the pattern operation is autonomous, radio capacity is low - and the number nodes can be very high.

Most sensor network for research purposes using ZigBee (based on the IEEE 802.15.4) as the communication protocol. Traditionally, sensor networks have been very simple and largely have proprietary protocols host used at the network layer. At the IETF is working on the other hand, working with an open standard (6lowPAN) such that the IPv6 can be used over the IEEE 802.15.4. This standard makes it easy to connect wireless sensor networks with existing IP-based data networks.

### 1.2 PSO

This algorithm is inspired by the origin of the world of life. Another source of inspiration, claimed by the authors, James Kennedy and Russel Eberhart, is socio-psychology.

The PSO method is constructed on the collaboration of individuals with each other. It also has similarities with ant colony algorithms, which also rely on the concept of self-organization . This idea is that a collection of unsuspecting individuals can take a complex inclusive organization. Thus, thanks to very simple displacement rules (in the solution space), the units can gradually converge towards a local minimum. This metaheuristic, however, seems to work better for spaces in continuous variables [1].

The "***Particle Swarming Optimization***" method, created by **James Kennedy** and **Russell Eberhart**, is currently among the meta-heuristics of optimization algorithms, based on patterns of nature (such as representing the movement of each individual within a flock of birds or a school of fish), which are more popular in this area and appear to be the most promising algorithm for solving the most diversified optimization problems in both science and engineering. Since its creation, many variants have been developed to solve practical problems related to optimization [2].

## 1.3 Statement of the Problem

Designing inexpensive sensor networks has become easy thanks to the improvements in wireless communications and electronics. The sensor networks can be used in healthcare systems, in the army, in agriculture, at homes, and in the environment. The sensors must be cheap, so the batteries will be inadequate. Moreover, the life span of these networks is greatly influenced by the amount of energy saved. Energy can be saved by means of appropriate routing protocols. In this thesis, we suggest some protocols that will of use in saving more energy and increasing the endurance of networks when compared to the protocols classically used especially in networks that a lot of sensors.

## 1.4 Procedure

This thesis aims to make an evaluation of a clustering-based method in homogenous wireless sensor networks. In this method, the probability of cluster head election will be changed so as to allow it to be more dynamical and more efficient. The protocol performance will be compared with distributed energy-efficient clustering and stable election protocols. The performance of this system is expected to prevail over the previous works.

This thesis claims that using optimization approach (Genetic Algorithm and/or Memetic Algorithm and/ or Particle Swarm Algorithm) will help save the nodes energy. For this purpose, the network area will be divided into several sections for parametric study. The proposed work will be compared with LEACH.

## 1.5 Purpose of the Study

This thesis will contribute to reducing the total consumption of energy in WSN. The cluster head election probability will be made more dynamical and more efficient, which will cause the sensors to use low energy and to save much more energy in the whole network.

## 1.6 Requirements

Hardware requirements: One personal computer (Laptop Lenovo), Processor: Intel Core i7-4702MQ CPU 2.20 GHz, RAM 6.00 GB.

Software requirements: MATLAB 2017a

# CHAPTER II

# REVIEW OF LITERATURE

## 2.1. Review of Literature

In [3], they analyzed the schemes that balance the consumption of energy in nodes and that help improve the life span of networks through a balance of the load of data traffic as equally as possible. The network lifespan was assumed to be instant when the first sensor node died. In addition, strategies for balancing energy were examined that would extend the lifespan of sensor network. Load balancing techniques were used to reach an ideal solution. An experimental technique was used apart from the possibility to use other routing techniques such as shortest-path routing.

The algorithm in [4] was developed for the purpose of setting up an inexpensive energy efficient system and prolonging the lifetime of sensor network. The algorithm optimum clustering and an optimum counterpart algorithm were compared in terms of their performance. Costs of astronomical prohibitive synchronization were taken into consideration in this algorithm.

In [5], An outline of how to increase the lifespan of the network in WSNs was presented. There is a reduction in the whole energy consumption along the path, where the data transmit route is selected. They used cluster to limit the energy required by the resources, which prolonged and improved the network lifespan.

In [6], it was stated that the greatest problem of sensor nodes was WSNs as next generation sensing machines and structures with restricted battery energy. There had to be a proper balance in the load of data transfer in the sensor nodes needed to so that the energy in the WSNs could be distributed. Clustering algorithms is one of the chief methods to balance the load of commutations. Clustering algorithms may sometimes lead to an increase in the number of clusters with more node members than other clusters may do in the sensor network. The imbalance in the size of clusters may impact the load balance in the WSNs adversely. It is suggested cluster algorithm will balance the load in the generation of clusters. The cluster head completely creates clusters and cluster nodes as well as affecting the performance of clusters. Each part is further divided into another part if necessary and this is based on the master node and the nodes in the part that is divided.

The traffic is maintained by sensor nodes only and all other nodes that remain. Radios are turned off to reduce the consumption of battery energy. The energy is consumed completely and a longer network lifespan is realized when compared with the other remaining techniques [7].

Energy plays an important role in renewing nodes battery and in increasing the life span of sensor network [8].

In Sankar and Liu [9], an LP formulation is presented with an aim to maximize the network lifetime. What is proposed is a spread direction-finding algorithm that achieves the best solution with relatively as fewer errors. The major disadvantage of this is that it disregards sensor location and issues of sensor motion arrangement. In addition, energy consumed in in receipt of the data packets is not considered.

In Hua and Yum [10], directing the data to the sink node is considered in order to take full advantage of network lifespan and the shortest lifetime of all the nodes. Tracking node's traffic can be done only through its downstream neighbors. The problem was first formulated as a mathematical program with the aim of minimizing the maximum normal nodal power consumption by the bottleneck nodes.

The normalization was done by means of nodal battery energy. Linear flow conservation was a constraint.

Pham et al. [11] divided the sensor network into grids. Any sensor in the cell is assumed to cover each grid cell. Data packets can be transmitted to any sensor in the adjacent cell through a sensor in a cell. They aimed to find the total data flow among the cells so that the lifetime could be lengthened until the first cell lost its area of coverage. A LP is used to maximize the network lifetime. Flow balance and battery energy are the limitations since they are written for the cell but not for each sensor. Simulations indicate that the method has increased the network lifespan.

## 2.2. Sink Location

Since the use of global information in the network is impracticable sensor networks in a wide area (Vincze et al. [12]), a new algorithm that carries out the sink deployment is proposed, basing only on the information of the location of the neighboring nodes. The comparison of the two algorithms shows that their performance is very close to each other.

Consequently, a relocation algorithm was used to relocate the multiple sinks in a coordinated way. The simulation results indicate that the algorithm extends the network lifespan to a great extent. However, the energy consumed in sensing and processing as well as in routing the data packets were not clearly considered although sinks were positioned optimally.

The first limitation was that the total energy consumed in getting and transmitting packets and in setting up/discharging paths was less than the energy in the battery when the sink was moved to a place for each sensor. In addition, the creation of a route for the sink and the removal of cycles were other limitations. The control experiment group of sink movements spread completely and localized shows that the network lifetime has increased considerably. However, the energy used in sensing, processing, and in directing the data packets in the MILP design was not taken into consideration. Moreover, the sink can last only for one hour during the network lifespan, which is not very realistic [13].

## 2.3. Works Completed in Some of the Design Issues

Patel et al. [14] proposed the second MILP model in which placement, data routing and sink location issues were integrated with the purpose of minimizing the total cost of placing the sensors and the sinks. The limitations were ensuring the necessary quality and conserving the flow of the sensor field. In this MILP, the energy limits the energy spent in data routing as well as those of the coverage and flow balance.

In Hou et al. [15] a mixed-integer nonlinear program was used with an aim to maximize the network lifespan. It was made sure that the flow was balanced and that the energy in receiving and transmitting the data packets were limited. As it was difficult to solve the MINLP problem on the computer, a heuristic algorithm was established. The statistics show that the heuristic algorithm solved the problem better and provided some important insights into understanding the problem in question.

Communication between the two nodes is carried out by the transmitter node by sending the message to its cluster head, and the remaining parts will be finished by the cluster head. Once the message is received by the cluster head, it will be sent to cluster heads of the receivers. The node will send the message to the last receiver node which will result in more efficient energy use. Besides this, such communication structure will decrease the complexity since all the nodes do not need to know the whole topology.

The authors in [16] state that LEACH can reduce energy dissipation by over 7 % more than direct communication. There are still some problems with energy consumption and data collection in spite of the fact that LEACH offers adaptive energy consumption in addition to increasing the effectiveness of wireless sensor networks.

The possibility that nodes can become a cluster head in LEACH algorithm may sometimes lead to unwanted topologies.

However, network becomes stuck after certain number of rounds, which is disadvantageous. Since most of the nodes will have less energy after some certain rounds, the threshold will be less likely to become a cluster head. The network will have already become stuck [10] because the threshold will have less energy though there will still be some nodes with sufficient amount of energy to send data.

The authors found a solution to the problem of stuck network by modifying the formula and thus reaching more effective level of energy consumption than LEACH. A 30 percent increase in the lifespan of micro sensor networks can be attained through such modifications.

Two variations of LEACHs for cluster-head selection algorithm were proposed by the authors in [10]. Upon the identification of the clusters and cluster heads, a predefined number of head set nodes will be selected in accordance with the signal strength of the acknowledgement messages.

### 2.4. Network Management

Self-motivated structure of WSNs, active schemes for monitoring and managing components it requires. Similar to any network architecture, SCAs, network administrators, or requires efficient administrator tools so system user’s container easily interact with the sensor nodes on the network. Though, in WSNs, the transmission of information is expensive and undependable because of low power wireless connections. For this reason, high energy efficiency and reliable management poses a major challenge. Also, the sensor nodes are limited in terms of data processing and memory.

Network management tasks typically take place in two steps: network controlling and management monitoring. The information from the WSNs should be collected efficiently as part of the network monitor, assessing the present state of the network.

## 2.5. ZigBee

ZigBee is a short-range wireless networking standard developed in the IEEE 802.15.4 infrastructure and established using standard spiral networks and application profiles. It has multiple network topologies including star connection and point-to-point connection. Considering the advantages such as reliability, low cost and energy saving, PC input devices, sensors and network management devices are suitable standards for wireless connections [17]. ZigBee enables automatic searching of wireless channels and the coexistence of multiple wireless networks. It is widely used to provide wireless communication in indoor environments, in remote imaging applications, automation and control systems, in KAAs. ZigBee devices operate in the 2.4 GHz ISM frequency band, which is open to license-free use worldwide. These devices; At 2.4 GHz frequency band, it is possible to reach speeds of 20 kbps with 10 channels at 250 kbps, 40 channels at 6 channels at 915 MHz frequency band and 1 channel at 868 MHz frequency band. ZigBee devices range from 10 to 100 meters depending on the transmission power, transmission power and environmental factors. ZigBee devices have deep sleep modes and save energy depending on the data flow. Thanks to the advanced features of sleep cycles, low power consumption and ideal connection techniques, the battery life of ZigBee devices is very long [17].

Wireless Sensor Networks have several purposes and also many kinds of applications such as healthcare and sensitive areas monitoring, and since the communication between the network devices in the WSN is WIRELESS, therefore it requires an extremely secure environments. Sensors are the network parts which are used for monitoring purposes and as sensors play that role in the network then they require seeking energy efficiency and security. Sensors operate on batteries and might be placed in tough places, thus it will be difficult to replace or recharge their power source (Battery); because of that reason the power consumption of the sensors should be brought to minimum. In order to achieve such goal sensors periodically put their nodes into sleep mode to save as much power as possible; however and attacker can manipulates the information of the sleep time in order to reduce the life time of the node. An attacker can apply the denial of sleep attack by intercepting the information between the Base Station (BS) and the nodes to crack the secret key. The BS and the nodes share a public key and also each node has its own private key. Since the attacks target the key; thus the key is considered as a weakness point; so they've proposed a system in which the key is not transferred directly to the node from the BS; instead the BS calculates a value of v=s2 mod N in which s is the node's private key and N is the public key and then the node is given the value of v when it make a request; therefore the private remains a secret [18].

Clock skew is the deference between the clock frequencies of two clocks, Moreover, studies on the clock skew came to results that can be helpful for improving the security in wireless sensor network, those studies had shown that at a room temperature the clock skew of any clock is stable and is considered unique thus can be used as a fingerprint to every device in a communication network. And since the clock skew is fixed; an attacker can easily generate a fake clock skew which is identical to the clock skew of the victim's parent node in order to deceive the victim node by changing the timestamp of the packets sent to the victim for the purpose of confusing the victim between the attacker node and the parent node. In this paper they develop an algorithm for faking the clock skew of the parent node by calculating the difference between the attacker node and the one to be faked and derive the same clock skew of the target node. And then they propose a defend algorithm against this kind of attack (Replication Attacks) by changing the time period of the synchronization (Burst Mode) when an attack is detected so that the time period of the synchronization can nerve be predicted since it changes periodically (Every 7 rounds) during the attack [19].

More and more applications contain wireless sensors that communicate with each other in a network. How can these sensors talk to as many neighbors as possible and use as little energy as possible? It is late at night when you drive into your car at a gas station. A lamp lights up outside. You drive on and there is another light on and so 'it goes on. It seems like you are being followed. You feel uncomfortable. For that feeling to avoid, we are working on more subtle lighting where lamps are not just on or off, but in a pleasant way are dimmed. Get a gas station such a smart, energy-efficient lighting that roughly knows where you are as a motorist drive and where it should be lighter, without giving you the feeling that you are followed. More electrical wiring is needed for such a smart sensor network. That is expensive; that is why we opt for wireless sensors that talk to each other. The sensor network has to know exactly where a motorist drives to provide a pleasant tailor-made lighting. The Dutch company Chess manufactures wireless sensors for this filling station application, but also for many other applications. Chess specializes in the development of custom hardware and software. In addition to wireless sensors, the company has, for example, developed a real-time readout of an MRI brain scanner, a way to measure the deflection of an airplane wing with a laser beam, but also systems for micro payments. Chess is based in Haarlem and has about one hundred and fifty employees. In 2006, the company also participated in the Mathematics Study Group with Industry. Also, it was about the reliability of a wireless sensor network that detects a forest fire. This time we wanted to know how a wireless sensor network can communicate as well as possible with one as low as possible energy consumption [20]. A single wireless sensor is small, cheap and energy efficient. His processor power and memory are limited. In a network, the sensors communicate with each other on the same radio frequency. Any other sensor located within the radio range can receive the signal from the transmitter. But how many receiving neighbors that is, depends a lot on the circumstances, such as obstacles on the way or the amount of moisture in the air. The range can vary from five to fifty meters. The number of bucks that receive the signal from a transmitter can also vary from moment to moment. Furthermore, the problem is asymmetrical: that sensor B can receive a message from sensor A, does not automatically mean that sensor A can also receive a message from sensor B. When two or more sensors send at the same time, they interfere with each other and the other sensors involved do not hear anything. Chess therefore stands for the assignment to develop a communication protocol that is as efficient as possible for a dynamic network of sensors [21]. In order to do as long as possible with their batteries, the sensors do nothing for the most part of the time and only communicate in a short period of time. Typically they are active in a few milliseconds and do nothing for the rest of the second. For example, each sensor is long inactive, briefly active, long inactive and so on. When designing a communication protocol, a tension is created between the number of neighbors that receive a signal from a sensor and its energy consumption. The more neighbors, the better in principle communication goes, but also the more energy the network uses. We would therefore like to know the optimum number of neighbors with which a sensor must communicate [22].

The cognitive radios have to gather the required information about the radio communication environment, before adjusting accordingly. The characteristic of the cognitive radio is called, "Cognitive Capability", which results the cognitive radio to be aware of the radio frequency spectrum, waveform, communication network type, communication network protocol, geographical information, local resources, which are available, demands of the user, security policies and so on. When cognitive radio fulfills the gathering of the required information from the radio environment, it can change the transmission parameters according to the environment variations dynamically, and accomplish the optimal performance, which is called as "Configurability".

**Functions**

A duty cycle of the cognitive radio consist of  the following items : [23]

- Spectrum sensing and analyzing.
- Spectrum management and handoff.
- Spectrum allocation and sharing.

While sensing and analyzing frequency spectrum, cognitive radio can find the spectrum white spaces, which are not used by a license holder by that moment, and utilize the white space spectrum. Cognitive radio can also detect when a license holder (primary user) starts to use their licensed spectrum again, and does not interfere with them as a secondary user.

After finding the white space spectrum, the cognitive radio provides the secondary user to choose the best frequency available, and change between multiple frequency bands according to the time varying characteristics of the channel and to meet the Quality of Service (QoS) requirements. When a primary user starts modulating in their licensed frequency band, secondary user redirects their transmission to an available frequency band, the optimal band is automatically chosen according to the channel capacity, noise, path loss, interference level, holding time, channel error rate, and so on.

The problem of spectrum underutilization in wireless communication can be resolved in a good way utilizing Cognitive radio technology. Cognitive radios are created in order to support extremely dependable communications for each users of the network all time needed and to simplify effective usage of the radio spectrum at [24].

Energy saving by putting the node in low power (sleep mode) is periodically in [25] a fundamental mechanism in the WSN MAC protocols.

Which Mac Asynchronous protocol combines the estimation mechanism to predict the wake-up time efficiency for proper sending. Recently, the responsibility for basic communications is constantly transferred from the sender to the recipient. The change is actually logical, even though the receiver is ready to receive fast, effective, and responsive response to the connection brakes, and allowing target recipients is a potential problem. This will limit the unused frequency of the transmitters, while ensuring that the transmitter reaches the receiver pointer. Another method to explain this is that LPP-based MAC protocols provide high-efficiency, the amount of energy generated is usually less than the LPL-based MAC protocols in the traffic loading script, because the length of the MAC LPL protocol processes, the time to give the point A little longer. Which is more appropriate affiliate program. MAC protocols from asynchronous and arbitrary applications, nodes are the result of a long initial delay for the case report. This is a prospective study path in asymmetric MAC protocols. The concurrent MAC protocols connect a group of nodes to a common application. In this category, data transfer from the common exploitation period to the course has not been used. The sharing period applies to organizing the data channel in the blank period (sleep). Transition scheduling is a good way to reduce latency just for a package. They are very weak leakage. It is very necessary to provide a more robust planning program that can use the data transmission channel from sleep (inactive). MAC concurrent protocols may eventually be developed into a TDMA adaptive traffic application that works with the time of sleeping well with the efficient traffic environment. Similar events have been sighted in TRAMA, where the efficient usage of channels was not properly executed due to the lack of efficiency in the process of assigning the slots, which in turn causes a delay in the accessibility of channels during the cycles for the nodes.

# CHAPTER III

# CONCEPTS OF PARTICLE SWARM OPTIMIZATION

## 3.1. Particle Swarm Optimization

In computing, PSO refers to a Meta heuristic that evokes the behavior of particles in nature.

PSO techniques are originally qualified to investigators Kennedy, Eberhart [26] and Shi [27]. In the first step they were perceived to intricate models of social behavior [28], for instance the movement defined by living creatures in a herd of birds or a bank of fish. The procedure was basic and demonstrated to be suitable for optimization problems. The work by Kennedy and Eberhart [29] characterizes numerous theoretical sides of particle swarm optimization and swarm intelligence. A comprehensive study of PSO applications can be found in Poli [30].

PSO is a field of meta heuristic, as it assumes little or no hypotheses about the problematic to be enhanced and container be applied in large areas of elect solutions . Yet, like all fields of Meta heuristics, particle swarm optimization does not undertaking an optimum resolution in all cases.

### 3.1.1. Analogy with Nature

The bees in search of food try to locate the region of the space with greater density of flowers, since that is where presumably there is more amount of pollen . Each bee flies erratically through space, always remembering the region where it has seen more flowers. In turn, the swarm collectively knows the region of space, among all explored, where more flowers have been found. Each bee will individually vary its movement according to these two directions, flying somewhere in between. It is possible that the bee during the flyover finds a region with more flower densities than the one known until then (local optimum), or even that known by the swarm (global optimum); In the latter case, the whole swarm will guide the search for that new direction. After a time, if another region with greater floral density is discovered, the swarm will redirect the search towards there again, and so on.

### 3.1.2. Algorithm

A particle swarm optimization algorithm perform its work with a population (called a *cloud* or *swarm*) of elect solutions (called *particles*). These elements get about along the exploration area according to straightforward mathematical rules. The motion of each particle depends on its best location obtained, as well as on the best overall position found in the entire search space. As new and better positions are discovered, they move to orientate the motions of the particles. The procedure is repeated with the objective, not guaranteed, of finding at some point a satisfactory solution.

The above described can be formalized as follows: let $f : \mathbb{R}^n \rightarrow \mathbb{R}$ be the cost function to be reduced. The function $f$ takes as an argument a nominee solution, represented as a vector of actual numbers , and outputs a actual number that mentions the value of the objective function for the nominee solution obtained. The best locations correspond to the best values of the objective function $f$. The objective is to find an answer **to** check $f(\mathbf{a})$ less than or equal to $f(\mathbf{b})$ for all **b** in the exploration area, which would imply that **a** is the global minimum. The inverse process, useful in maximization problems, can be achieved by considering a function $h = -f$ .

Let S to be the number of particles in the cloud, every of which has a location $\mathbf{x}_i$ ℝ ℝ $^n$ in the exploration area and a speed $\mathbf{v}_i$ ℝ ℝ $^n$ . Let $\mathbf{p}_i$ be the best known location of a particle $i$ , and **g** the best known global location. A basic PSO algorithm might be described as follows:

- For each particle :

  - Initialize the location of the particle by a regularly distributed random vector, $x_i \sim U(b_{lo}, b_{up})$ ,and $b_{lo}$ and $b_{up}$ Are respectively the lower limit and upper limit of the search space.

  - Initialize the best recognized location of the particle to its primary location: $p_i \leftarrow x_i$ .

  - If $f(p_i) < f(g)$ Update the best recognized global location: $g_i \leftarrow p_i$ .

  - Initialize the speed of the particle: $v_i \sim U(-|b_{up} - b_{lo}|, |b_{up} - b_{lo}|)$

- As long as the stopping criterion (eg maximum limit of iterations, a satisfactory solution is not found), reiterate:

  - For each particle: $i = 1,...., s$ : then

  - For each dimension: $d = 1,...., n$ : then

  - Choose Unsystematic Numbers: $r_p, r_g \sim U(0,1)$

  - Update particle speed:
    $v_i \leftarrow \omega v_{i,d} + \varphi_p r_p (p_{i,d} - x_{i,d}) + \varphi_g r_g (g_d - x_{i,d})$

  - Update particle location: $x_i \leftarrow x_i + v_i$ .

- If $f(x_i) < f(p_i)$ so:

- Update the best recognized location of the particle: $p_i \leftarrow x_i$

- If $f(p_i) < f(g)$ Update the best overall location: $g \leftarrow p_i$

- Give back ***g*** as the best solution found.

The parameters $\omega, \varphi_p$ and $\varphi_g$ are defined by a specialist and regulate the behavior and effectiveness of the *PSO* method.

### 3.1.3. Parameter Selection

Two-dimensional graph showing the performance of a PSO variant against a benchmark of problems based on two parameters.

In PSO, the choice of the parameters is a determinant aspect in the performance of the optimization algorithm. Therefore, selecting a set of parameters that favor a good performance of the algorithm is and has been the subject of extensive research [31, 32].

In an intuitive way, it can be imagined that the objective function gives rise to a hypersurface of dimensionality equivalent to the number of parameters to be optimized (search variables). The irregularity of said hypersurface will, of course, depend on the particular problem. Also, the quality of the search will depend on how exhaustive it is, depending on the parameters chosen. In order to obtain solutions with a "little irregular hypersurfaces" in general few particles and iterations are needed; On the other hand, to obtain solutions of hypersurface "more irregular" requires a much thorough search, involving more quantity of particles and repetitions. This behavior is similar to that observed in real situations, The search for the best pastures carried out by transhumant livestock , where large herds have to traverse difficult and abrupt terrain to reach the best meadows (read global optimum), while smaller herds can suffice with less dense land in vegetation (optimum Local), using few iterations.

In PSO, the parameters can also be adjusted for various optimization scenarios [31, 33] using a "superimposed" optimizer, a concept known as meta-optimization.

### 3.1.4. Topologies

The basic particle swarm optimization usually simply incurs local optimum . This precocious concourse can be avoided by ignoring the best recognized overall location **g** , and instead attending to the best recognized location of the "surrounding" sub-swarm to the moving particle. This sub-swarm can be defined geometrically-eg. "The nearest m" particles - either socially, ie as a set of related particles, regardless of the distance that separates them.

### 3.1.5. Internal Operation

There are different interpretations as to how and why a PSO algorithm is able to optimize variables.

One commonly accepted notion by researchers is that "swarming behavior" varies between "exploratory behavior" (search in a broad area of the solution space) and "exploitative behavior" (local search that is rapidly approaching to an optimal, possibly local). This is the predominant criterion since the beginning of the PSO [34], and argues that the particle swarm optimization algorithm and its parameters should be carefully selected to achieve a proper equilibrium between exploration and utilization, In order to avoid a precocious concourse towards native optima, and, at the same time, ensure a good convergence rate at the global optimum. This interpretation has given rise to numerous variants within the PSO, as discussed below .

Another perspective argues that it has not yet been possible to understand exactly how the behavior of the swarm affects the quality of the optimization process, especially in optimization problems with multidimensional, discontinuous or time-varying search spaces. From this point of view, it would suffice to find algorithms and parameters that in practice give a good performance, regardless of what balance between exploration and exploitation the swarm adopts. This approach has led to the simplification of PSO algorithms, as explained in a later section .

### 3.1.6. Convergence

In the context of the PSO, the term "convergence" is usually used with two meanings (sometimes mistakenly as synonyms):

- Convergence can refer to the best recognized global location **g**, which approaches (converges) the optimal problematic, irrespective of how the swarm acts.
- Convergence can refer to a concentration of the swarm, where all the particles converge towards a point of the exploration area that may or may not be the finest.

In the literature we can find some attempts to mathematically analyze the convergence in PSO. These analyzes have served to establish guidelines for selecting the parameters that would determine the concourse, difference or fluctuation of the swarm particles, which in the end has led to new variants in the PSO [34, 35]. However, these analyzes have been criticized as being too simplistic, [20] they assume that the swarm possesses a single particle, without random variables, and that the best recognize location of the particle and the best overall location **G** of the swarm remain constant during the optimization process. Also, certain analyzes admit an unlimited number of repetitions in the optimization, that is not potential in a real scenario. Therefore, the study of the convergence characteristics of the various PSO algorithms and their associated parameters is strongly linked to the empirical results.

### 3.1.7. Biases

As the particle swarm optimization algorithm progresses, dimension by dimension, the answer point is informal to find if it is in an axis of the exploration area, diagonally or even easier, if it is right in the center [36, 37].

A principal way to avoid this bias, allowing for more balanced comparisons, is to refer to non-biased problems as a reference, and then to rotate or shift them [38]. Another option is to modify the algorithm itself to make it less sensitive to the coordinate system [39].

### 3.1.8. Variants

Even a basic PSO algorithm can result in numerous variants. Some of these options and their potential impact on performance have been discussed in the literature [40].

As a result, new and more sophisticated PSO variants are constantly emerging in order to improve the performance of the optimization process. Certain trends can be distinguished in the research carried out; One is to achieve a hybrid optimization method that combines PSO with other optimizer mechanisms [41, 42], eg. Incorporating an effective method of learning [43]. Another way of research is to counteract premature convergence (ie, the stagnation of the search at a local optimum), eg. Reversing or disturbing the drive of the particles. Another approach proposes dealing with premature convergence through the use of numerous swarms; this multi-swarm strategy is also applicable to multiobjective optimization. Also, advances have been made in adapting the behavior parameters during optimization.

### 3.1.9. Simplifications

As noted earlier, there is a current of opinion that believes that the PSO should be simplified as much as possible, as long as it does not affect performance, under the Occam knife . The simplification of the PSO was first proposed by Kennedy, and consumes since been extensively studied [44]. Improvements in performance, easier adjustment of parameters and more consistent behavior in the face of different optimization problems have been observed.

Another argument in favor of simplification is that the efficacy of a metaheuristic can only be empirically tested by testing on a finite number of optimization problems [45]. The bias was due to a programming error, which has already been corrected.

If it is desired to initialize the velocity associated with the particles, additional inputs are required. A simple APSO sample code is available *online* [46].

### 3.1.10. PSO Binary, Discrete and Combinatorial

At each iteration, the algorithm identifies a new "optimal candidate" in the research space, based on a specific quality measure (fitness). The PSO is part of the aegis of meta-heuristics, since it does not make any assumptions about the problem and allows the exploration of vast spaces of solutions. As the algorithm is structured, however, there is no guarantee that the optimal solution will ever be found.

The algorithm does not use a gradient in the course of optimization, so the differentiation of the problem to be analyzed is not required, which instead happens in traditional optimization methods such as the descent of the gradient. For this reason, it can be successfully used in irregular, noisy, time-varying optimization problems, and so on.

The PSO move in the examine space on the basis of simple formulas, which take into account their current displacement speed, their knowledge of the space of fitness (ie the best solution they have explored so far) and shared knowledge (ie the best general solution identified). The algorithm allows you to weigh these three components (inertia, cognitive and social) and uses small random jittering to minimize the possibility of trapping in local minima.

The PSO is generally credited to Kennedy, Eberhart and Shi, [47] who introduced it in the study of simulated social behaviors, studying the movement of flocks of birds or shoals of fish. The algorithm was simplified when it was realized that it could perform optimization [48].

However, the calculations of motion make use of operatives that control four actions:

- Calculate the difference between two positions (the result defines an offset)
- Multiply a speed by a numerical coefficient
- Add two speeds
- Apply a velocity to a location [49].

## CHAPTER IV

## SIMULATION RESULTS

### 4.1. Proposed Method

In this thesis we used particle swarm intelligent for wireless sensor network. We select the 200*200 meter area and 100 sensor randomly in this area. The schematic of proposed method is presented in Figure 4.1.

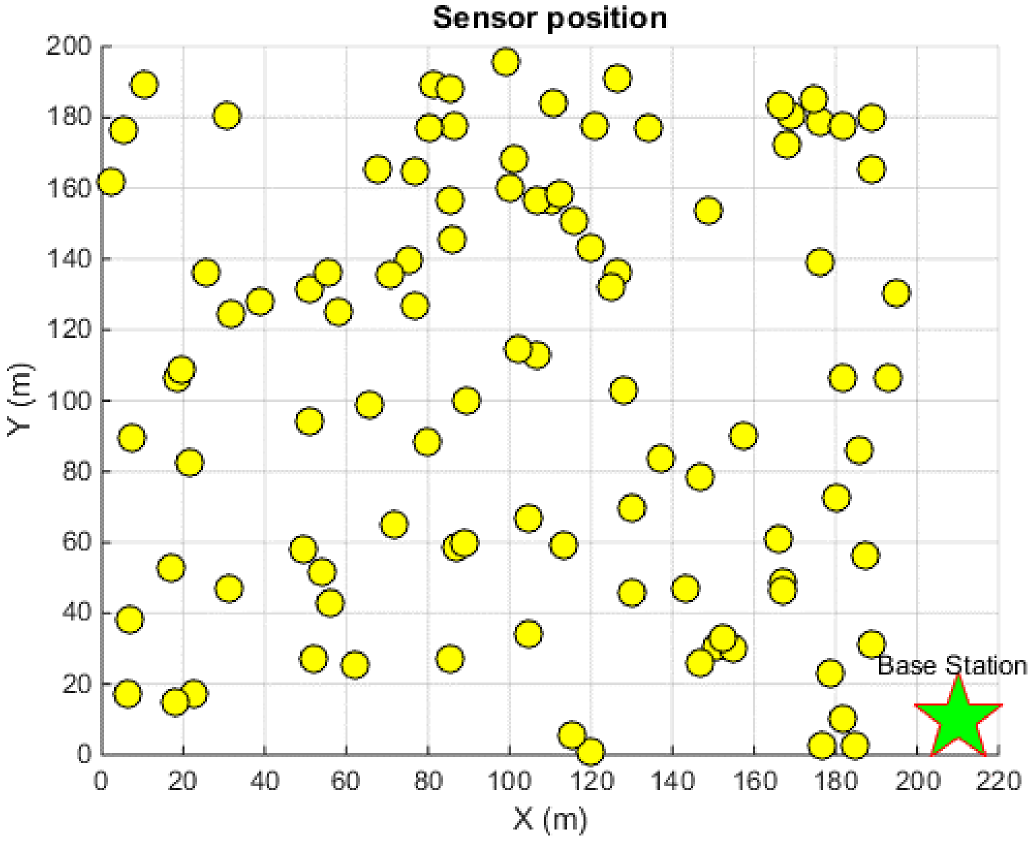


**Figure 4. 1.** The schematic of proposed method

As shown in this figure we select the base station in the right down side. These sensors selected randomly and in each running the position of these sensors will be change.

## 4.2. Summary of Proposed Method

The flow chart algorithm is shown in Figure 4.2.

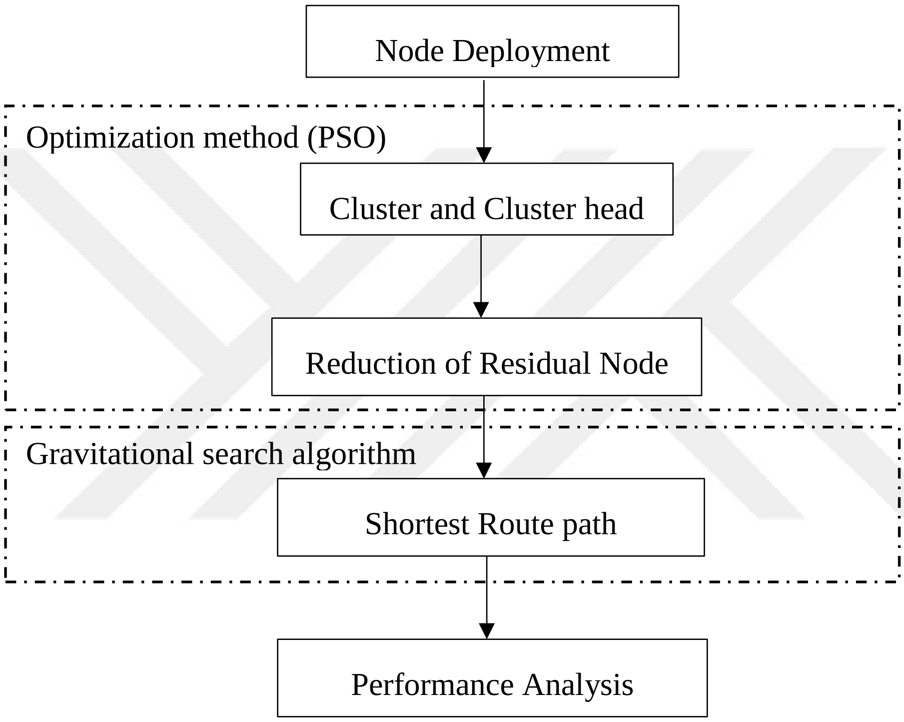


**Figure 4.2.** Summary of proposed method

In this thesis, flowing steps have been used for performance analysis:

1. Residual Node Reduction
2. Load balancing Ratio
3. Reduce the total energy consumption
4. Increase the packet delivery ratio
5. Increase the network lifetime

The first cluster and cluster head is shown in Figure 4.3.

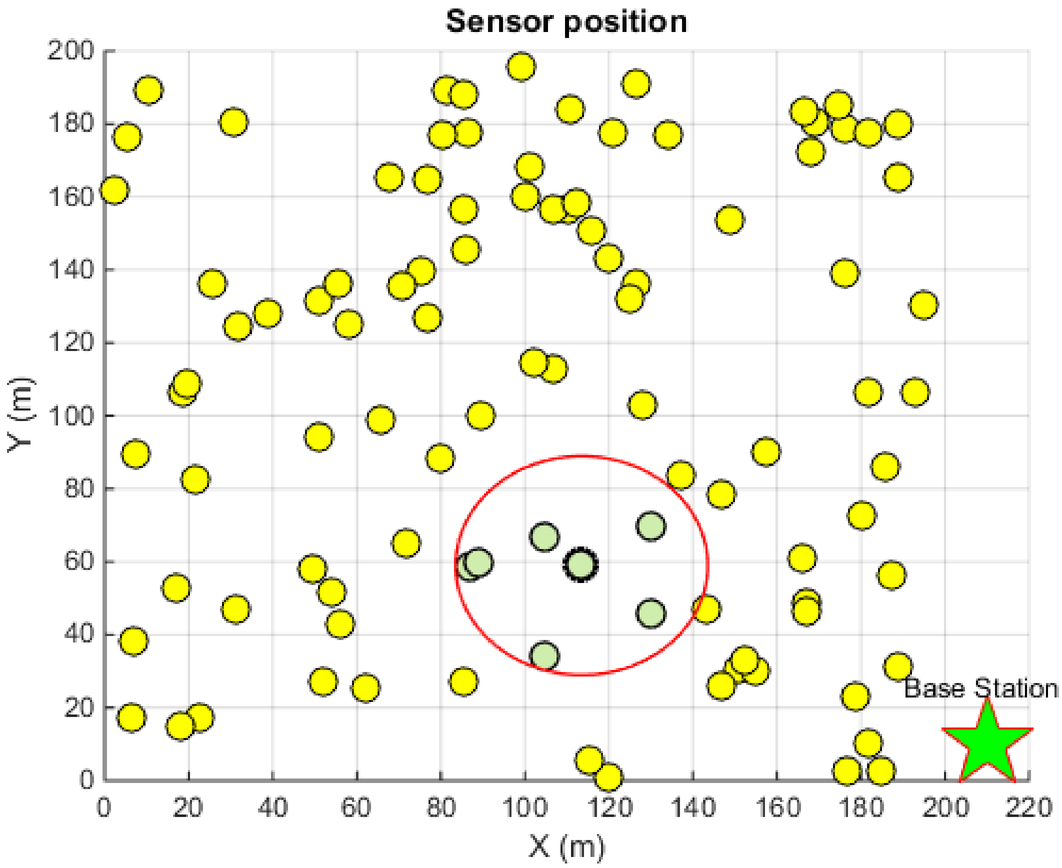


**Figure 4.3.** The first cluster and cluster head

The second cluster and cluster head is shown in Figure 4.4.

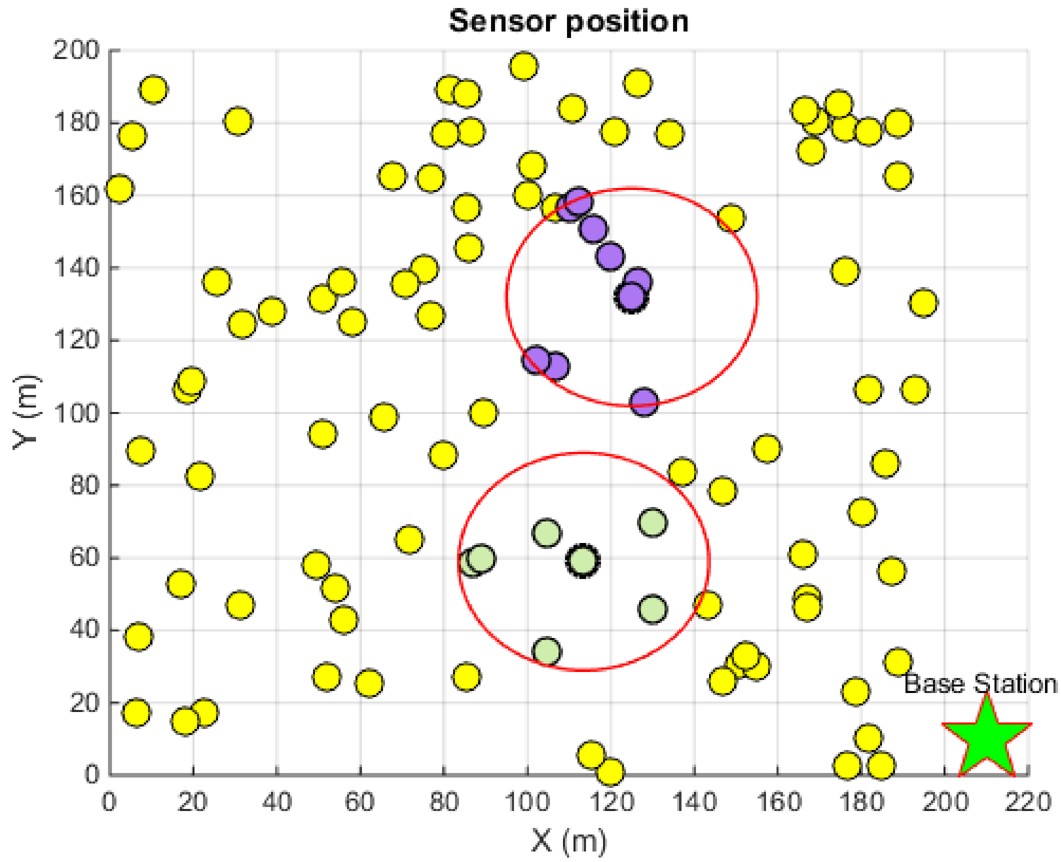


**Figure 4.4.** The second cluster and cluster head

The all cluster and cluster heads is shown in Figure 4.5.

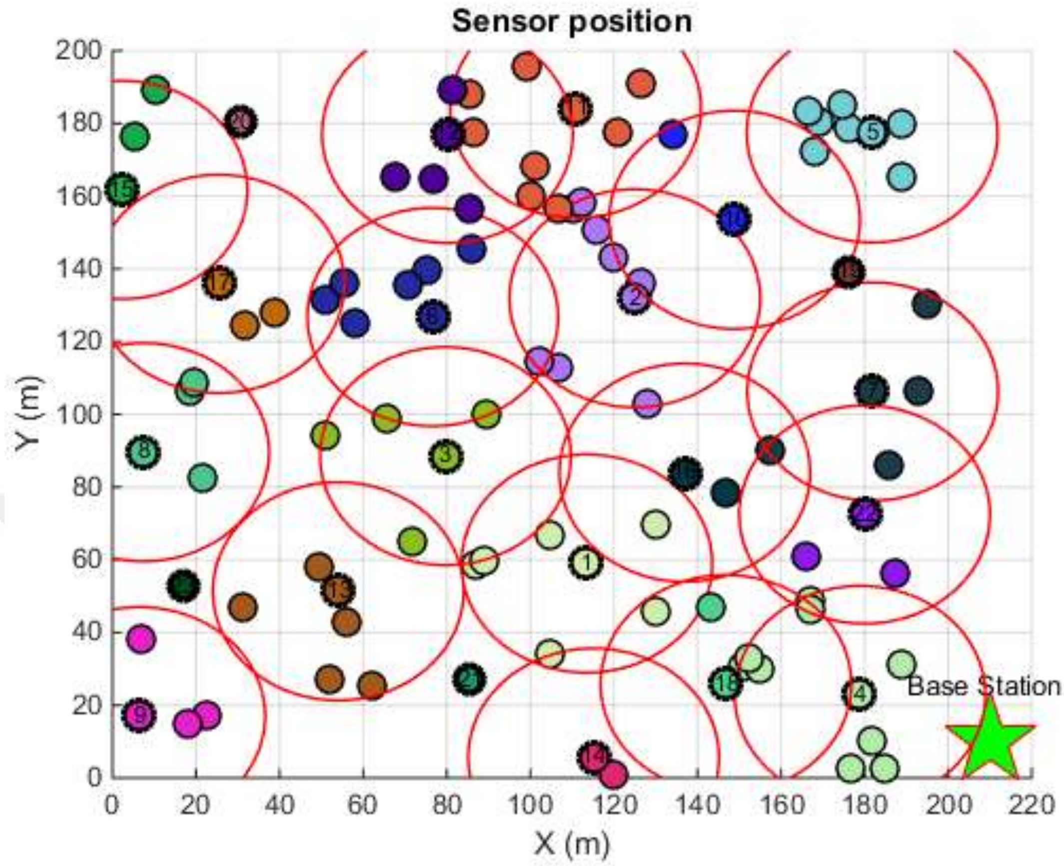


**Figure 4.5.** The all cluster and cluster head

As shown in this figure there are 19 clusters. These clusters in each run will change and the cluster head will create.

The first routing is shown in Figure 4.6.

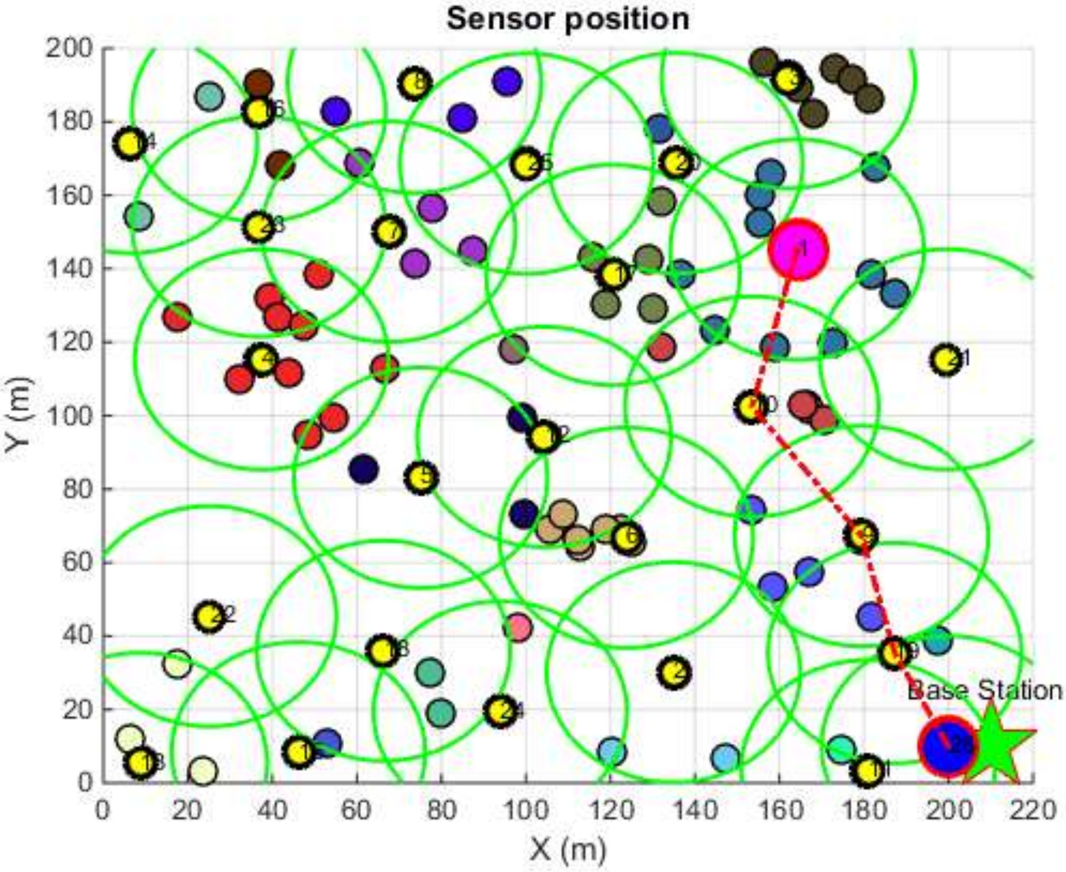


Figure 4.6. The first routing in cluster head sensor

As illustrated in this figure the shortest path has been selected between the cluster heads. Totally 5 cluster head is selected for sending of the data to the base station. This means the 5 cluster head will use the energy for sending the information. If the route is long that time the energy which use will more than the short path. For example if there is only one cluster head for sending the energy that time this cluster head will use low energy. This scenario is shown in Figure 4.7.

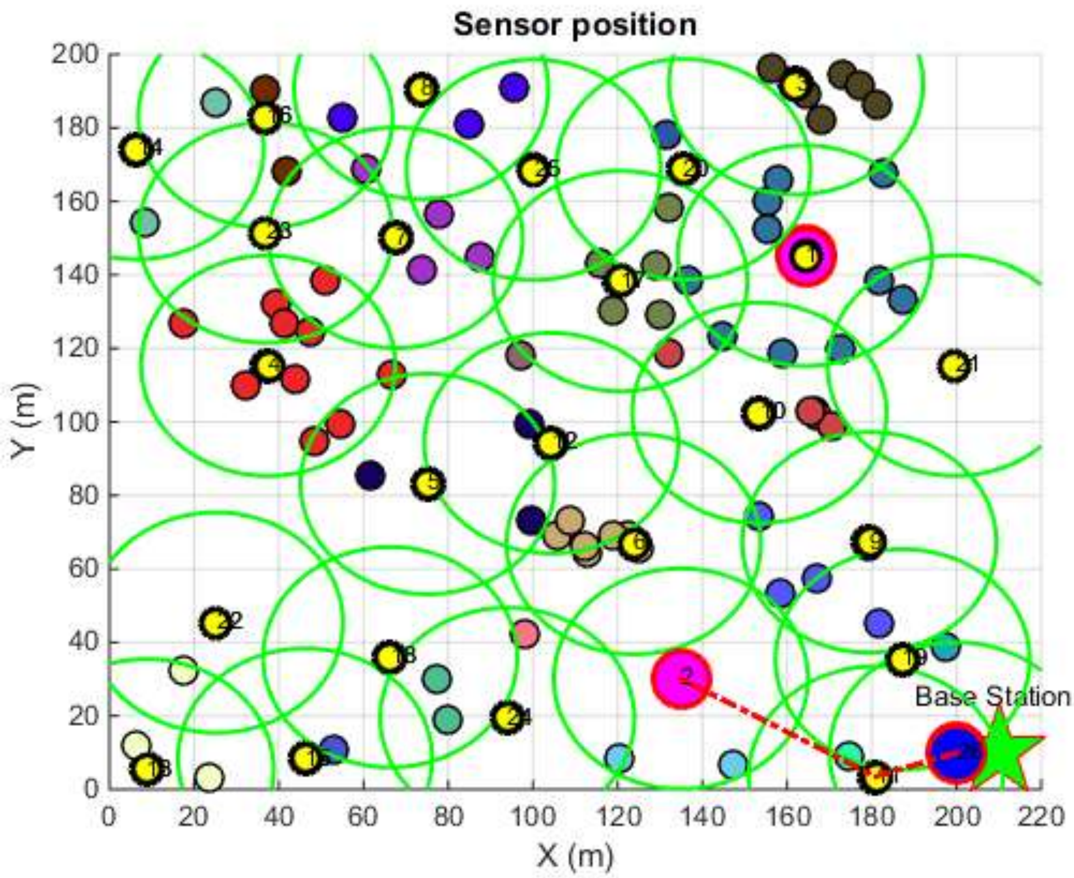


**Figure 4.7.** The shortest path scenario

The last routing is shown in Figure 4.8.

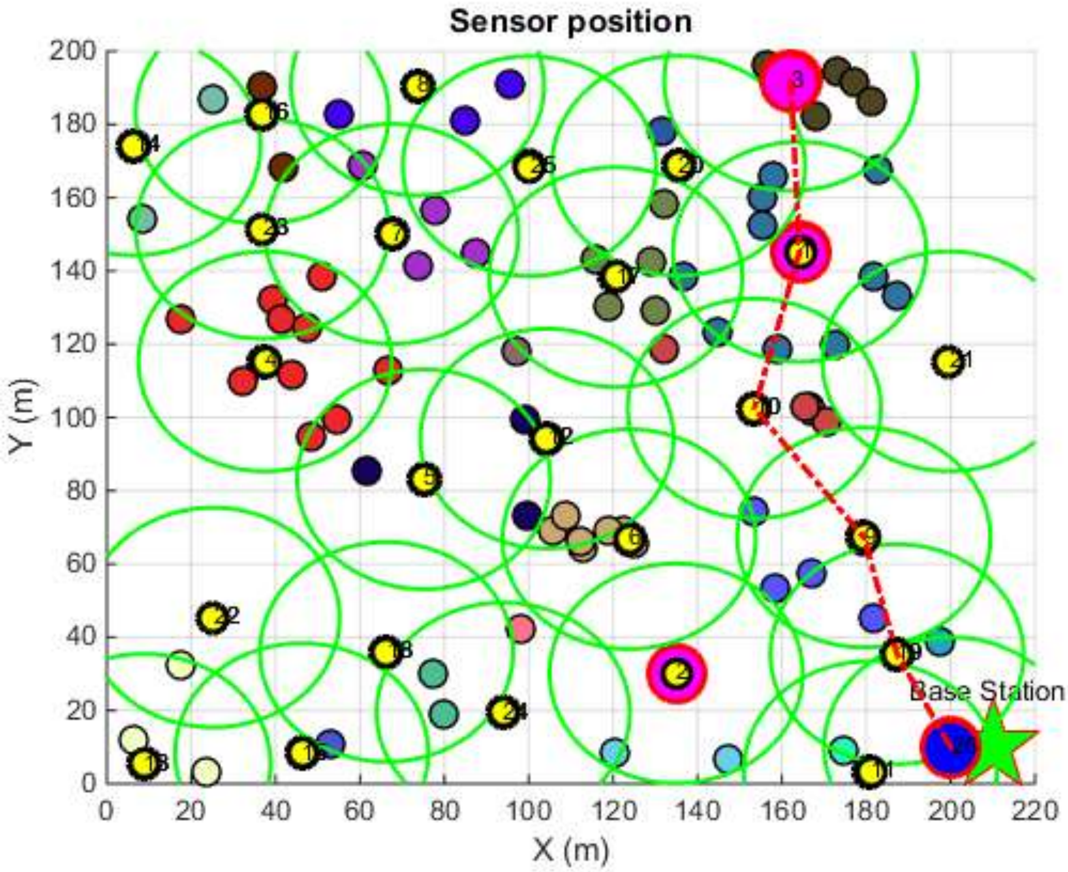


**Figure 4.8.** The last routing

After finishing of the routing protocol we calculated the 4 parameter. These parameters are total energy feeding, throughput, packet delivery ratio and overall network lifetime. Total energy consumption is shown in Figure 4.9.

In this thesis we compared the proposed technique with LEACH and Optimized Energy Efficient Routing Protocol (OEERP) methods. In the OEERP method [50], the lifetime of a WSN is improved by using a cluster-based protocol in which the node acting as the cluster header changes over time in each slot. This WSN life cycle improves mainly for two reasons. The first reason is that the unloading of the battery is uniform in nodes, and the second reason is that no node for infrared transmitters for a long time does not depend on access to the access point.

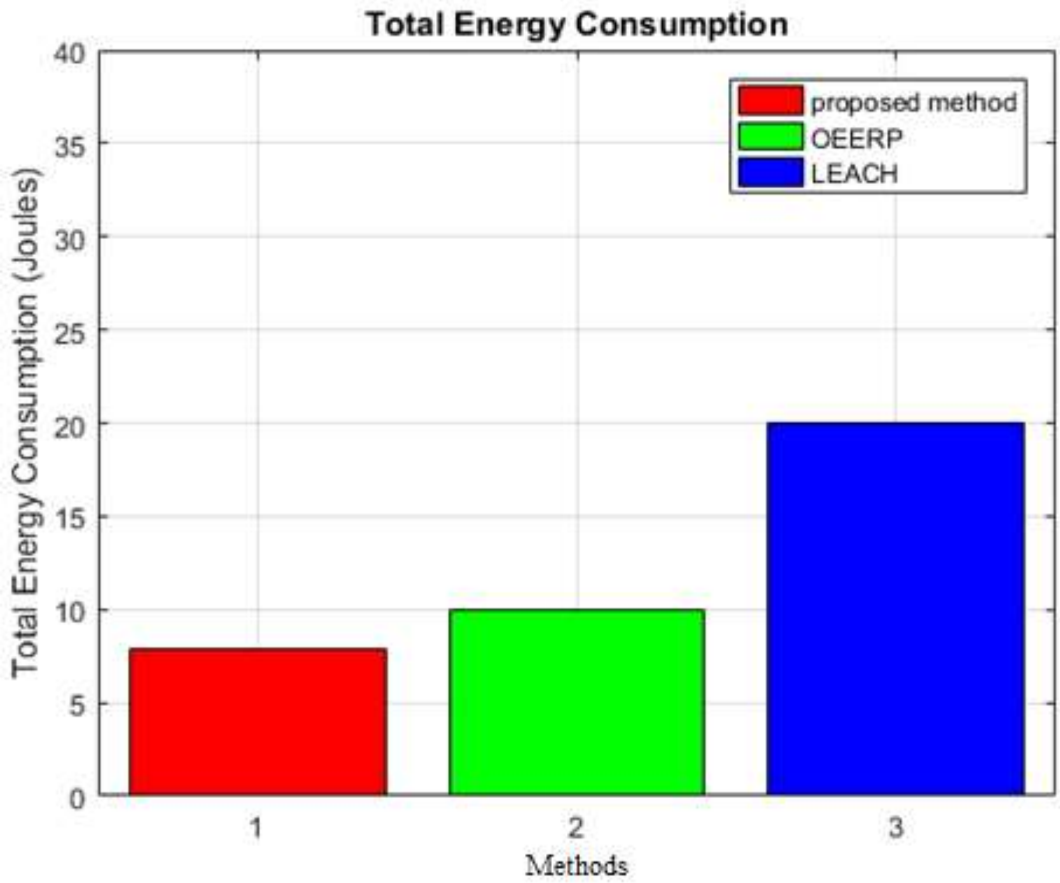


**Figure 4.9.** Total energy consumption vs. time.

As shown in this figure the proposed method has lowest one than the other two method. This value is about 8 Joules. The OEERP method has 10 Joules and the highest one is the LEACH method which its energy is 20 Joules. We reduced 20% the energy consumption from OEERP and 60% from the LEACH method.

The throughput is shown in Figure 4.10.

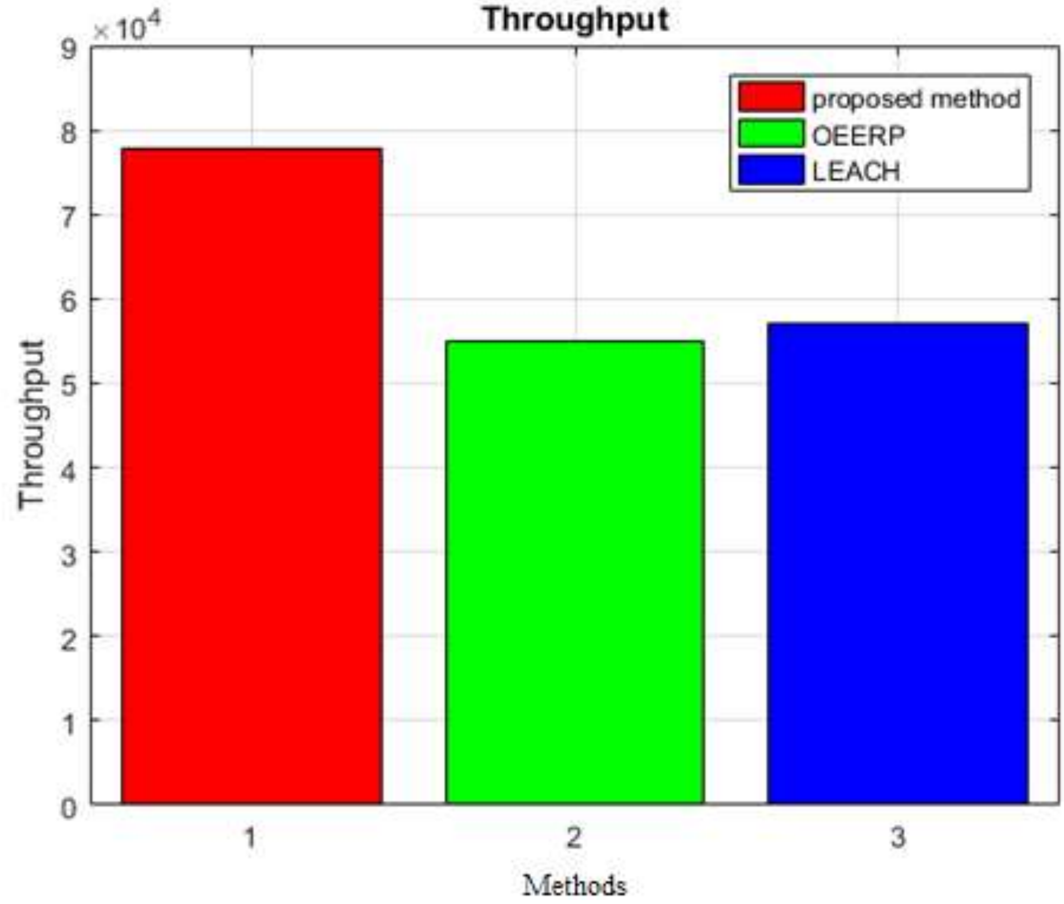


**Figure 4.10.** The throughput vs. time

The throughput of the proposed is high than the other methods. That’s mean the power operation of proposed method need more than the other methods.

The packet delivery ratio is shown in Figure 4.11.

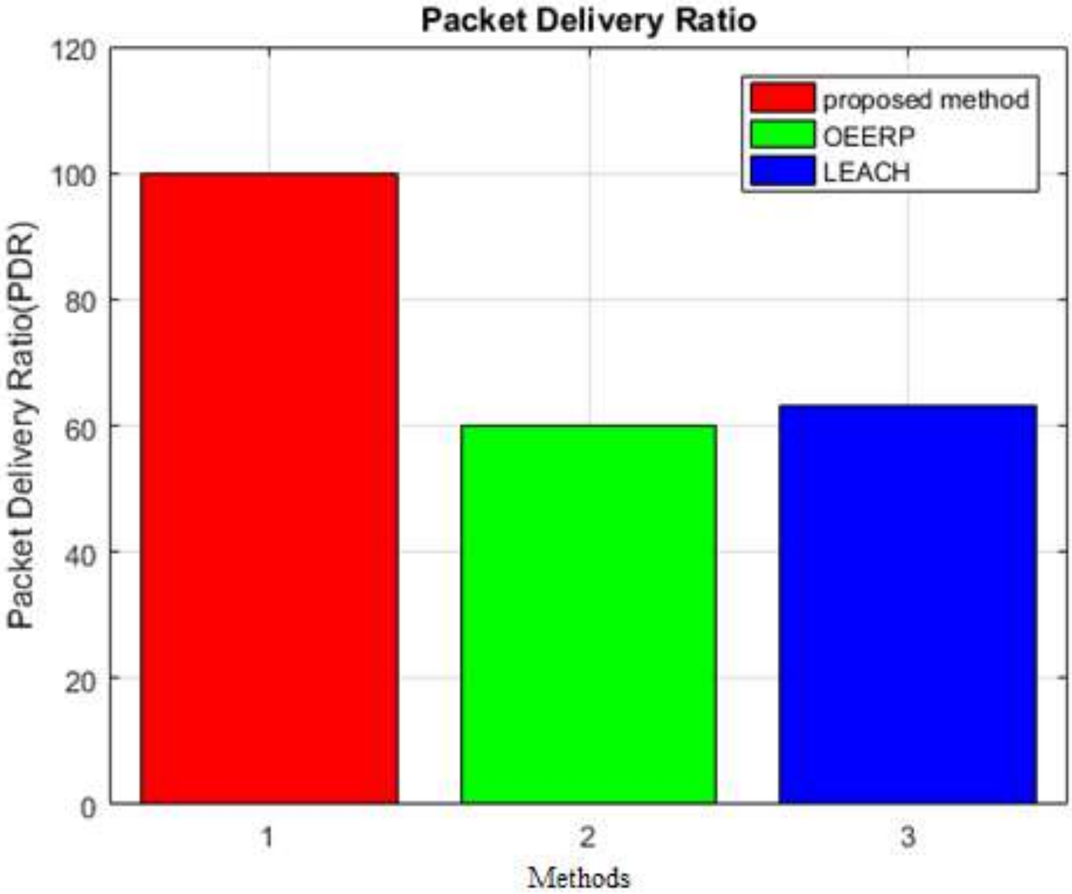


**Figure 4.11.** The packet delivery ratio vs. time

The packet delivery ration in proposed method is high than the other methods. As shown in Figure 4.11 the packet delivery is 100. This values only the base value and for 4000 bit packet that time 400,000 packet will send to the base station. For OEERP and for LEACH this value is 60 and 64 respectively. We increased the packet delivery ration approximately 1.67 times that the other methods.

The overall network life time vs. time is shown in Figure 4.12.

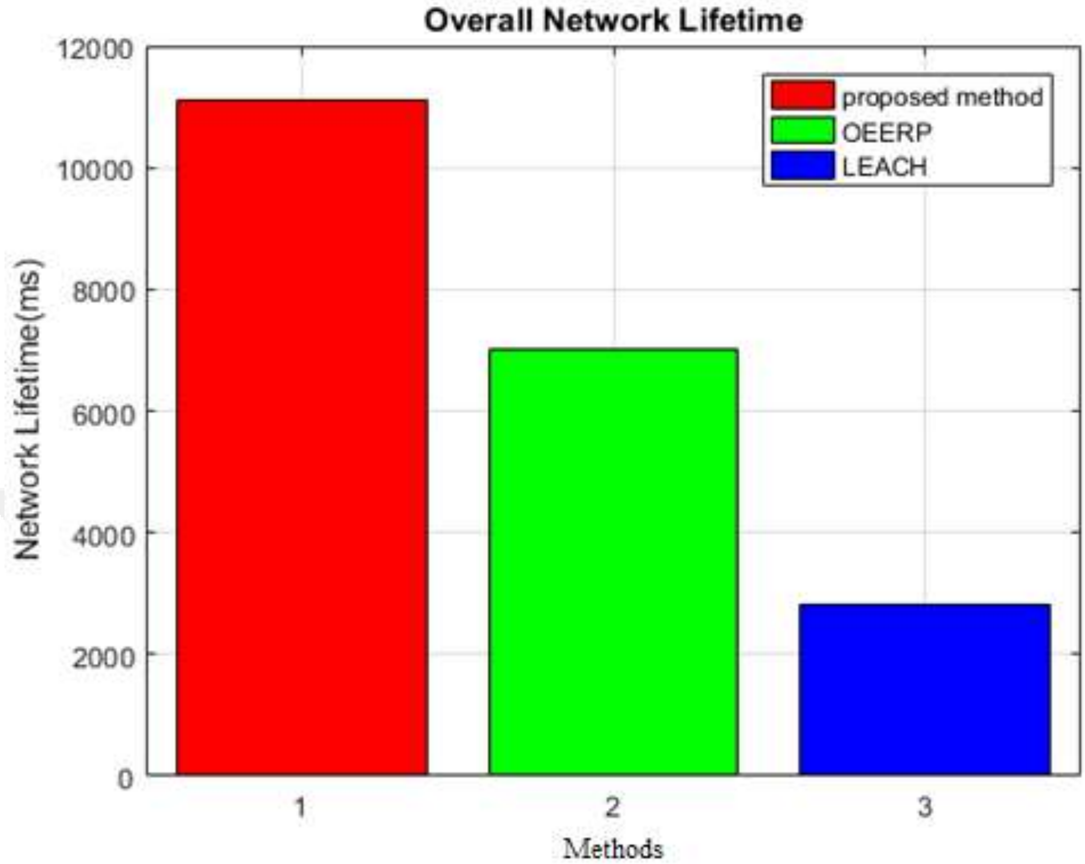


**Figure 4.12.** The overall network life time vs. time

Also the overall lifetime for proposed method is 11000 (ms). For OEERP and for LEACH this value is 7000 (ms) and 3000 (ms). As seen from the result we improved the overall lifetime and the improving factor for OEERP and LEACH is 36% and 72% respectively.

## 4.3. Advantage and Disadvantage for Each Algorithm That We Used in Our Work

In leach method the sensors send their data to CH and cluster head send this data to BS. In proposed method the sensors send their data to CH and then this cluster with the best route send to base station. This situation shows in Figure 4.13 and 4.14.

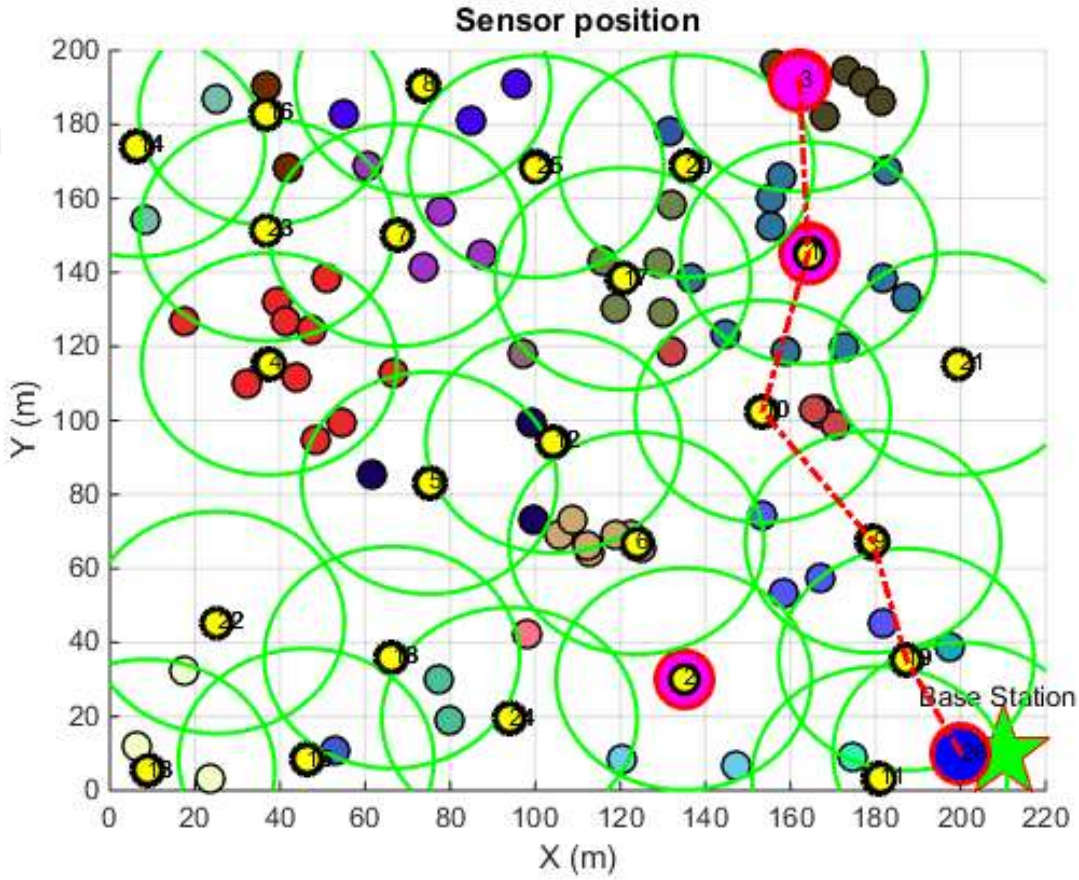


**Figure 4.13.** CH send the information by other CH to base station.

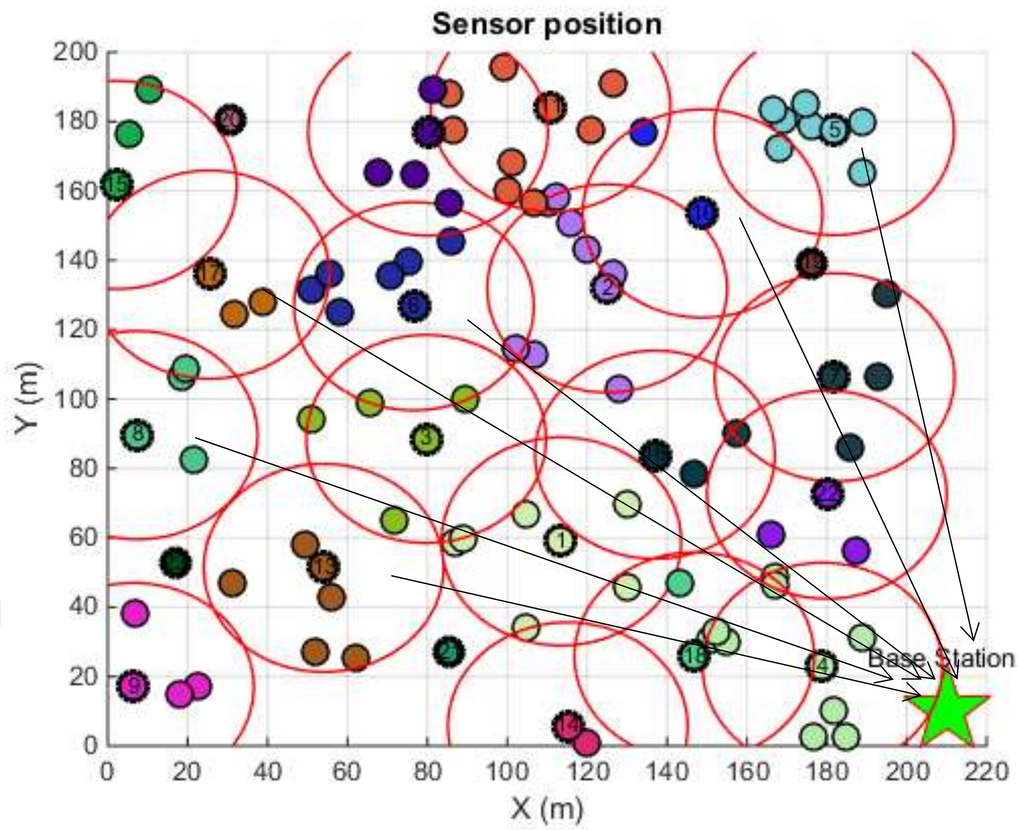


**Figure 4.14.** CH send their information directly to base station

With this method (LEACH) the CH will lose a lot of energy, but in proposed method the CH will not use huge energy. Also with PSO method the sensors will find the best CH for sending the information.

The advantage of the LEACH is to find the CH randomly and they send information fastly to BS. But in this method the life time will not more.

The advantage of PSO method is to saving more energy and finding the best CH. About transferring the data is disadvantage and the transferring data need more time. Because the CH will not send their information directly to BS and they send their information by the other CH.

## 4.4. The Details of Comparing

The comparison between PSO method and LEACH method is based on the:

i. Increasing the energy consumption
ii. Increasing the Throughput
iii. Increasing the Packet delivery ration
iv. Overall network lifetime

In this thesis we improved these 4 criteria.

We compared our result with OEERP method which available in [50].

We show that proposed method has good performance than these two methods (LEACH and OEERP)

## 4.5. Advantage and Disadvantage of Clustering Technique

The advantage of the clustering method is saving more energy. With clustering method the sensors will not send their information directly to BS. If they send their information directly to base station that time they use more energy. This situation shown in Figure 4.15.

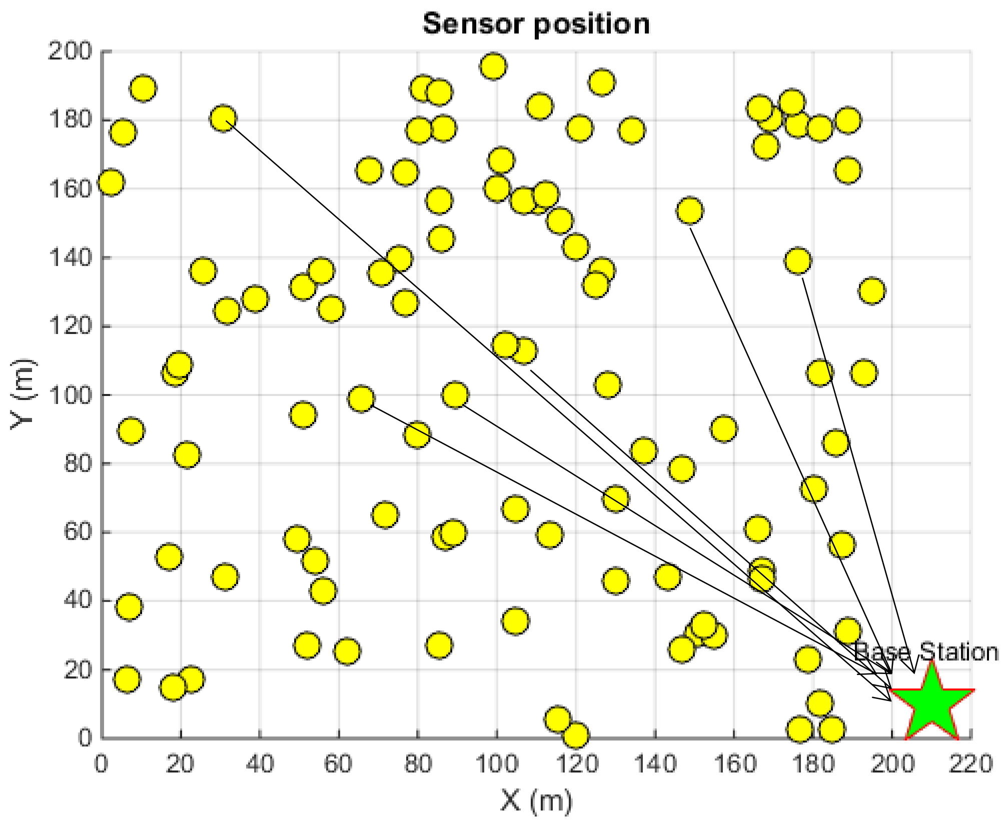


**Figure 4.15.** The sensors send directly their information to BS

In clustering method the sensors send their information to CH and this CH send to base station. This situation shown in Figure 4.13.

As shown in this figure the sensors will save a lot of energy than the without clustering method. In this method just CH will use more energy, but in each round the CH will change.

# CHAPTER V

# CONCLUSION

## 5.1. Conclusion

In the proposed method, the energy of the efficient routing is enhanced and the system used the Particle Swarm Optimization for eliminate the individual nodes in WSN. In this thesis the Gravitational Search Algorithm is used for finding the subsequent finest hop. The location of the nodes, force between the CH and velocity are measured for selecting subsequent finest hop. This method removes the individual node foundation that results in relatively best network lifetime. This method improved the network lifetime. The data loss efficient is reduced. Also the performance level was high.

In simulation result the 20% of the energy consumption from OEERP and 60% from the LEACH method is reduced. It mean that the proposed method is 40% of the LEACH and 80% of the OEERP. In proposed method the packet delivery ratio is high than the OEERP and LEACH method. As result the packet delivery is 100. This values only the base value and for 4000 bit packet that time 400,000 packet will send to the base station. The packet delivery for OEERP is 60 and for LEACH this value is 64. Proposed method increased the packet delivery ration approximately 1.67 times that the other methods. The overall lifetime for proposed method is 11000 (ms). For OEERP and for LEACH this value is 7000 (ms) and 3000 (ms). As result shows the overall life time and the improving factor for OEERP and LEACH is 36% and 72% respectively is improved.

## 5.2. Future Work

In future work we can implement the proposed method on the devices and then we can get the result. Also for routing we can use the ant colony optimization for instead of the particle swarm intelligent for the finding of the best routing between the CHs and the BS. Ant colony use the minimum distance among the nodes and the CHs. Also ant colony is not guarantee way to finding the minimum distance. But this method can test and analysis on the network.

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