Sinks Localization Optimization in Wireless Sensor Networks based on Shortest Path in Graph

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Abstract

Wireless sensor networks use in different area as network technology for data collecting and gathering. This network in different application have some common challenges which consider sensor node deployment, routing, clustering, security, coverage, energy consumption, quality of services and others. This research present a structure of wireless sensor network which sensor nodes deploy in random areas and energy consumption and quality of services such as throughput and sink localization accuracy estimation will be performed. Initial deployment of sensor nodes will be done with initial energy of each sensor nodes in determined area of wireless sensor network and then some sink nodes use for optimized data transmission with minimum energy consumption and green structure. Therefore, a graph-based approach named minimum path in graph between sensor nodes for sink localization in data transmission use. The reason for using graph structures is that in wireless sensor networks, the paths are mapped to a graph and based on the minimum distance between the two sensor nodes or to the sink node, the optimal mode can be optimized. Simulation results in MATLAB represent that proposed approach has better energy consumption and quality of services and also has high accuracy in sink localization.

Keywords: Wireless Sensor Network, Sink Localization, Energy onsumption, Minimum Path of Graph

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1.Introduction

Wireless sensor networks have undergone extensive changes in the type of sensors due to the growth of electronic technology. Sensing the environment with the aim of gathering information, performing calculations and communicating is one of the tasks of a wireless sensor network that consists of a series of equipment and hardware. These networks allow the network administrator to observe and react appropriately to the event or phenomenon [1]. The environment in which the wireless sensor network is implemented can be a physical location, a biological system or a framework based on information technology principles. Thanks to many advances in other computer networks, especially the Internet of Things (IoT) and cloud computing, wireless sensor networks have entered new areas with the aim of feasibility, monitoring, management, data collection, exploration and processing. Each wireless sensor network consists of four basic components [2]:

- ✓ Sensors located in an area
- ✓ The sensors are connected in a network
- ✓ Existence of a main point or base station for collecting data in clusters
- ✓ Use computing or processing resources in the base station or in the sensors to control the data

To deploy nodes randomly it should be considered when a number of nodes are left in the environment at once [3]. Of course, in such an application, it is not possible to determine exactly the location, how the nodes are located and the density in the environment and the volume of nodes in one place may be more than other places [4] or in some nodes or not taken in any places [5]. In general, sensor nodes have three sensor models [6]:

1. Active status: In this case, the sensor node is present in the environment and can communicate with other sensor nodes in the network.
2. Sleep state (idle): In this state, the sensor node cannot transmit data or perform data sensing. When a node receives a signal or any data, it can activate its mode, which receives the received signal from other sensor nodes or from the base station. When a node is in the sleep state, it loses less energy than in the active state.
3. Shutdown status: In this mode, the node is completely off.

Data is collected in a wireless sensor network through a large number of sensor nodes that are in a specific dimension of the environment. Depending on the network and the application required, thousands of small sensors may be used in the network. These nodes act wirelessly in the network, making it wireless mode where conventional wiring is costly (e.g. large-scale environments), difficult (e.g. underwater), or even impossible (typically impossible) [7]. The existence of low costs and small dimensions of wireless sensor network structures makes it possible to consider this network in a wider dimension with different purposes and implement it scientifically and practically. On the other hand, despite advances in wireless sensor networks, these small sensors generally rely on low-power batteries to power themselves due to their large number and small size. Because they are wireless, they generally operate in the absence of a separate power supply mechanism and are therefore dependent on the energy provided by their limited batteries. A sensor node, which is actually a small computer has an average power of about 1 mW. From the beginning of its operation in the network, each node continuously receives and processes data and finally disseminates it until all its stored energy is drained and then it becomes a dead node. Sensor nodes in wireless sensor networks become active nodes when inactive, idle and dead in power outages. It is not possible to recharge or replace dead nodes due to wireless sensor networks are typically used in complex and inaccessible environments due to their specific uses. Therefore, energy management with available resources has become the main limitation of the sensor network. Although energy consumption is a key issue in all wireless networks, this is a major concern for wireless sensor networks, especially because of the energy hole problem [8].

Due to the fact that the sensor nodes that act as relays and intermediary for the transmission of data generated by other nodes that want to access the sink, therefore, the nodes that are close to the sink must be very large. They transfer information and load to the network and as a result, their energy consumption is higher than other nodes that have less load. This feature of wireless sensor networks has a strong effect on the energy consumed by the sensor nodes and especially the network life [9] (network life is the period of time when the network stops operating due to discharging the batteries of all effective nodes). The information of each node must pass the complete path from the node to the sink to be transmitted; obviously, the longer the distance, the greater both the grid latency and the grid energy consumption. If a node loses all its energy storage and becomes a dead node, it will have virtually no role in the network, so the private data that that node collected and sent will no longer be available to the network. As a result, removing a node from the network lowers the network reliability. In networks where instantaneous applications (with minimal latency) or maximum lifespan or both are considered, routing algorithms are very important [10].

According to the mentioned points, the optimal location of sinks in a wireless sensor network is of considerable importance in the amount of network energy consumption. In the case of optimal location, the data transmission paths from the node to the sink are shorter which results in energy consumption reduction due to data transfer and ultimately energy consumption of the entire network. Adopting a good solution that determines the best location for a network sinks is necessary to save more network energy. This stored energy can increase the life of the network or can be used for other applications. For example, if the amount of energy consumed by the network is reduced by optimizing the network by properly locating the sinks, more nodes can be added to the network if more information needs to be collected on the network [11].

In order to achieve the goal of optimizing the energy consumption of the network, an acceptable model for the network should be presented and based on that model, a method should be used to determine the optimal location of the sinks. In this plan, initially the goal is to obtain a simple but effective model to introduce the features of the system [12-14]. For this purpose, a graph is used to represent the network in which the weight of the links between the two nodes represents the energy consumed to transfer data from one node to another. Creating an optimal structure to identify the exact location of sinks and even other sensor nodes in a wireless sensor network requires an effective and intelligent solution that can actually solve the location problem for the sink and sensor nodes. To do this, the proposed approach presents a wireless sensor network structure at the time of node deployment randomly with the aim of accurate locating the sink prior to routing and clustering operations. This is because it can be the basis for the next sections to improve a number of metrics, including Quality of Service (QoS) metrics (including throughput, latency, bit error rate, bandwidth, etc.) and the energy issues. Therefore, it is interesting to use different methods that have the ability to be smart. One of these structures is the use of graph methods and graph alignment which is done by using distance detection and identification of the shortest path to in addition to the optimal location of sinks in wireless sensor networks, the ability for energy consumption reduction and improve standards. Quality of service is also included in this method. All these operations must be performed in a simulation environment and platform with programming language to guarantee the proposed approach that will use the MATLAB environment.

2. Literature Review

In the last twenty years, much research has been done to increase the lifespan of wireless sensor networks by network power consumption reduction. In this research, there are three approaches: In the first approach, nodes are examined which the issue of location or routing is not raised and the solutions are based on strengthening network elements or reducing network vulnerabilities. Solutions in this approach include: using more powerful nodes (for example with improved battery capacity) presented in [1], reducing the number of nodes using the estimation algorithm presented in [2]. In the second approach, network sinks and various routing mechanisms are investigated. Different routing mechanisms are proposed for different applications. These routing mechanisms are fundamentally different in terms of routing objectives and routing techniques and these techniques are mainly influenced by network characteristics. In the second approach, the network is often modeled analytically and the best or shortest routing is selected from different methods. For example, in [3], the problem of locating sinks is formulated as a maximum flow problem. The use of multiple sinks to reduce network energy by reducing the average length of paths leading to the sinks is presented in [4]. In [15], by turning the problem of locating sinks into a problem of facilities and solving it, he has provided a solution to find the optimal location of sinks to reduce network energy consumption. The third approach is to use node-based clustering protocols. In these types of protocols, network nodes within clusters are organized in such a way that high-energy nodes (threaded nodes) can be used to process and send data, while low-energy nodes can be used to perform target measurements. The data of each cluster is sent to the sink by only one threaded node; as a result, the number of data communication paths is reduced and less energy is consumed. Many clustering algorithms have been proposed in recent years. The following are two of the most widely used and important algorithms: In 2000, the LEACH algorithm based on the clustering protocol was introduced in [16] and has found a special place among network routing algorithms. Many optimizations have been made based on this algorithm, too. This algorithm builds the clusters in a distributed manner and uses the energy of each node as a priority for the design of the clusters. Another widely used algorithm based on the clustering protocol was called HEED and was introduced in 2004 [17]. This algorithm uses the combination of residual energy and communication cost as a criterion for selecting elliptical nodes. Many other researchers have been done in this field, but they have often followed the three mentioned approaches. In [18] provided an overview of advanced methods for localization, deployment and locating sensor nodes and sinks in wireless sensor networks. In [19], as an overview, advanced location methods in wireless sensor networks along with its various models and classifications are presented and compiled. In [20] provided an overview of methods and techniques for measuring the location of sinks in wireless sensor networks, along with descriptions of models, methods and algorithms and at the end, a case-by-case comparison between these methods is made. Using directional antennas led to optimal results for sink localization in wireless sensor network. In [21] with a model named Reliable Data Collection Mechanism (RDCM). The results obtained that quality of services in compare of recent models and methods achieve the best. In [22], a systematic review proposed for 10 years between 2011 to 2021 for routing optimization of wireless sensor networks based on sink localization and deployment.

3. Proposed Approach

The most important purpose of creating wireless sensor networks is to deploy sensor nodes to collect information from an environment. Of course, gathering information will require energy. Therefore, the issue of energy in this network is considered as an important issue. Likewise, node deployment is predefined as random mode. These nodes can be movable or fixed to collect information. This type of sensor nodes structure divide the configuration of wireless sensor networks into two categories, including dynamic wireless sensor networks with moving nodes and static wireless sensor networks with fixed nodes. The approach of this research is to use dynamic structure in wireless sensor networks where the nodes are mobile, as well as the network structure is heterogeneous, i.e. all nodes including sensor nodes, sinks and relays (which relays are not considered in this study), have different values. Of course, sensor nodes will have the same values, but sink nodes do not have the same values and parameters. Therefore, the structure of the proposed wireless sensor network is dynamic and heterogeneous.

In general, based on [18], sinks localization algorithms in wireless sensor networks include 4 main categories: 1) Spars-based methods, 2) Fixed and dynamic methods, 3) Out-of-area methods, 4) Anchor-based and free anchor-based methods. The fourth part, i.e. anchor-based and free anchor methods are divided into two general categories based on their names. In the first category, anchor-based part and also free anchor, there are two approaches based on sensor interval and sensor free interval. The approach that this research presents in the sinks localization in wireless sensor networks is based on free anchor methods based on sensor range. It is also necessary to specify the problem of sinks localization in a classic and standard way which the reference [19] has provided the main and standard model for methods of sinks localization in wireless sensor networks. In all methods of sinks localization, the distance from the anchor nodes is estimated first. Anchor nodes are sensor nodes that were initially deploy. Then the positioning algorithm is applied and then the unknown positions and locations of the nodes are obtained [19]. It is also necessary to specify the classification of measurement techniques for sink localization algorithms in wireless sensor networks. According to reference [20], a classification of measurement techniques for sink localization algorithms in wireless sensor networks has been investigated.

The techniques for measuring sinks localization algorithms in the wireless sensor networks presented in the reference [20] which are divided into three categories, which include 1) Angle of Arrival (AOA), 2) use of RSS structure and previous information, 3) Methods are related to distance. The third section, distance-related methods is divided into three sections which include 1) based on connections, 2) based on previous information or RSS, and 3) based on time of propagation which consists of three other sub-sections includes time division or TDOA models, round trip and one-way paths. In this research, the approach of measuring the sink localization in the wireless sensor network is based on the distance and its sub-section, based on the propagation time and its sub-section is the round trip.

It should be noted that in the structure of wireless sensor networks, no input data is required for processing. In fact, instead of a set of data, a series of nodes in a specific dimension should be defined and based on that, mechanisms should be provided to meet the objectives. The nodes in the wireless sensor network are provided in two dimensions. Initially, a series of potential points and positions are defined by default so that sensor nodes can be identified and positioned during routing. It should be noted that all sensor nodes located at potential points are fixed and are in fact assumed to be static. If they are dynamic and mobile, the calculations will be a little more complex, which is not the subject of this study. If the paths are within the sensing range of the sensor nodes, the routing and placement operations will be covered by them. Each sensor node can touch more than one target. In each round, data collection operations are performed from the nodes. Between all these rounds, all existing sensor nodes including pre-determined target points and other sensor nodes, sense the target and during two rounds. In one area in terms of distance to reduce energy consumption, the radio transmits information. This operation follows the MAC protocol. The base station announces the target and the targets calculate and then store the energy remaining during each cycle through Eq. (1).

$$V_i(t) = [Initial\ - E_i(t)]/r \tag{1}$$

In Eq. (1), $Initial$ is the initial energy, $E_i(t)$ is the residual energy and r is the current cycle. An area for sensing should be assumed. A sensor interval which is the interval between sensors, can detect specific areas of an area. When an area of the network is covered by a sensor s, then the degree of coverage of that particular area will be one, because between the sensor area with only one sensor which cover the operation. There are two sensors, $s1$ and $s2$. Both of these sensors are shared when the sum of the radius of the region is less than and equal to the distance between each center of that region, the equation of which will be in the form of Eq. (2).

$$r_1 + r_2 = \sqrt{((x_2 - x_1)^2 + y_2 - y_1)^2)} \tag{2}$$

As it can be seen in Eq. (2), it can be said that Euclidean distance is considered. Based on the conditions for the sharing operation, there will be Eq. (3) between the two sensors $s1$ and $s2$.

$$r_1 + r_2 \leq \sqrt{((x_2 - x_1)^2 + y_2 - y_1)^2)} \tag{3}$$

There are several specific situations that need to be considered. When the sensor range of the two sensors is separated, there will be Eq. (4).

$$distance(s1, s2) > r_1 + r_2 \tag{4}$$

When one sensor is in the range of another sensor, there will be Eq. (5).

$$distance(s1, s2) < (r_1 + r_2) \quad , \quad and\ \ r_1 > r_2 \tag{5}$$

When two sensors are just touched shared without creating a cover area, there will be Eq. (6).

$$distance(s1, s2) = r_1 + r_2 \tag{6}$$

Considering the three conditions of Eq. (4) to (6) is vital. Determining the area for sharing sensor nodes is also important. If the two sets of sinks $X = \{x_1, x_2, \dots, x_n\}$ and $Y = \{y_1, y_2, \dots, y_n\}$ are considered, the distance criterion defined for these two data which is an extension of the Euclidean equation is as Eq. (7).

$$d(X, Y) = \alpha. distance(num(X), num(Y) + \beta. diff(Plan_{set}(X), Plan_{set}(Y)) \tag{7}$$

In Eq. (7), the function $d(.)$ calculates the Euclidean distance between two data with numerical properties, the data obtained by the function $num(.)$. In fact, the $num(.)$ function of a data holds only the properties of its sync position and can be defined as Eq. (8).

$$num(X) = \{x_i \in Plan_{set}(X) | x_i\ is\ numerical\ ; i \in [1, |X|]\} \tag{8}$$

Also in the above Eq., the $Plan_{set}()$ function of a sink holds only its position properties and can be defined as Eq. (9).

$$num(X) = \{x_i \in Plan_{set}(X) \,|x_i \; is \; categorical \,; i \in [1, |X|]\} \tag{9}$$

As a result, the $diff(.)$ function calculates the distance between sinks. This calculation is done by counting the number of peer sinks that have different values with each other and is the result of dividing by the number of these sinks. In the above formula, the parameters $\alpha, \beta \in [0,1]$ determine the weight of each of the two sections of sensor nodes and sinks in determining the data distance. The output signal of a unit in a cell of pair cells is a function of the excitation signals received from the previous layer units and the inhibitory signals received from the same units. This mechanism is explained in terms of an intermediate or auxiliary unit called v. The signal of this unit is proportional to the Euclidean weighted norm of the signal sent from the input units. The signal sent from the blocking unit v or the sink is in the form of Eq. (10).

$$v = \sqrt{\sum \sum t_i c_i^2} \tag{10}$$

In Eq. (10), t_i is a constant weight from unit C to unit v which is the sum of the expressions on all units of the sinks that are connected to another unit in each array, such as v, and on all arrays, and v is the output of the unit V. Sinks are considered the C_0 level. Thus, a unit s constitutes a scaled input like Eq. (11).

$$x = \frac{1+e}{1+vw_0} - 1 \tag{11}$$

In Eq. (11), w_0 is an adjustable weight from unit V to unit S and $e = \sum_i e_i w_i$ is the excitation input from unit C and vw_0 is the input from unit V. The output signal of the sinks is also in the form of Eq. (12).

$$s = \begin{cases} x & x \geq 0 \\ 0 & x < 0 \end{cases} \tag{12}$$

The output of a unit in layer C is a function of the input that is input to it from all units in all S arrays. The input of the graph network is in the form of Eq. (13).

$$C_{in} = \sum_i s_i u_i \tag{13}$$

In Eq. (13), s_i is the output of unit S and u_i is the constant weight from unit S to unit C. The output will also be in the form of Eq. (14).

$$\begin{cases} \dfrac{C_{in}}{a + C_{in}} & if \; C_{in} > 0 \\ 0 & otherwise \end{cases} \tag{14}$$

In Eq. (14), the parameter a depends on the surface of the sinks based on their graph. Then the graph training process begins. The training process in the graph is taught layer by layer. The weights of units C can be changed to unit S and the weights of unit V to unit S can be changed. The weights of units C are fixed to unit V. Array weights S sinks are fixed to the corresponding array in layer C, which is stronger for units that are closer. Fixed weights are reduced uniformly from V units to inhibitory units as a function of distance. The weights entered into the S layer units are taught sequentially. The weights of the input units are taught to units s_1 and then fixed. After that, the weights of the input units are taught to s_2 units and fixed. The training process continues in a similar way in level by level mode to reach the output layer and complete the layout operation, so that the sinks find their position in the wireless sensor network.

The mobility of sink nodes in wireless sensor networks is an important issue and the identification and tracking of these nodes is in the field of localization and placement of sinks. If the sink node is within a sensing range of the network, the targeting and then placement operations will cover and determine the areas. Ability to touch more than one target for each sensor when covering and determining areas. In each iteration of the routing where the data is being sent and received, data is collected from the nodes. Among all these iterations in transmitting and receiving data between nodes, all available sensor nodes including the predetermined target points and sensor nodes sense a target and in two steps, the radio transmits a longer distance (due to reduced power consumption). There are a number of technical terms in the field of border coverage in wireless sensor networks which include the following:

- ✓ Crossing path: is any path that took advantage of gaps in the network and provided an unrecognizable path along the width.
- ✓ Strong barrier coverage: it is a type of border cover that has no gaps and in no way has a passing path. That is by selecting each path in it, identification will be done at least once. At the opposite end of the spectrum is a weak border covering one or more passages. Of course, even in poor coverage, all direct routes are blocked.
- ✓ Range: The area detected by the sensor is called the board. The range is normally a circle determined by its radius and sensor coordinates. In some special cases, such as bipolar radar sensors, the range can be in other forms.
- ✓ Coverant and vacant region: the area covered that is at least within the range of a sensor. Any area that is not covered is called an unprotected area
- ✓ Overlapped Sensors: Sensors whose range has one thing in common. In mathematical terms, $|X_i - X_j| < 2r$ where the left side of the inequality is the distance between two sensors.

In general, the proposed approach works by placing a series of sensor nodes in a random position in specific dimensions of wireless sensor networks. This random deployment can involve the installation of sensor nodes and the subsequent initial deployment of sinks. Since the sensor nodes have certain amounts of initial energy, but the sinks have no energy limitation, the wireless sensor network is heterogeneous and since there is mobility in the sensor nodes and sinks, the wireless sensor network is also dynamic. The distance between each sensor node is detected during routing, and then the sinks based on this distance and the shortest path in data transmission between the sensor nodes form a graph to move on it and in that graph will transmit data from the source sensor node to the destination or from the sensor node to the base station. The task of the sink here is to be able to solve the problem of energy in transmitting and receiving sensor nodes as much as possible, as well as to have the best data throughput.

4.Results Discussion

A series of initial values for the main structure are required in the simulation phase of wireless sensor networks. In order to be able to provide optimal sink localization in the wireless sensor networks in an informed manner of energy consumption and quality of services criteria, it is necessary to use network settings which are listed in "Table 1".as initial settings.

Table (1) wireless sensor network settings

Wireless sensor network scale	100x100 m2
Number of sensor nodes	200 nodes
Initial energy of each node	1 Jules
Total energy of nodes	200 Jules
Radius of each node	1 mm
Initial deployment mode of nodes	random
Sink nodes	Mobility with required number in different dimensions
Initial route numbers between sensor nodes	120 possible route for data transmitting and receiving
Sinks energy	No limitation

In fact, 200 nodes in the dimensions of 100×100 m2 of wireless sensor network are to be used for data collection and in the meantime, the position of the sinks to transmit and receive data between these nodes will be optimized to consume less energy. The type of node deployment is random. Each sensor node has 1 Jules of energy at its initial settings, i.e. each node has 1 Jules of primary energy, which consumes this energy when transmitting and receiving data to each other or to the sink node. Also, these sensor nodes are mobile and their mobility also carries energy. There are 200 sensor nodes in the network, so the result is that the initial energy of the entire wireless sensor network is 200 Jules. Each sensor node must transmit data at a certain interval which is determined by the distance between the nodes and the Euclidean distance. This value is considered to be 1 m2, i.e. each sensor node in its initial position and at the time of movement can transmit data up to 1 m2 with adjacent sensor nodes. Otherwise, the sink node which is assumed to be mobile, receives data information from a sensor node and transmits it to the destination node on its way to consume less energy in terms of routing and distance between nodes. This is done using the method of finding the shortest path in a graph. It should be noted that between the sensor nodes, there are only 120 primary paths from which data can be transmit and received. 200 sensor nodes are initially randomly deployed in a 100×100 position from the sensor network when networking is performed in the MATLAB environment which is done at a specified time. The final result is the initial deployment of the sensor nodes is as shown in "Figure 1".

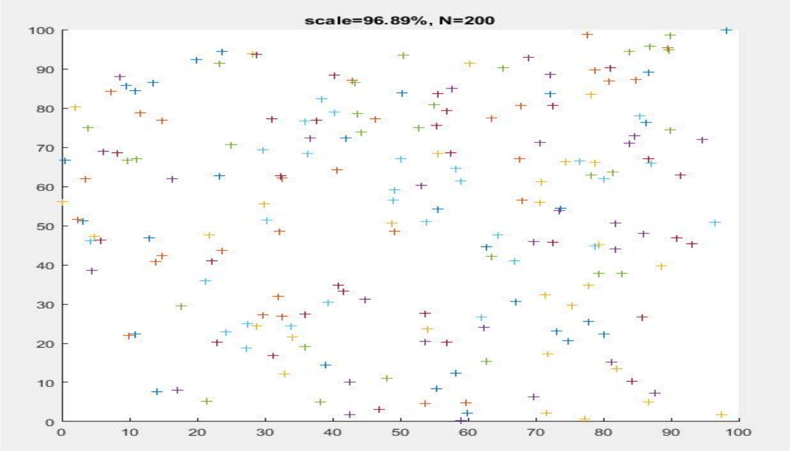

Fig. (1), initial deployment of sensor nodes in wireless sensor network

Based on Fig. (1), it can be seen that 200 sensor nodes in the x and y axes with dimensions of 100×100 m2 of the wireless sensor network have found their initial location randomly. N=200 indicates 200 sensor nodes and Scale=96.89% shows that in the dimensions of 100×100 m2, only 96.89% of the dimensions and coverage of the entire sensor network is wireless and 3.11% of the error rate in the initial deployment and there is network coverage. This rate is relatively low and can be relied on for the initial deployment of sensor nodes in the network. If the scale value is less than 90% in various other performances, the results cannot be relied on as it may not be optimal. This is due to the random placement of sensor nodes in the wireless sensor network environment. With different performances, different results can be seen. Random deployment can have advantages and disadvantages. One of its advantages is that the position of the sensor nodes is not known, and when the wireless sensor network starts working and the sensor nodes are mobile, they can be further positioned by tracking methods in the sensor nodes themselves or packets by considering their data. Also, the random structure has less computational complexity. However, a predefined non-random deployment structure requires the formulation and coordinates of each sensor node for deployment which increases computational complexity, but prevents nodes from overlapping and it seems that it can making noise between them. But this research considers a fast structure without computational complexity, i.e. random deployment. This research presents a performance and shows the results that were the most optimal among 10 execution cycles. Next, these sensor nodes will begin to move. The result of this mobility is shown in the form of a "Figure 2".

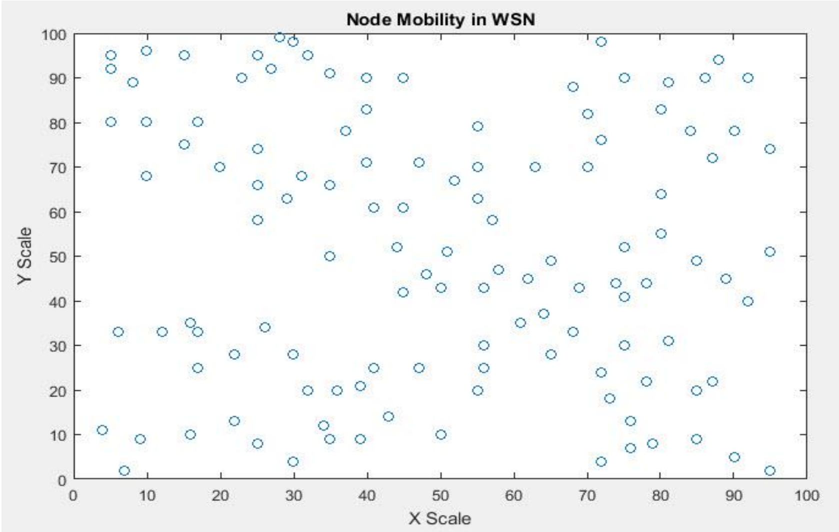

Fig. (2), sensor nodes mobility after initial random deployment

It can be seen that the position of the sensor nodes has changed compared to Fig. (2). These changes in the initial position show the movement of sensor nodes in the 100×100 dimensions in m2 unit which is associated with energy consumption. There is supposed to be only data transmission in the dimensions of 1 m2 based on the radius between each node, but since the nodes are far apart, they cannot transmit data to each other and this job consumes energy. The energy consumption will be very high, because the role of the sink is essential here. The sinks localization for data transmitting needs to be determined. Therefore, the paths of transmitting and receiving data between sensor nodes are determined based on the shortest path in the graph, the output of which will be as shown in "Figure 3".

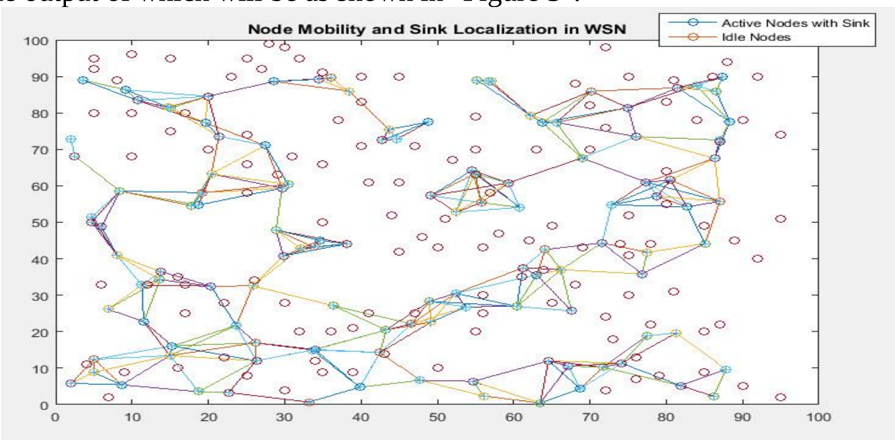

Fig. (3), data transmission paths between sensor nodes and sinks localization

At the output of Fig. (3), blue and red nodes are visible. Red nodes are idle nodes that do not transmit data and blue nodes are active nodes that will transmit data. The paths between the sensor nodes are shown together in a radius of 1 m2 with three colors green, blue and red. Green paths indicate the minimum energy consumption between sensor nodes during data transmission. Blue paths have a balanced energy consumption in data transmission and also red paths have high energy consumption in data transmission which requires a sink. Therefore, a new path is created for data transfer between sensor nodes over a radio radius of 1 m2. The data transmission path of these nodes is done with the help of a sink and is displayed in orange. In fact, the optimal positioning of the sink has been measured as much as possible based on the shortest interval between graphs in the active sensor nodes. It is necessary to show the data transfer between sensor nodes as well as sinks, that the unit of this is transient. Transferring data from the transmitter node to the destination node directly or having the message sent by the sink and sending it to the destination shows the issue of data throughput which should have an upward rate close to 1. The closer it is to 1, the better the network will actually be. The throughput is directly related to the number of sensor nodes and paths in the network. 200 sensor nodes with 120 paths started working, only part of which was active and the rest were displayed as idle nodes. The throughput output is as shown in "Figure 4".

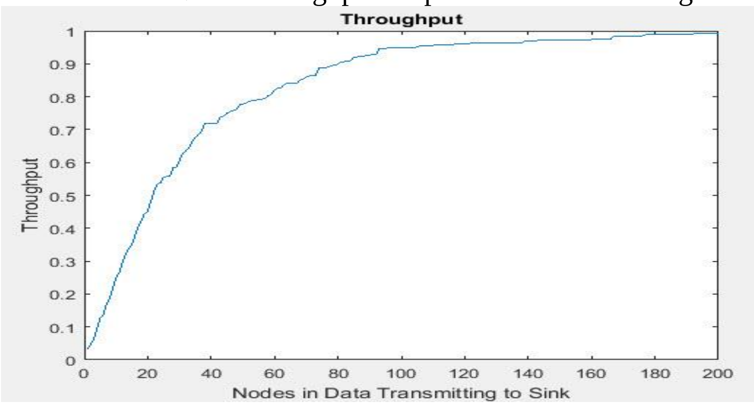

Fig. (4), throughput in proposed approach

Based on Fig. (4), it is shown that by increasing the number of nodes from 1 to 200 sensor nodes, the throughput is growing and up to a number close to the end which indicates that the proposed approach has improved in terms of quality of services criteria. The issue of energy consumption needs to be discussed further. The total energy consumption with the resulting outputs based on proposed approach which was to use the shortest path in the graph to find the optimal sinks localization in the wireless sensor network, out of a total of 200 Jules of energy, only 6.32 Jules of energy was consumed. That is in all sensor nodes, the energy remains 193.68 Jules of energy, which indicates that the proposed approach is green. Also, the energy consumption of each sensor node can be obtained by dividing the total energy consumption which was 6.32 Jules, by the total number of sensor nodes which is as follows:

$$Total\ Energy\ of\ per\ Nodes = \frac{6.32}{200} = 0.03$$

That means each sensor node consumes 0.03 Jules of energy on average. That is each sensor node that has 1 Jules of energy, 0.97 Jules, will have the energy remaining after applying the proposed approach and transmitting data in 120 paths which indicates that the proposed approach is green. The green of a network means that the life of the network increases. Increasing life expectancy is directly related to reducing energy consumption and improving network efficiency or performance, but at times it may be computationally complex or time consuming. But this approach takes 10 seconds to run which varies depending on different systems with different hardware. Execution time is related to computational complexity, so that the higher the computational complexity, the higher the execution time. But the 10-second implementation of the proposed approach and the results obtained so far indicate that the computational complexity has been reduced as much as possible. This can also be a good reason to reduce energy consumption, increase grid life, improve efficiency and reduce runtime. Next, it is necessary to consider the error rate in sink localization with the proposed approach in the dimensions of 100×100 m2 with 200 sensor nodes and the existence of 120 paths for transmitting and receiving data. The error rate will be the accuracy of the work which is expressed as a percentage. After the results, the sink location error rate was equal to 4.65%, i.e. the total accuracy of the sink localization in the wireless sensor network with the proposed approach can be expressed as follows: $Sink\ Localization\ Error = 100\ \% - 4.65\ \% = 95.35\ \%$

It is observed that the proposed approach has 95.35% accuracy for optimal sinks localization in the wireless sensor network. The current rate is reasonable, but there is a 4.65% error rate which can certainly have an impact on more advanced wireless sensor network issues including security issues, sink reliability, and others. Therefore, this section can be presented as a starting point for new researches.

5.Conclusions

In this research, the sinks localization in the wireless sensor network has been considered. To do this, distance measurement criteria are used between sensor nodes in data transmission. If the radio radius of a sensor node exceeds a predetermined range - which is considered to be 1 m2 - a sink node is used which can move the data of a sensor node on a moving basis with transmitting and receiving to the sensor node at a distance or to the base station. Of course, sinks will also consume energy and the structure of its energy consumption in this study is considered without any limitations. The proposed approach of this research for sinks localization is to use a graph-based method in routing that uses the shortest path structure to transmit sensor data. The simulation results in MATLAB environment show positioning and localization with maximum accuracy of 95.35% and indicate the improvement of energy consumption for each node equal to 0.03 according to each sensor node equal to 1 Jules of energy and the total network with energy consumption of 6.32 Jules with 193.68 Jules remaining. Improved data transfer performance also indicates an improvement in the proposed approach. In general, this research has been able to use an optimal method to find the shortest path in the graphs, sinks localization in a way that is energy consumption aware and quality of service criteria, including the throughput as much as possible and has been able to calculate runtime reducing, improve network performance and increase network lifespan.

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