A NEW ALGORITHM INTRODUCED TO OPTIMIZE THE LIFESPAN OF WIRELESS SENSOR NETWORK

Raad Sadi Aziz
Technical Institute of Alsuwerah,
The Middle Technical University, (MTU)

Sif .K. Ebis
Wassit Education Directorate, Ministry of Education, Iraq

ABSTRACT
In this paper, a different scheduling method has been introduced through the construction of a new algorithm, with the purpose to elongate the lifespan of wireless sensor network. At all times, half of the full coverage of sensors is provided. As a result, the information on the distances between the sensor’s neighbor nodes and its sensing areas are the only requirement for each sensor in the new algorithm. Furthermore, based on the simulations, noticeable improvement can be seen from the lifespan of several existing maximization algorithms, which is a result of the newly proposed algorithm. Besides, the runtime of sensor network is improved with this new algorithm. Following that, a comparison with other algorithms has been done in order to show the accuracy of new algorithm.

Keywords: Maximization the life time of WSNs, Sensor coverage, Wireless sensor network.

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1. INTRODUCTION
Wireless sensor networks (WSNs) are designed in order to conduct an observation on the environment. This is the environment where the possibility for the distribution and collaboration of a large amount of sensors (nodes) with sensing, signal processing, wireless communication capabilities, and limited battery energy is enabled with another sensor during data collection. Furthermore, collection of the data sensed by each sensor can be performed, followed by the transmission of it to the sink through the network. Due to the flexibility and low cost of the sensors, a large variety of surveillance applications is available, such as the
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Instruments for environment-monitoring (e.g.: traffic and seismic surveillance, fire detection, earthquake and volcanoes detection [1], weather prediction [2], [3], [4], biomedical health monitor [5,6], natural disaster relief [7], and surveillance on places that put the presence of human in danger or hazards [8]. Examples of such places are dangerous war zones, deep seas, and the polar regions of Earth.

In order to evaluate WSN’s effectiveness, coverage and lifespan are two main issues taken into account. Furthermore, the coverage in WSN is important for a complete coverage of the monitored area with a higher reliability. The importance of WSN’s coverage is the impacts it brings on sensors utilization, their placement, connectivity, and power. Additionally, there is an interrelationship between coverage and sensor placement. To illustrate this, many types of sensors monitoring the same location are required for a higher degree of coverage, in order to produce more reliable results.

The synchronization of time in a wireless sensor network brings impacts on routing of signal and power maintenance. On the other hand, time inaccuracy will result in the reduction of network’s lifetime. Therefore, energy conservation can be achieved with fewer clashes and resend of nodes, or in other words, the duty-cycling of nodes. Besides, data can be collected and transferred in accordance to what is scheduled for them through the synchronization of total time.

Various methods have been introduced in literature [9], [10], [11], [12], [13], [14]. Among all methods, the essential method implemented in order to extend the network lifetime is through the selection of a set of active sensor nodes. This method is performed through central control by a defined protocol. Furthermore, a scheduling scheme is proposed in [15]Through this scheme, a subset of nodes is occasionally selected for the execution of network tasks, which leads to the energy-saving state displayed by the remaining nodes.

The objective of this work is to increase the lifespan of wireless sensor network to the maximum, while always keeping half of its coverage. In order to achieve this objective, the time taken for each coverage process at all sensors is calculated. This is followed by the scheduling of the sensors, where the one with the most amount of coverage is chosen. Then, the coverage’s size is checked and compared with half of the coverage. The scheduling of this sensor will be carried out when the equation of comparison is true and the lifespan of the network amounts to (10). Otherwise, another sensor among the ones with minimum intersection will be chosen by the selected node. With these procedures, the equation of comparison can be obtained. Then, after the repetition of the process of selection for all sensors, there will be an increase of the network’s lifespan, which amounts to (10) each time the equation is obtained. Moreover, the multiplication of the times by (10) during the acquirement of the equation equals to the overall lifetime of the network. In addition, the structure of this paper is organized as follows: an overview regarding the coverage in WSN is presented in Section 2. Then, the problem regarding maximum network lifespan is formulated by Section 3, and a new algorithm is also proposed, in order to optimize WSN’s lifespan. Next, Section 4 displays the simulation results by different schemes, new algorithm, randomized algorithm, and simulated annealing. Last but not least, the conclusion of the paper is drawn in Section 5.

2. OVERVIEW

Coverage in wireless sensor networks

In order to determine the sensor coverage of a certain area, the evaluation performed on the effectiveness of WSN is highly important. Furthermore, the efficiency of the server is influenced by its WSN. Not only that, the application of WSN influences monitoring quality.
Therefore, in comparison to other applications, major applications, such as target tracking, require more coverage.

For a higher amount of coverage, a user is required to use multiple sensors when monitoring a specific location in order to produce reliable results. The presence of a body of knowledge is with the purpose of putting particular focus on the energy consumption patterns during monitoring. Meanwhile, in order to keep the amount of nodes at the minimum, some bodies of knowledge determine the number of methods utilized. This is essential in order to keep the coverage intact. However, the deployment of the sensor is proposed by a group of researchers during the time when a distributed detection is needed. This approach is highly recommended to users who manage large-scale sensor networks that cannot be managed through other approaches. In addition, the targets can be categorized into two separate classes. These classes consist of:

a. Area [16, 17, 18, 19, 10, 21].

b. Point [13, 22, 9, 23, 24, 25].

When it comes to coverage issues, a geographical map is usually utilized to determine the particular areas for sensor monitoring. However, in the case of point coverage, the discovery of sensors is within the area in geographical map. This is essential for target monitoring.

**Voronoi Diagram and Delaunay Triangulation**

The Voronoi model consists of a significant number of algorithms. Furthermore, borders are displayed on each side of the sensors. These borders are for a sensor network in its diagram. Therefore, there is a small distance between each of the points in a sensor’s border and sensor point figure of the network (1). On the other hand, Delaunay triangulation and the Voronoi diagram are closely similar to each other. To illustrate this point, a Delaunay triangulation is referred as the triangular points where the points in the triangles are removed. This removal takes place within the bonded circle in a specific area. Furthermore, the formation of a Delaunay triangulation can occur from a Voronoi diagram. This formation can happen when the sensors are connected to some drawn edges that are adjacent to each other. Additionally, the illustration of the Delaunay triangulation is displayed in Figure (2). The Delaunay triangulation is one of the techniques that may be utilized in order to effectively categorize two sites that are close to each other. This categorization is performed by identifying the short edges of the triangle.

![Voronoi Diagram](image1.png)

**Figure 1** Voronoi diagram
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3. DISJOINT SETS
There are many sensors in a dense sensor distributor. However, some of these sensors are not needed for coverage. The example of this situation is when the network’s lifetime must be expanded. Moreover, in order to retain the pace of the coverage and conserve the energy supporting the lifespan of the battery, unnecessary sensors should be switched off. In order to achieve this, separating the sensors into sets is a way to achieve this. In this case, every set should belong in the field of interest.

4. COVERAGE WITH CONNECTIVITY
There is a close relation between connectivity and coverage of sensors. These two elements are crucial for the efficiency of wireless sensor network. There have been attempts of combining both connectivity and coverage displayed by researchers, so that only one algorithm is formed. Additionally, the range of communication between the sensors is one of the most essential factors need to be considered. The aspect of communication is arguable. This can be shown from how the communication between the sensors should be at least two times the sensing range in a covered area. Furthermore, this method has significantly succeeded in developing some protocols, for example, coverage protocols. Moreover, a significant number of coverage protocols take the coverage configuration protocol (CCP) into consideration. In [20], coverage protocol is defined as a decentralized protocol that builds a network in order to form a certain degree of coverage. Furthermore, the CCP has adequate strength to change the extent of coverage of a particular network according to what is demanded by the application within a run time. In fact, CCP node consists of three modes, which are “listen”, “sleep”, and “active” modes.

The differentiated surveillance service is known as Protocol (DSSP). The protocol of this surveillance service, which is designed for various coverage degrees in WSN, is proposed by the algorithm in [26]. Furthermore, this protocol is one of the extended energy saving methods, which is adjusted to various degrees of sensor coverage. Meanwhile, according to the protocol of the differentiated surveillance service, consistency and awareness regarding locations can be seen from the sensors. In addition, there are two modes that the nodes within the differentiated surveillance service are possibly in: the working or sleeping mode. However, there are only two phases that the activation processes of the sensor nodes need to go through, which are the sensing and the initialization phase. To illustrate this, the initialization phase is the phase where a location is set by the sensor mode. Simultaneously, the time factor is in sync with its immediate neighbor's sensors. As the initialization phase is finished, it is followed by the sensing phase. At this point, a working schedule is arranged.
Besides, in this phase, time is separated into several rounds with equal duration. Moreover, during this phase, there is a specific time for a node to remain awake or asleep, and it is in accordance to its working schedule. The working schedule for each node consists of four tuples (T, Ref, Tfront, and Tend). Therefore, the duration taken for each of the rounds to finish is labeled as T, while the point which refers to random time is represented by Ref. Last but not least, the time that precedes the reference point is labeled as Tfront, while T labels the time that takes place after the reference point.

The optimal geographical density control (OGDC) is another protocol where the combination of connectivity and coverage is involved. This is the fruit of the knowledge of Hou and Zhang [27]. There are three possible conditions that the nodes may be in, which are ON, OGDC, OFF, or UNDECIDED. Furthermore, there is the possibility that time is quantified into various rounds during the node selection phase and the steady state phase, given any of the conditions mentioned. Originally, the initial nodes are in the UNDECIDED state. However, during the steady state phase, their conditions are then changed into either OFF or ON. As powerful nodes retain their activeness, even during the node selection phase, uniform energy consumption is recorded.

5. CENTRALIZED/DISTRIBUTED ALGORITHMS

In determining the degree of coverage in a certain area, an application of the centralized or distributed algorithm is performed when the sensors are utilized. Furthermore, a centralized algorithm can be used on several nodes which are placed in the central location next to the data sink. Normally, the use of distributed or localized algorithm is implemented on all nodes available in the network. Additionally, the nodes that work jointly function altogether with the distributed algorithm in order to overcome a particular computational challenge. On the other hand, based on a localized algorithm, it is indicated that all the nodes have different management methods conducted on an algorithm. These varieties of methods are based on the information that is gathered by each of the nodes. Moreover, the workload is distributed equally by the nodes, in comparison to the centralized algorithm. However, less complexity is shown by the centralized algorithm, in comparison to the distributed/localized algorithms. This is due to the flexibility of the distributed algorithm, in a sense that it can be managed on many nodes across the network.

Centralized and distributed strategies are displayed in the Figures below (3 and 4). A part or the whole algorithm is run by the colored sensors. Furthermore, both centralized and distributed algorithms were developed by Zhou, Das, and Gupta in [28]. Moreover, they are used when conducting a k-coverage becomes necessary. As a result, it was found that both centralized and distributed algorithms revert to their original conditions once an optimal solution is acquired.

Figure 3 Centralized Algorithm
6. PROBLEM FORMULATION

The issue regarding the maximum network lifespan may be described as follows:

There is the involvement of $n$ sensors, a set of $P$ locations with prominent factors, the lifespan of the battery for sensors $B$, and the importance of finding a schedule that maximizes the overall lifespan. The symbols and notations that are used in this paper’s problem formulation are as follows:

- $N$: the node set.
- $s_i$, $N(i)$: sensor $i$ and its neighbor set of sensor $i$, i.e., $N(i)=\{j \mid$ sensor $s_j$ represents the neighbor of sensor $s_i\}$.
- $P$: the set of locations.
- $w_i$: the importance factor of location $i$.
- $W(i)$: the built-up importance factors within the detected locations, i.e., $W(i) = \sum_{j} w_j$.
- $T_i$: the time taken for the coverage of location $P_i$, where $P_i$ is covered by at least one sensor.
- $L$: the lifespan of the sensor network.
- $B$: the lifespan of the battery.
- $C$: the overall successful coverage.

A new algorithm is proposed, in order to extend the lifespan of wireless sensor network to the maximum. A new algorithm is formulated as below:

1. Let $C_i$: coverage of sensor $i$
2. $C = \text{total coverage}$, $t=0$, $S=\phi$.
3. While there are sensors that occur at unscheduled times,
4. The sensor $X$ should be sought, with minimum intersection and the current sensors in $S$.
5. $S=S\{x\}$, schedule[$x$] = $t$.
6. If coverage of $S$ is greater than $C/2$.
7. $S=\phi$, $t=t+1$.

Figure 4 Distributed Algorithm

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7. RESULTS
In the simulation discussed in this paper, all sensor nodes and locations were utilized in an area with a measurement of approximately 10 meters × 10 meters square. Furthermore, the limitation set on the sensing range of each sensor node amounted to 1 meter. This limitation ensured that the communication range of sensors was maintained at 2, which was similar to many sensor platforms. Many sensor platforms set the minimum range of sensing range to half of the communication range. Besides, the sensors ranged from 100 to 600, and the range of locations was from 10 to 60. Moreover, each location was related to the importance factor in terms of the weight of location. Additionally, the network lifespan was utilized so that evaluation would be performed on different schemes. Then, the time taken by each algorithm was calculated, in order to present the results. A customized C++ simulator was used in order to run the simulations. Based on Figure (5), the effects of the number of sensor nodes are visible, with 40 as the number of location. Other than that, the increase of the sensor network’s lifespan is parallel to the increase of the number of nodes in all algorithms. In addition, is shown from the results that the new algorithm is the best algorithm amongst all. All different schemes, new algorithm, randomized algorithm [29], and simulated annealing algorithm (SA), [30] were placed close to each other. On the contrary, randomization was performed on the algorithms with the worst performance.

![Figure 5](http://www.iaeme.com/IJCIET/index.asp) Overall lifespan vs. number of nodes (number of location = 40)

From the figure above, the outperformance of new algorithm on other algorithms can be concluded as: when the number of nodes are increased, the new algorithm outdoes the SA algorithm by 9 % and by 24% on the randomized algorithm. Furthermore, the maximization of the gap of the performance will increase, along with the increase of the nodes. Figure (6) presents the impacts that are brought by various numbers of locations on the performance of the network’s lifespan, provided that the number of nodes is 300. It can be seen that the new algorithm goes beyond the SA algorithm by 11%. In addition, it also exceeds the randomized algorithm by 25%. The increase of the new algorithm occurs with the number of locations increasing in the field.
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![Figure 6](image)

**Figure 6** Overall lifespan vs. number of location (number of nodes =300)

Based on the figure, it is indicated that less time is spent by the new algorithm, in order to display the results in both when the nodes increase in number with 40 locations and when the nodes are maintained at 300, in terms of amount. Other than that, a variation on the number of locations can be seen, as illustrated in Table (1) and (2). Furthermore, a duration that is 700 times the time needed for the utilization of new algorithm is the approximated time required for the results to show using the SA algorithm. Furthermore, improvement in the randomized algorithm is performed by the new algorithm by 10 times.

**Table 1** Runtime for each algorithm vs. number of nodes (number of location =40)

<table>
<thead>
<tr>
<th>Run time / No. of locations 40</th>
<th>No. of nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>New algorithm</td>
<td>2.01</td>
</tr>
<tr>
<td>Simulated annealing Algorithm</td>
<td>4590.85</td>
</tr>
<tr>
<td>Randomized algorithm</td>
<td>108.12</td>
</tr>
</tbody>
</table>

**Table 2** The runtime for each algorithm vs. number of locations (number of nodes =300).

<table>
<thead>
<tr>
<th>Run time / No. of nodes 300</th>
<th>No. of locations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>New algorithm</td>
<td>7.29</td>
</tr>
<tr>
<td>Simulated annealing Algorithm</td>
<td>3553.87</td>
</tr>
<tr>
<td>Randomized algorithm</td>
<td>104.9</td>
</tr>
</tbody>
</table>

8. CONCLUSION

In this paper, in order to present different scheduling methods designed for the extension of the lifespan of wireless sensor network, a new algorithm is introduced. Furthermore, the lifespan extension is conducted through the presence of half coverage of sensors at all times. In this algorithm, the information regarding the distances between the sensor’s neighbor nodes and its sensing areas is essential for each sensor. This can be seen from the simulation, where the precision of the newly proposed algorithm is presented, in comparison to SA algorithm and randomized algorithm.
REFERENCES


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