COVERAGE IN WIRELESS SENSOR NETWORKS

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COVERAGE IN WIRELESS SENSOR NETWORKS

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ABSTRACT

COVERAGE IN WIRELESS SENSOR NETWORKS

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Wireless Sensor Networks are developing as a key sensing technology, with various military and civilian applications. In these networks, a large number of sensors are distributed to sensing a target field. The sensors coverage mean that every point in the target field is sensing by at least one sensor. Each sensor is a limited battery-operated device that can sense events in its sensing range and can communicate with neighboring sensors. Since the life time of the sensor is dependent on its battery, where this battery is impossible to replace or recharge it in rough places, it is necessary to find an efficient energy way for it. Consumption of these limit energy batteries can result in the end of network life itself. Therefore, extending the lifetime of wireless sensor networks is important. Designing a schedule for sensors is an important goal in sensor networks to maximize the lifetime of the network. In this thesis presents a different way of scheduling to increase the lifetime of wireless sensor network. At all times, half of the full coverage is provided. Each sensor in our algorithm only needs to know the distances between its neighbor nodes and its sensing areas.

Simulations show that new proposed algorithm noticeably improves several existing lifetime maximization algorithms. Also it improves the runtime.

Keywords: Wireless Sensor Networks, Sensors Coverage, Maximization the Lifetime of WSNs

ÖZ

KABLOSUZ SENSÖR AĞLARINDA KASPAM

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Kablosuz Sensör Ağları, çeşitli askeri ve sivil uygulamalarla birlikte, temel bir algılama teknolojisi olarak gelişmektedir. Bu ağlarda, büyük sayılardaki sensörler, hedef alanı algılama amacıyla yayılmıştır. Bu sensör kapsamı, hedef alandaki her noktanın, en azından bir sensörle algılandığı manasına gelir. Her sensör, kendi algılama aralığındaki olayları algılayabilen ve komşu sensörlerle iletişime geçebilen ve sınırlı bir pille çalışan bir cihazdır. Sensörün ömrü, piline bağlı olduğundan, pilin değiştirilmesinin ya da engebeli yerlerde onu yeniden şarj etmenin imkânsız olduğu yerlerde, bunun için enerji tasarruflu bir yöntem bulmak gerekmektedir. Bu sınırlı enerji pillerinin tüketilmesi, ağ ömrünün sonlanmasının ta kendisiyle sonuçlanabilir. Bundan dolayı, kablosuz sensör ağlarının ömrünü uzatmak önemlidir. Sensörler için bir program tasarlamak, ağ ömrünü en üst seviyeye çıkaracak sensör ağlarında önemli bir hedeftir. Bu tezde, kablosuz sensör ağ ömrünü artıracak, farklı bir program şekli sunulmaktadır. Daima, bütün kapsamın yarısı sağlanmıştır. Algoritmamızdaki her sensör, sadece kendi komşu ağları ve kendi algılama alanları arasındaki mesafeleri bilmeye ihtiyaç duyar.

Simülasyonlar, algoritmanın, mevcut birkaç tane, ömrü en üst düzeye çıkarma algoritmasını gözle görülür bir biçimde geliştirdiğini göstermektedir. Ayrıca bu işleyiş süresini de artırır.

Anahtar Kelimeler: Kablosuz Sensör Ağları, Sensör Kapsamı, Kablosuz SensörAğları’nın Ömrünün En Üst Seviyeye Çıkartılması (Maksimizasyonu).

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LIST OF ABBREVIATIONS

CCP	Coverage Configuration Protocol
DSSP	Differentiated Surveillance Service Protocol
FPGA	Field-Programmable Gate Array
MB	Megabyte
OGDC	Optimal Geographical Density Control
QOS	quality of services
RF	Radio Frequency
SA	Simulated Annealing
SDRAM	Synchronous Dynamic Random Access Memory
SQL	Structured Query Language
SRAM	Static Random Access Memory
TV	Television
WSNs	Wireless Sensor Networks

CHAPTER 1

INTROD U C T I O N

Wireless sensor networks (WSNs) are designed to monitor an environment, in which there are a large number of sensors(nodes) with sensing, signal processing and wireless communication capabilities and restricted battery energy can distributed and collaborate with another one in data collection. The network can collect data that are sensed by each sensor and transmitted it to the sink. Because sensors are flexible and cheap, they have a wide range of surveillance applications for example monitor the environment such as (traffic and seismic monitoring, fire detection, earthquake and volcanoes sensing [1], weather predicting [2], [3], [4], chemical discovery, biomedical health monitoring, natural disaster relief [5], and can be used to monitor the places where the presence of human is impossible or dangerous [6] such as in the depth of the sea, polar regions, and dangerous war zones.

There are two main issues used to evaluate WSN's effectiveness, coverage and lifetime. Coverage in a WSN is important to guarantee that the monitored area is covered completely with a higher reliability. Coverage is essential because it has an effect on the sensors deployment, the placement of these sensors, connectivity, and power. Coverage is interrelated to sensor placement. A higher degree of coverage requires various sensors monitoring the same location to produce more reliable results.

On the other hand, the strict lifetime is the requirement of the surveillance application, which demands the network to work for a specified period of time at least. Unlike other battery-powered tools, a sensor's battery impossible to be recharged and it is difficult to replace the expired batteries for sensors because of logistics issues such as inaccessibility or remoteness of distribution areas. While the energy of wind and solar can be used, but such energy supplies are unreliable. So using energy efficiently will leads to maximize the network lifetime. The number of active nodes and communication between the network determine network sensor lifetime.

Routing and power maintenance are depend on the time synchronization in a wireless sensor network. The time inaccuracy is cause to reduce of the network’s lifetime. When there are less clashes and resend or nodes are duty-cycled, the energy will be saved. The nodes can cooperate and transfer data in a scheduled way by the synchronization of total time.

Electing a set of active sensor nodes through central control by a defined protocol is an important technique for extending the network lifetime, and there are a different methods has been offered in literature [7], [8], [9], [10], [11], [12]. In [13] proposes a scheduling scheme which occasionally picks a subset of nodes to execute the network tasks and sends the remaining nodes to energy-saving state.

Scheduling technique of the sensor activity is the base of the method of dividing all sensors into separate sensor subsets or sensor covers and each sensor cover needs to satisfy the coverage constraints.

Our goal is to schedule the sensor activity within the designated period to extend the total lifetime as max as possible. Since the battery lifetime of sensors may not be enough to cover for the whole period, we define a way to schedule the sensors to improve the performance of the network and extend its lifetime. In particular, the effective coverage time of any sensor is defined as the sum of the importance factor of the locations that sensed by this sensor.

The objective considered in this work is to maximize lifetime while always half coverage is provided. First, calculate the individual coverage time at all sensors, then start the scheduling of the sensors by choosing the one with max coverage and check if its coverage is greater than the half coverage or not. When the equation is true this sensor will be scheduled and the lifetime of network equal to (10), if not, choose another one among the ones with minimum intersection with current chosen node to achieve the equation, repeat the choice process for all sensors and every time the equation is realize the network's lifetime will be increased by (10).

The total lifetime will be the product of multiplying (10) by the times when the equation is achieve.

CHAPTER 2

WIRELESS SENSOR NETWORKS

2.1 Remote Sensing (Sensor)

There are many definitions of remote sensing, and the following are the four most important of these definitions:

- Total operations, which allows to obtain information about something, without that there will be no direct connection between it and the device of capture this information.
- Is that science, which uses the properties of electromagnetic waves reflected or emitted from terrestrial objects, or from the air, or from sea or ocean water to Identify them.
- Group agents of planes, satellites, balloons, and data capture devices, receiving stations, and the group receiving the data processing programs, which allow an understanding of materials and phenomena through their spectral properties.
- Is the science in which can get reflectance and spectral behavior of data objects, which can be transformed into information through the induction treatment processes.

So term of "remote sensing" is used to mean a set of data, which we get from a certain distance, as a result of the interaction of electromagnetic radiation energy with the item, or the circumstance that we study, and measured by one way of remote sensing.

These definitions are sometimes in a high degree of complexity, so the studying of materials and wealth ground and its contains which is not far from the devices make use of "remote" phrase a position to question sometimes. Also Some of them believe that the other media violation of radiation energy for example the sound must be covered by these definitions.

2.1.1 Types of Remote Sensing(Sensor)

Remote sensing Can be classified according to the type of the receptor data into:

A. Active Remote Sensing :

The receptor data in this type is spectral reflection, where the carrier platforms of sensors send electromagnetic waves to the targets to be studied and crash with them and then reflected to be picked up by sensors that send to the Ground Reception Stations.

B. Passive Remote Sensing:

Receiving data in it is spectral emission of objects.

2.1.2 Remote Sensing Techniques

Sensing techniques depend on carrying multiple types of sensors to record the phenomena to be studied and measured, based on the concept that anything radiates and reflects the amount of electromagnetic energy, are often in distinct groups called "Spectral Signature " describes information about a particular property of the body.
In general, the radiation can be reflected through the body, absorbed or get distracted by the body, or may be reflected, which means that the radiation return without change, in this case the body is like a mirror.

The wavelength of each material will determines the choice of previous interactions, which mainly depends on the structure of molecules and surface properties, and this is the measurement rules by remote sensing. It is worth mentioning that the atmosphere of the earth has some features for its own, and influential in the choice of optical ranges in sensor.

Each remote sensing device accuracy is different from the other by degree of differentiation resolution which achieved by the monitoring of targets, and this depending on the properties of each material for reverse rays falling on it, or absorbed part or whole of these ray.

2.1.3 Remote Sensing Mechanism

Sensing mechanism is passing through four stages

1- Collecting the information by the sensors, and broadcast it to the ground receiving stations.
2- Processing and correcting this information is subject to pretreatment, and then final processing.
3- Interpreting this data after convert toed it to images.
4- Using the images to drawing of accurate data and maps.

2.2 Definition of Wireless Sensor Network

Wireless Sensor Networks is a collection of sensors (sensor nodes) which are used for transmission or follow-up a specific physical or chemical phenomenon (such as temperature, humidity, vibration, light etc ...), then transfer the information about the phenomenon wirelessly to the data processing center to take advantage of them without human interiority in the place of the physical phenomenon.

2.2.1 What is the Sensor (Sensor Node) ?

The sensor is a device that has a microprocessor with a monitoring capacity and wireless connectivity and may also contain small screen to display readings, usually sensor suffers from small size of memory of both types fixed and volatile, also suffers from limited energy stocks.

2.2.2 Sensor Components and the Idea of Its Work:

Sensor components consists of the following modules:

1- Sensor Unit.
2- Memory and Micro-controller.
3- Recover & Transmitter Unit.

The unity of the sensor consists from a sensing device and tool which converted data from analog to digital. The main task of this unit is to convert sent or received data formula to suit with the nature of the data that used in the storage and processing unit. In the beginning strong received signal from sensor and then convert it to digital format through data conversion tool, and the storage and processing unit are an accurate chip have limited memory unit and data process.

As a complement to the preceding two units there is a transceiver module, consists of a device to send and receive radio waves through the antenna installer in sensor.

In addition to the above-mentioned units, there are three optional modules, namely:

- Location determine Unit-its design depend on application type that used and its function determine the coordinates of the sensor in the control field compared with a fixed point.
- Movement Unit is used to move the sensor from one place to another depending on the requirements of the network.
- Energy Generating Unit where the re-mobilization of energy stocks.

The modern applications in the wireless areas of sensors requires devices with large default life time, on the other hand, these devices usually have a limited source of energy, also there are several factors that effect on energy consumption, for example, energy affected by the following factors:

- Inputs Received.

- Processing.
- A period of transmitter and receiver.
- Environmental conditions such as temperature surrounding.
- Accuracy of required readings.
- Radio waves are used.

2.3 Energy

Sometimes provide each sensor device with two of battery type AA recharging, but with use of hundreds of thousands of these devices in the field monitoring recharge the batteries are considered useless process, So should search for new strategies for energy conservation, such the process of integrate chips logic programming (FPGA) with sensor device (ATMEL) .

Take advantage of the means of renewable energy such as solar or generated by vibration an important means by which will overcome on energy problem.

2.4 Memory Size

The sensors contains memory modules with small size, which leads to minimize of time that required to store the data before analysis or sent it to neighboring devices, the old types of sensors used volatiles techniques memory with both types of (SRAM) and (SDRAM) while the new sensors contain these two types of memory together as built in chip device itself as well as the use of external memory shiny, for example, the sensor (Imote 2) contains a built-in memory with a capacity of 256 KB and 32 MB of type (SRAM) and 32 MB of type (SDRAM), in addition to the 32 MB of flash memory. Although, the technology of flash memory requires more space of chip device compared with computer memory of the type SRAM or SDRAM, but it is the most efficient in the rationalization of energy, but it is less efficient in the case of repeating a lot of writing.

2.5 The Ability to Process the Data

Processor of sensor has important role in the analysis and process of the data which observed by the device itself or received by other devices, after completion of analysis this data will be sent in a message–may be coding-to neighboring devices, this requires control of the radio waves and dealing with the messages code and store it. In addition, the processor has another function, namely data collection, sometimes the responsible of this function is a sensor which integrated between local and receiving data, some of these collection data may refuse and others may be sent to neighboring devices, one of these modern devices with high-efficiency processors called (Imote2), (PXA271 Intel XScale) is the processor which used in this device, so it supports low frequencies -13 MHZ- and can work with low energy consumption mode (8.5 Volt) which is commensurate with complex applications such as monitoring using digital cameras.

2.6 The Contact

The most important components of the sensor is the radio, which is also more energy- consumption units, and estimated that 97% of the consumed energy related by reception and transmission is either by direct use of the unit or as a result of the processor waiting for completion of the radio unit transmitter or receiver, and noted that the current radio technology works on the basis of data sent on short waves, this includes a standard technology such as (UWB, ZigBee and Bluetooth), for example, ZigBee technology allows to communication 254 sensor at the same time with 2.4 MHz frequency, other technology may be used to transfer various data and this may limit the ability of sensors networks.

2.7 Uses and Applications of Sensors Wireless

Sensors networks can be used in various applications as shown in (figure 1), such as environmental monitoring, border security, health care and some military applications and disasters management, these applications can be classified depended on the sensors networks operations into three categories: Paid by data and Paid by events or a combination of both, in the first category the main station may be required from a specific set of sensors to monitor some of the phenomena, while in the second category, the sensors send a report on the observed data upon the occurrence of an event, the following we review some of the applications in each of:

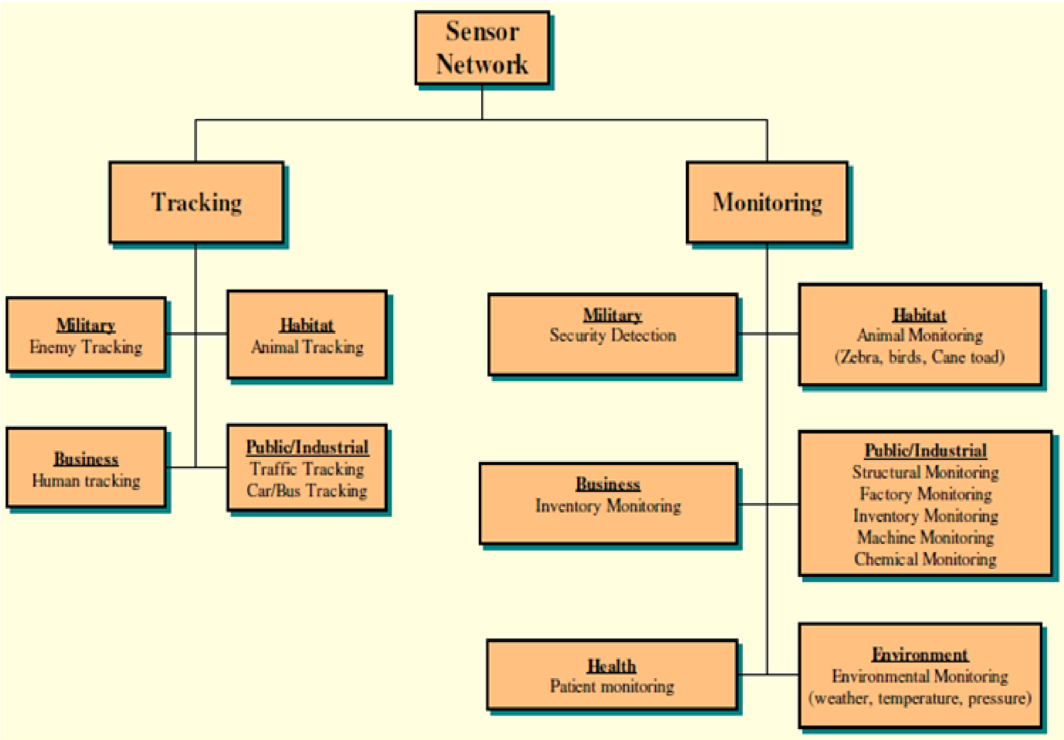

Figure 1 Classification of wireless sensor network's applications

2.7.1 Paid Applications from the Data

Used in applications in which the data are extract from sensors by a language similar to SQL, this method consider an effective way if we look at the amount of consumption energy and that because the number of the transmitted messages between the sensor and the lowest as possible. However, this method requires uses of smart sensors that can store data for long periods of time dealing with various queries which sent from the main control station, and these properties may not be available for small-sized sensors. For example, the reading of temperature and humidity by specified sensor in observer field, also smart homes for the elderly, is another example of these applications so they can be request from the sensor to see if the main door is closed or not, or if the TV was switched off or not, or to ask to know whether there is a shortage of available foods in the refrigerator (fridge). In addition in some complex applications may require more than one sensor to study the phenomenon in a particular geographic area.

2.7.2 Paid Applications from the Events

Sensors send its reports about the data that collected when an event was happened

2.8 Advantages of Sensor Network

- For espionage purposes of and surveillance the enemy installations.
- For scientific research and monitoring of the planets and the stars by satellite.
- The possibility of studying the urban environment.
- Provide the cities of two information classification :

* Fixed phenomena information: The size of the city and the number and sizes of roads and functions of its areas (residential-commercial, industrial).

* Changing phenomena information: phenomena that can not be seen due to quickly change or it is not visible, such as traffic movement , social and economic characteristics and population statistics.

- Recording data which can not see by the human eye so the eye is sensitive to visible radiation. A quick and accurate measurements for the space, distances and elevations.

2.9 Disadvantages of Wireless Sensors and Their Treatments

2.9.1 Security

Currently, there are many network security ways, such as use of the secret key for encryption and use of encrypted passwords-these methods have proven effective in the past few years – but disadvantages of it that it is require high computing power, which is disproportionate with the nature of the current sensor, at the same time sensor networks may be used in transfer of very important information. For example, in emergency medical operations using the network to transfer of medical records of the patient and history of his illness, and likewise may use the network to transfer military information which needs to be super-secret, add to privacy and authentication of users, two of them are the important cases in the field of network security issues, so the doctors and nurses at the emergency, for example, they need to get on the eligibility of access to encrypted data of patients as soon as possible-note that this research is still in its early stages and needs more research.

2.9.2 The Mistakes of the Network Trouble Treatment and Routing Information

If we take control of highways by using sensor networks as an example, we find that the network is responsible for the transfer of information that available to many users, and the control unit in the roads and this information have a direct impact on our daily lives, and therefore in such applications must be deployed sensors on highways and this environment increases the probability of loss and disabled it, and then must be an efficient and fast system to processing bugs which resulting from the loss or stop one of these devices while ensuring that there is not overlapping between the uses devices signals.

2.10 Changing in the Internal Structure of the Wireless Sensor Network (Printability to Navigate)

The internal structure of the wireless sensors network may be changed as a result of the continuous movement of its devices, we find that in (FireNet) type, for example in the_form of amortization they holders this constant hardware move always, and therefore the information that from these devices need be sent instantly, and so the design of an efficient and fast protocol to send this information-taking into account the changing nature of the internal structures of the network and the nature of the spreading environment-still needs further research.

2.11 Wireless Sensor Networks is Still in its Initial Stages:

The field of sensor networks is still in its initial stages, and the structural and protocols used in this area is still in a state of continual development and this requires the presence of metrics can help to preview and the amount of efficiency, and to develop these standards can benefit from the research that available in the field of temporary wireless networks - which developed in the former - few years, which has determine the standards of efficiency when studying these networks.

CHAPTER 3

COVERAGE IN WIRELESS SENSOR NETWORKS

An evaluation of the effectiveness of the WSN is critical towards determining an area's sensor coverage. The task of determining the efficiency of the server is determined by its WSN. The monitoring quality depends on the WSN's application. Some of the major applications such as target tracking have to be covered to a higher degree when compared to others. On the other hand, applications such as the habitat and environmental monitoring can cope with low coverage levels. A higher coverage degree demands that a user uses multiple sensors when they have to monitor a certain location with an aim of producing reliable results. A body of knowledge exists which pays special attention to the energy consumption trends during the monitoring exercise. There is some body of knowledge which determines the various techniques used to set a minimal number of nodes to keep the coverage alive. However, there is a crop of researchers who propose a deployment of the sensor when there is a need for a distributed detection. This is mainly recommended when handling large scaled sensor networks that cannot be handled using other procedures. One may classify the targets into two distinct classes. They include:

- **a.** Area [14, 15, 16, 17, 18, 19].
- **b.** Point [11, 20, 7, 21, 22, 23].

For a coverage problem, there is usually a geographical region that is used for monitoring the sensors in a certain area. However, for a point coverage issue, the sensors appear in a geographical area, their role is to monitor the targets.

3.1 Approaches to WSN Coverage

3.1.1 Art Gallery Problem

The art gallery problem is one of the challenges that affect the coverage. The problem has been widely examined in computer geometry. In this form of a problem, one represents it in form of a polygon that guards all the main points in the area. The main aim of this is make sure that all the parts of the room are being monitored by the guards. This operation is identical to the coverage problem. Therefore, it can be used as a base to solve many other coverage problems.

3.1.2 Voronoi Diagram and Delaunay Triangulation

The Voronoi model has many algorithms. The Voronoi diagram has borders on each side of the sensors for a sensor network. Hence, each of the points in the border of a sensor is closer to the network's sensor points figure (2). The Delaunay triangulation is almost identical to the Voronoi diagram. A Delaunay triangulation refers to the triangular points that do away with the points in the triangles that are inside the bonded circle in a particular area. One may create a Delaunay triangulation from a Voronoi diagram. They may do this through connecting the sensors to some drawn edges that are adjacent to each other. Figure (3) illustrates the Delaunay triangulation. The Delaunay triangulation is one of the methods that may be used to effectively determine two sites that are close to each other through identifying the short edge in the triangle.

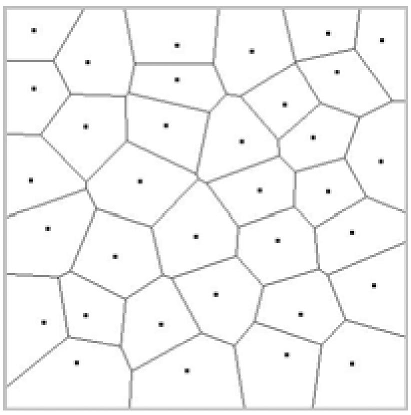

Figure 2 Voronoi diagram

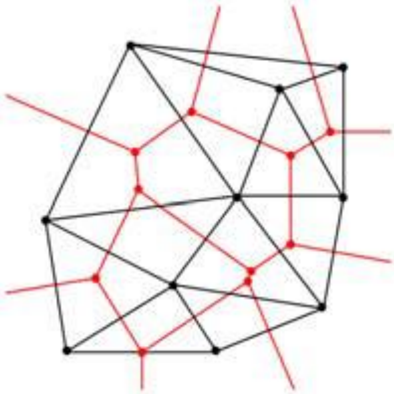

Figure 3 Delaunay triangulation

3.1.3 Worst or Best Case Coverage

Sensor network application's coverage may be identified depending on the vision point. An examination of the coverage on a best point is one of the measures towards identifying and solving various problems.

3.1.4 Probabilistic Sensing

Many scholars who have carried out studies on coverage admit that the sensor's capability determines its range in every point. The sensor is mainly used to determine this point as it has a better power to identify physical objects. It is recommended as it uses a minimal RF signal. A probabilistic coverage model examines the impact of distance to the node's sensing power.

3.1.5 Disjoint Sets

A dense sensor distribution has many sensors. Some of these sensors are not necessary during a coverage. In such an instance, one ought to expand the network's lifetime. Moreover, one may turn off unnecessary sensors to retain the pace of the coverage and save energy alongside the life of the battery. This may be achieved through dividing the sensors into sets. In this case, each of the sets should fall in an interest field.

3.1.6 Coverage with Connectivity

Both connectivity and coverage are closely related. The two are some of the critical conditions needed for the efficiency of the wireless sensor network. Researchers have tried to combine both connectivity and coverage to form only one algorithm. One of the most important factors that they ought to consider is the range of communication between the sensors. Arguably, it should have a value of at least two times the sensing range in a covered area. This procedure has been quite successful in the development of some protocols such as:

3.2 Coverage Protocols

There are many coverage protocols. They include the Coverage Configuration Protocol (CCP): CCP [18] this refers to a decentralized protocol that creates a network to come up with a certain coverage degree. The CCP is powerful enough to change the coverage degree of a certain network depending on the application's demands in a run time. There are three modes of a CCP node. They include the listen, sleep and active.

Each of the nodes sends a Hello packet on a regular interval. The packets indicate the node's position and status at that particular moment. For instance, in the listen mode, it assembles many node messages from its immediate neighbors and performs the Ks-coverage algorithms to determine its eligibility. The Ks eligibility algorithm determines the appropriateness of a node to the various states of the switch. If there is an area in the node range that is not yet covered by the Ks active nodes, the nodes become active. Failure to do this makes the nodes relapse back to sleep.

The nodes in an active mode update the neighboring table to activate the Ks coverage algorithm. This determines whether or not the nodes will remain active or inactive. However, in the sleep mode, the node may turn off the radio for the timer to expire before moving to the listen mode.

The Differentiated Surveillance Service Protocol (DSSP): Ref. [24] is an algorithm that proposes a different surveillance service protocol for various coverage degrees in a WSN. The protocol is one of the extended energy saving schemes that adapt to various sensor coverage degrees. In the differentiated surveillance service protocol, the sensors are aware of their location and are fixed. The nodes in the differentiated surveillance service protocol may either be in the working or sleeping mode. The sensor nodes are active in two phrases only. They are the sensing and the initialization stage. It is at the initialization phase where the sensor mode creates a location. Similarly, it synchronizes the time factor with its immediate neighbors. As soon as it is through at the initialization stage, it joins the sensing phase. At the sensing phase, it sets up its working schedule. The sensing phase divides the time into equal duration rounds. Moreover, at this phase, there is a working schedule which determines when a node is supposed to remain awake or asleep. Each node has a working schedule of four tuple (T, Ref, Tfront, Tend). In this case, T represents the length in each of the rounds while Ref refers to the random time reference point. Lastly, T front refers the time that precedes the reference point while T is the time after the reference point.

The Optimal Geographical Density Control (OGDC) is the other protocol that combines both connectivity and coverage. The protocol was a brain child of Hou and Zhang [25]. The nodes may be in any of the three states. They include ON, OGDC, OFF, or UNDECIDED. In either of the states, it is possible to quantify the time into various rounds in the steady state phase and the node selection phase. Initially, the nodes are UNDECIDED. Later on, they are altered to become either OFF or ON in the steady sate phase. Powerful nodes remain active even in the node selection phase. Therefore, the nodes record a uniform energy consumption.

3.3 Issues in Wireless Sensor Network Coverage

When developing a plan for the sensor network coverage, one ought to consider a number of factors. Some of these factors rely on the nature of the application that they wish to address. The ability of the sensor node that one is using should also be examined.

3.3.1 Coverage Types

Deploying a wireless sensor network is a step to step procedure. Initially, one should determine what they want to monitor. For instance, one may monitor the whole area, watch the targets and examine if there is any breach. Covering the whole area is also referred to as the blanket or full coverage. Hence, in each of the points, there should be a sensor node. To attain a full blanket coverage, one must deploy minimal sensor nodes in a particular field. To address any challenges that arise in this process, the author recommends that one places the nodes in an r-strip construct [20]. In this case, each of the nodes should be surrounded by a significant distance away from its immediate neighbors. In this case, (r) represents the sensing area's radius. One may achieve a blanket coverage if they place the strips to overlap each other. One of the challenges facing this form of a solution is because it is very impractical to deploy the sensors in that form. A target coverage entails the recognition of some targets. It is one of the forms of coverage that have clearly defined military operations [26]. On the other hand, barrier coverage entails detecting the movement of the sensor's barriers. The main aim of this is to determine a fixed arrangement of the nodes. Such an arrangement minimizes the instances of undetected penetration in a barrier. The differences in the barrier coverage are referred to as the sweep coverage. It may either be less or equal to the moving barrier.

3.3.2 Deployment

A wireless sensor network has two modes of deployment. They are the sparse or dense deployment. The dense deployment records a large number of sensor nodes in a certain field of interest. On the other hand, the sparse deployment has a minimum number of nodes. The model of dense deployment is recommended in an instance where there is a need to detect each event. Moreover, it may be used where there is a need to cover a certain area using multiple sensors. There are instances where dense deployment may not be ideal as it may be too expensive. This is mainly the case in an instance where there are too many sensors, thus, making the dense deployment non-feasible. In such an instance, a sparse deployment is recommended as it assures one of maximum coverage when they have minimal sensors in a certain location in an area. Many fields that examine the coverage of sensor nodes in an identical location indicate that the nodes do not move once they are deployed. Only the recent nodes have the capability to move once they are deployed. Such nodes are also referred to as the mobile nodes. One may deploy the sensor nodes through placing them in locations that have been arranged previously. Similarly, they may deploy the nodes randomly. One of the main examples of a random placement entails dropping some of the sensors off from a plane. Developing a covering scheme is easier if one wishes to determine the placement of the sensor nodes. Similarly, it is easier when compared to the random placement. However, many of these deployments are either impossible or impractical because it not easy to create a deterministic mode to deploy the sensor nodes. Some of the major examples of both the deterministic and random placement are shown in figures (4 and 5).

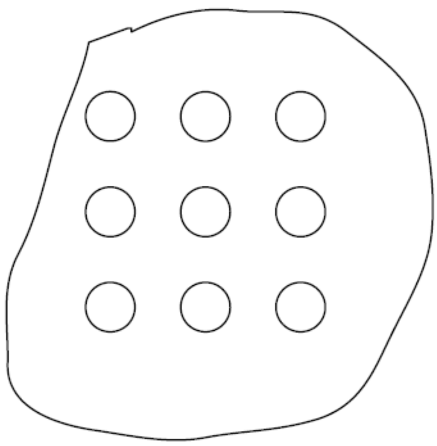

Figure 4 Deterministic Placement

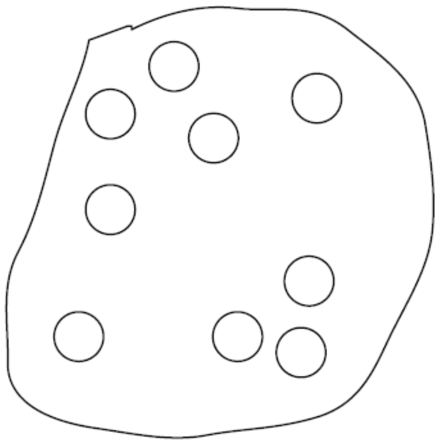

Figure 5 Random Placement

3.3.3 Node Types

The sensor network nodes fall in either the homogeneous or heterogeneous node group. A homogeneous group classifies the nodes depending on their capabilities. On the other hand, in heterogeneous groups, there are some nodes which are more powerful while others have less power. A small group consisting of very powerful nodes is referred to as the cluster heads. The cluster heads collect data from the non-powerful nodes.

Some of the examples of both homogeneous and heterogeneous nodes are given in figures (6 and 7).

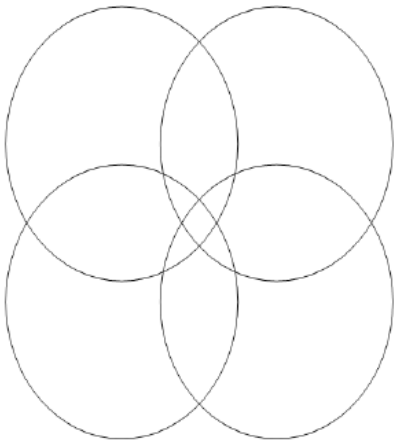

Figure 6 Homogeneous Sensors

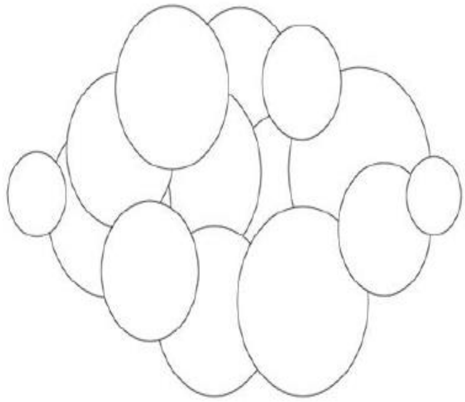

Figure 7 Heterogeneous Sensors

3.3.4 Constraints

One of the factors that should be considered when developing a coverage scheme is the energy constraints. For instance, the sensor nodes are dependent on batteries as their main source of energy. Noteworthy is the fact that replacing a battery in many deployments is impossible. Hence, it is critical to save energy and ensure that the battery being used is long lasting. One may do this through a number of ways. Some of them include placing unnecessary sensors in a low energy sleep mode. Similarly, one may do this through changing the mode of transmission to ensure that the nodes consume energy only when transmitting to a neighboring node. Organizing the sensors in a hierarchical network entails the use of group heads to collect data and minimize the sinking of information. This reduces the node load through minimizing the transmission path; thus, increasing their life time. Making data collection an easy task besides routing may be some of the methods that may be used to conserve energy. Using multiple sensor nodes to collect information consumes too much energy, thus, it is not recommended. Reducing the unwanted sensor nodes helps minimize the energy loss. In addition, one may improve the routing technique to ensure that the data takes a short path using a minimum number of nodes that do not consume too much energy. Coverage becomes more efficient through the use of minimum energy for routing and extends the lifetime of the nodes.

3.3.5 Centralized/Distributed Algorithms

A centralized or distributed algorithm is applied when the sensors are deployed to determine the degree of coverage in a certain area. A centralized algorithm can be enforced on some nodes in the central location next to the data sink. A distributed or localized algorithm is normally applied on all the nodes in the network. A distributed algorithm entails the nodes that work jointly to solve a certain computational challenge. On the other hand, a localized algorithm indicates that all the nodes run an algorithm separately depending on the information that each of the nodes has gathered. All of them spread the workload evenly when compared to the centralized algorithm. However, the centralized algorithm is less complex when compared to the distributed/localized algorithms. This is because the distributed algorithm can be run on many nodes across the network.

Figures (8 and 9) show centralized and distributed strategies. The colored sensors run part or the entire algorithm. Zhou, Das, and Gupta developed both centralized and distributed algorithms which are used when there is a need to conduct a k-coverage [27]. They found out that both centralized and distributed algorithms go back once they attain an optimal solution.

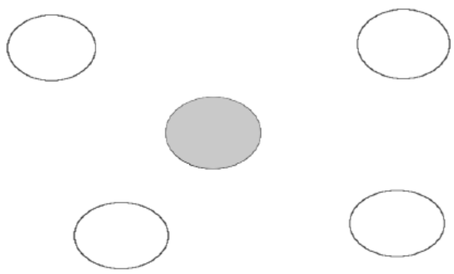

Figure 8 Centralized Algorithm

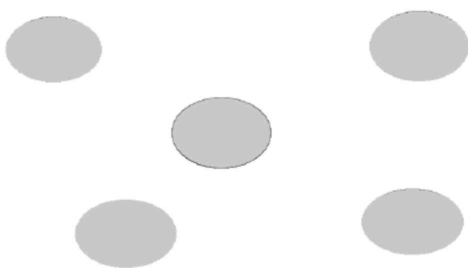

Figure 9 Distributed Algorithm

3.3.6 Three Dimensional Coverage

The two dimensional field has been an extensively used model. Many scholars admit to having used it when handling a coverage problem. They argue that it is easier to develop than the three dimensional algorithm. However, it is not ideal for the real world environment. The following Figure (10) is an example of a three dimensional coverage.

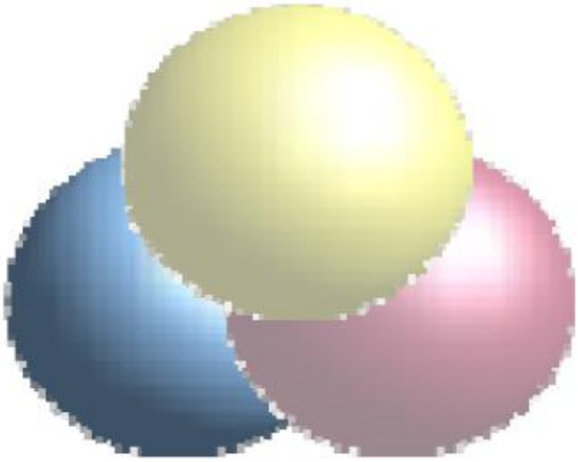

Figure 10 Three Dimensional Coverage

CHAPTER 4

PROBLEM FORMULAT I O N

The importance object in sensor networks to maximize the lifetime of the network is designing a schedule for sensors, this is, by organizing the sensors as a sequence to activate in every time slot. Maximizing the lifetime of the network by scheduling the activation of sensors is an effective way to build wireless sensor network with energy saving. As a result, designed an efficient schedule for sensors will lead to increase the lifetime of the network. To achieve this we present an algorithm for this problem with assurance on the lifetime attained by the calculated schedule.

To compute the total lifetime of the network, we need to find the coverage of all individual sensors. First we need to compute the total effective coverage that is the summation of all weight of locations which are covered by a sensors, and then we will design a schedule of the sensors which achieve this equation Sensor (or sensors series) coverage must be greater than the half of the total effective coverage.

The maximum network lifetime problem can be formalized as follows.

There are n sensors, a set of locations P with a known important factors, the battery lifetime of sensors B, we want to find a schedule which maximize the total lifetime.

Below lists some symbols and notations that will be used in our problem formulation.

• N: the node set.
• s_i, N (i): sensor i and the neighbor set of sensor i, i.e. N(i)={j │ sensor s_j is the neighbor of sensor $s_{i.}$

• P: the locations set.

• w_i: the importance factor of location i.

• W (i): the accumulated importance factors of the sensed locations, i.e., W (i) = $\sum wi$

• Ti: the coverage time of the location P_i, during which P_i is covered by at least one sensor.

• L: L is the network lifetime.

• B: is the battery life of S.

• C: the total effective coverage.

4.1 Our Algorithm

We propose a new algorithm to maximize the lifetime of wireless sensor network.
We can formulate this algorithm as below:

1. Let Ci : coverage of sensor i

   C = $\sum ci$ total coverage , t=0 , S=ϕ.

2. While there are unscheduled sensors.
3. Find the sensor ,X, with minimum intersection with current sensors in S.
4. S=S∪{x}, schedule[x]= t.
5. If coverage of S is greater than C/2.
6. S= ϕ, t= t+1.

4.2 Randomized Algorithm

In this algorithm the schedule of each node is generated randomly. To do this we create a random permutation of sensors. We choose some sensors to be turn on begins with (the first one, second, third,….) to provide half of the total coverage, then choose the next group, and so on, until picked all sensors.

4.3 Simulated Annealing Algorithm

The foundation of this algorithm is the neighborhood search figure (11). First we create a random permutation. Neighbor is the one with 20 interchange in the current permutation. We use an initial temperature. Begin with an initial solution, and then select new solution which is the neighbor of the current solution if the coverage obtain by it is greater than that obtained by the previous, another solution will select if not, we will use some probability until close to optimal solution.

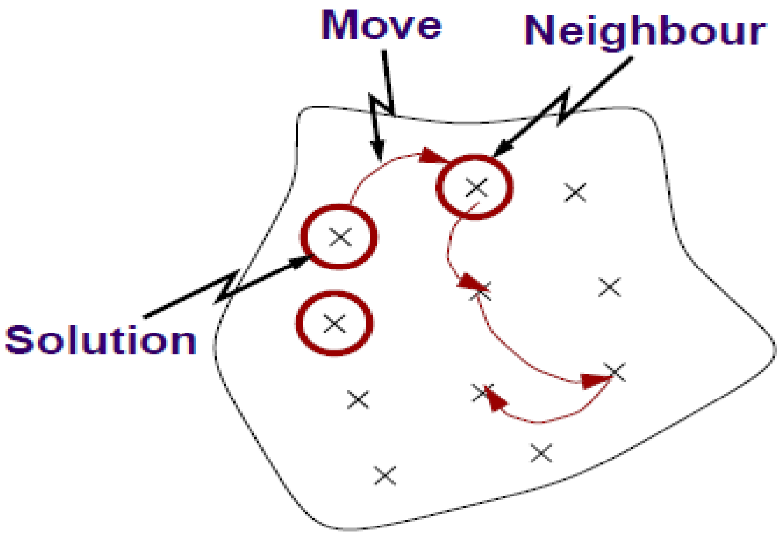

Figure 11 Neighborhood search process

SA is a strategy which sometimes allows uphill moves in a controlled manner figure (12).

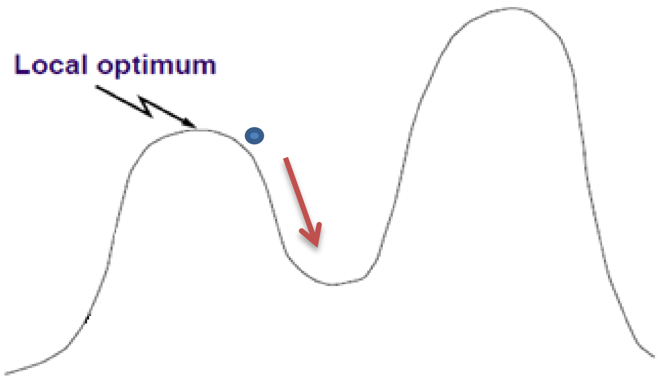

Figure 12 Moving strategy.

In order to escape local maximum you have to allow uphill moves figure (13).

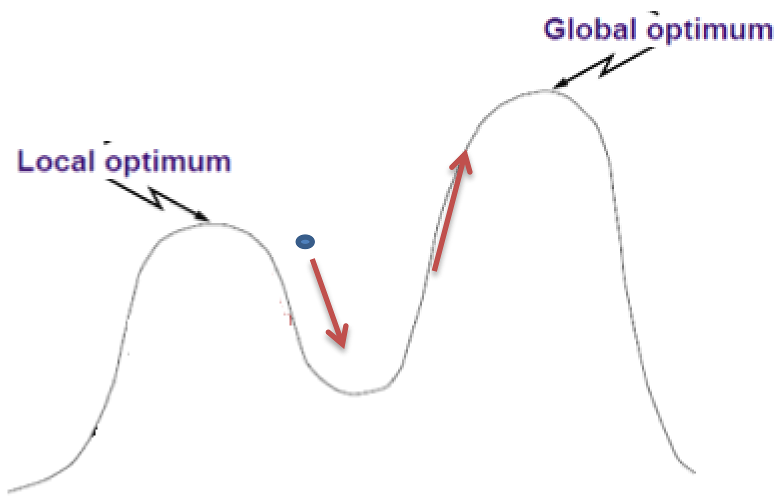

Figure 13 Uphill movement.

4.3.1 Simulated Annealing Strategy

1. Let L: lifetime, T: an initial temperature.

2. Let neighborhood N(x) is a set of solutions that can be reached from x.

3. Construct initial solution x_0, $x^{now} = x_0$.

4. While T >1.

5. Select new, acceptable solution $x' \in N(x^{now})$.

6. If L increased then accept new state.

7. Else accept new state with probability $e^{-10/T}$.

8. T=T*0.99.

CHAPTER 5

EXPERMENTAL RESULTS

In this chapter, we use simulations to compare our algorithm with two other schemes. Since most existing works focus on the lifetime of network.

Randomized Scheme: the schedules of the nodes are generate randomly. And make swap to the sensors location to achieve max time to optimizing the life time of network.

Simulated Annealing (SA): The strategy of this algorithm is a neighborhood searching and it is occasionally allows to move to another solution to achieve the optimal one, with uses some probability.

Our algorithm: Built schedule for each sensor and choose the one with min intersection among the others to optimize the life time.

5.1 Simulation Setup

In our simulation, the deployment of all sensor nodes and locations is randomly in a 10 meters × 10 meters square area. The sensing range of each sensor node is a fixed of 1 meter. So that the communication range is 2 as in many sensors platforms where the sensing rang is half of the communication range at least. With sensors varying from 100 to 500 and locations from 10 to 50. Each location is related with importance factor, which is the weight of location. The network lifetime is used to evaluate the different schemes. And we are calculate the time that each algorithm was took to show the result.

For each simulation scenario, the results are averaged of 100 runs with different random sows are conducted. And the simulations are done with a customized C++ simulator.

5.2 Simulation Results

We show the effect of number of sensor nodes, when number of location = 30. In figure (14), as expected, the network lifetime increases when the number of nodes increases in all algorithms. The result shows that our algorithm is best.
Among different schemes, our algorithm, randomized algorithm and simulated annealing algorithm stay close to each other with worst performance to the randomized.

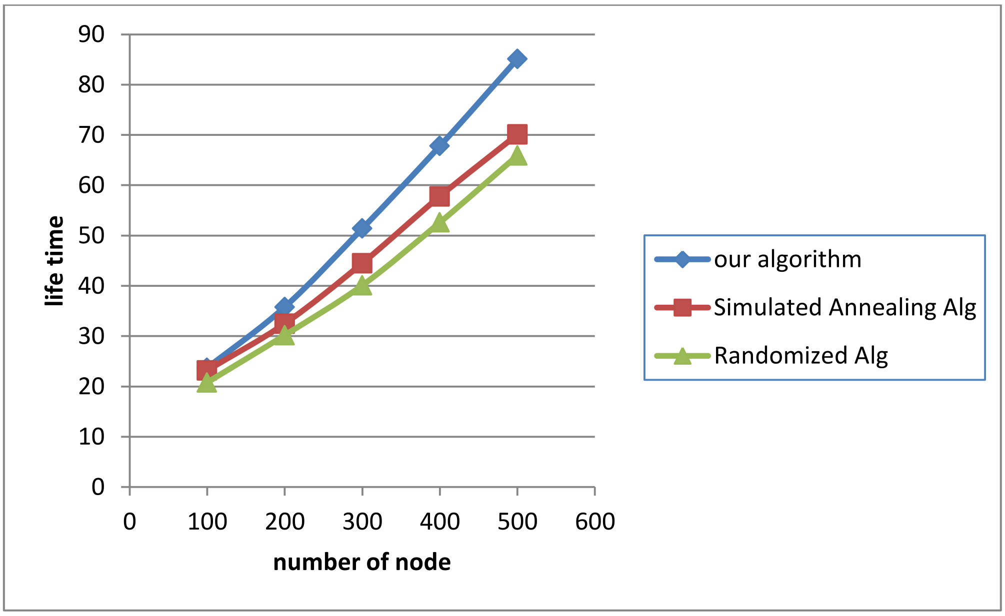

Figure 14 Total life time vs. number of nodes (number of location =30)

It can note the outperformance of our algorithm on the others, when the number of nodes are increase the outdoes by 13% on the SA algorithm and by 23% on the randomize algorithm, and the gap of the performance is maximized as the nodes increases.

Figure (15) study the effect of different number of locations on the performance of the lifetime when number of nodes = 200. It can be seen that our algorithm improves the SA algorithm by 8% and the randomize by 20% as the number of locations in the field increases.

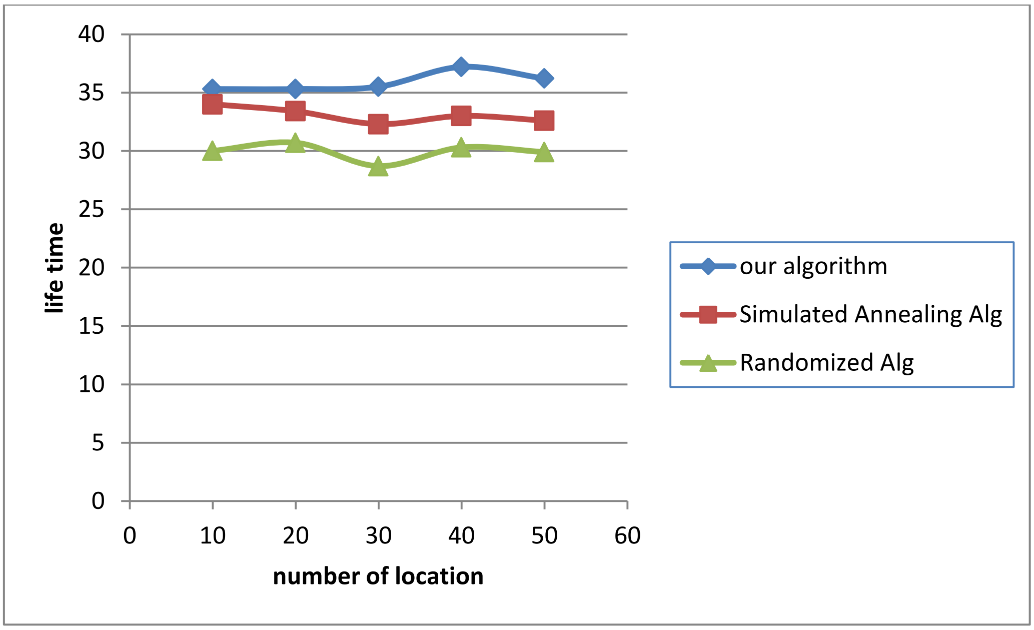

Figure 15 Total life time vs. number of location (number of nodes =200)

Tables (1 and 2) show that the run time of the three algorithm that we used. We show that our algorithm spend less time for showing the result in both when increasing the number of nodes with 30 locations and when the number of nodes fixed to 200 and the number of locations are vary. The time required for appearance of the results by using the SA algorithm approximately 1000 times the time needed when we use our algorithm.

Also our algorithm improves the randomize algorithm by 50 times.

Run time / No. of locations 30	**No. of nodes**				
	100	200	300	400	500
Our algorithm	1.31	2.71	8.88	16.58	25.94
Simulated annealing algorithm	1648.59	3330.18	4962.49	6595.79	8385.71
Randomized algorithm	52.33	52	48.2	52.07	49.74

Table 1 Runtime for each algorithm vs. number of nodes (number of location =30)

Run time / No. of nodes 200	**No. of locations**				
	10	20	30	40	50
Our algorithm	1.43	2.87	3.45	5.36	5.86
Simulated annealing algorithm	1130.04	2241.65	3236.33	4196.85	5498.79
Randomized algorithm	53.44	51.83	52.95	52.12	52.35

Table 2 Runtime for each algorithm vs. number of locations (number of nodes =200).

CHAPETR 6

CONCLUSION

Unlike other networks, WSNs which contain a number of sensor nodes each skillful in sensing environment and transmitting data, was designed for specific purposes. These purposes include, environmental monitoring, industrial machine monitoring, surveillance systems, and military target tracking, etc. Each application has different requirements and characteristics of all the other. WSNs became the focus of attracting a lot of research efforts because of the speedy developments in their technologies and their ability to adjust to new conditions.

One of the most important issue in WSNs is the coverage problem, because it can be described as a measure of quality of services (QOS) of sensing task for a sensor network and it reflects how a sensor field is monitored. A higher coverage degree can be obtain by using multiple sensors to monitor a certain location.

Second performance metrics for sensor networks is the energy efficiency, as the power supply of sensors is generally limited that should be saved so as to maximize the lifetime of the network to make it more efficient in monitor the target field.

In our work we discuss the various methods of scheduling for maximization the lifetime of wireless network. Our effort of work is to increasing the lifetime of WSN by following a new way to schedule the sensors activity in an organization to realize it.

The affecting features in energy efficient designing by our algorithm is presented. Through the simulations, we do a comparison among the proposed algorithm and the other schemes, with note the important improvements in performance. We proved that the total lifetime achieved by our algorithm approximates the maximum possible lifetime. Exactly, in thick network (i.e., sensor density is high), it is better than randomize algorithm by 23% and SA algorithm by 13%, although the similar performance is show by proposed algorithm when the density of location is high, it improve the lifetime of the network by 20% on the SA algorithm and by 8% on the randomize algorithm. In addition, the time that spent by our algorithm to show the result is the least compared with the other schemes.

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APPENDICES A

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