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Optimal Drone Nodes Deployment to Maximize Coverage and Energy in WSNs Using Genetic Algorithms

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ABSTRACT

Increasing coverage and reducing the energy consumed in wireless sensor networks is an interesting field for researchers since the discovery of wireless sensor networks and it is an open problem. Activating the lowest connectivity range for each node individually depending on its remaining power and the place it covers, while maximizing coverage by placing it in the optimal place will reduce the energy consumed and increase the lifetime of wireless sensor networks. In this paper, we find an approach to increase coverage by optimizing correlation and residual energy using genetic algorithms by placing each node in the optimal position to maximize coverage, assuming that each node has a different energy from the other nodes. We will use drones to carry and move sensors to optimal position. The aim of the proposed work is to cover the largest area of a given region by using the least range of connection and increasing the Lifetime. We ran a succession of simulations and found the proposed model better than the strategies we found in literature.

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1. *Introduction*

Wireless sensor networks (WSNs) have been considered as the main interest field in most recent years. Which is consisting of built-in devices called sensing node. These sensing nodes are very small and contain limited resources of sensing and processing [1]. The development in electronic devices is motivated to develop devices that help in emergencies. Wireless sensor networks have become necessary for several fields such as artificial automation, infrastructure, health care, agriculture, environment and military management [2]. The wireless sensor networks

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focus on monitoring regions, its relays on small nodes interested in small data sensing and communicating with possessing collected data to generate important information, its uses self-organizing system to monitor data for different life fields [3]. The service quality of wireless sensor networks relays on different important features such as sensing, coverage and communicating which is an important challenge for researchers [4]. The field of interest (FOI) is said to be covered, if each point in this region is monitored by least one-sensor node [5]. Energy consuming considered as the main factor of WSNs design. When sensing nodes are deployed in complex environment, it is hard or impossible to replace batteries or recharge it. The cost of transmission unit is higher than the cost of sensing and processing, so there is need to maximize energy by using best deployment strategies [6][7].

The contribution of this paper is to maximize the lifetime and coverage of WSNs by design and implementation a new genetic algorithm based approach and compare it with traditional method using agent based modeling supported results analysis.

This paper is structured as follows. Section 1 is an introduction to the WSNs. Section 2 shows WSNS components. Section 3 presents Genetic Algorisms. Section 4 presents related works. Section 5 presents Suggested Approach. Section 6 presents experimental results. Section 7 presents discussion and section 8 is the Conclusion.

2. Wireless Sensor Network Components

The basic single node of wireless sensor network consists of four main units: Sensing unit, computing unit, transmission unit and energy unit as well as there are three optional units, which can be, used other quality of nodes like GPS, mobilizer and generator of power. Fig. 1 shows the parts of a typical wireless sensor node [8].

(A) Sensing unit: The function pf this unit is to sense the physical phenomena and give the output signal to ADC to convert it to digital data and send it to computing unit.

(B) Processing unit: used to manage and process instruction that related to sensing, communicating and self-organizing. It is consisting of processor chip, active memory to save sensing data, flash memory and internal timer.

(C) Communication Unit: It is corresponding to whole transmission and reception operations of sensing data.

(D) Energy Unit: This unit considered as most important unit in the wireless sensor node, which is support other parts by nodded energy, there are other elements in some of wireless sensor nodes, such as GPS, and energy generator. Fig. 1, Shows The Parts of a Typical Wireless Sensor Node.

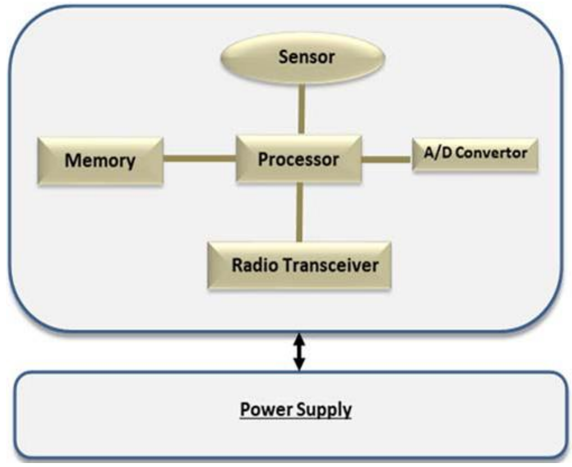

Fig. 1, Shows The Parts of a Typical Wireless Sensor Node.

3. *Genetic Algorithms*

In the present, the genetic algorithms are used greatly as technique to learning, adaption and solving complex problems. Meta heuristic method is used in hybrid computing challenges. The GA are uses selection factor, crossover and mutation to manage search system strategies by active method. This algorithm is inspired from nature selection and genetic science. GA is considered as intelligence using for random search support with historical data to contribute in the search in the improved result field within coverage framework. These algorithms are widely used to conserve problem improvement and investigate it. It is common that this technique is statically investigation operation to search for suitable solution [9]. The Genetic Algorithms are a developing technique is used commonly to solve problems stand for optimization. Each chromosome in the population represents as possible solution. We can consider the chromosome is merging of genes. The coding of chromosome use specific coding for specific problem [10]. The selection of genetic algorithm relays on different ways, such as roulette wheel, elite and championship. In the crossover of GA, hybridization of gene is done from two parent to present new genes series. The goal is to fined chromosome from the population that meet the best requirement. The first step is to prepare a set of chromosomes. In the next steps, there are a series of stages such as selection, mutation and crossover. The population is created and each chromosome contain a set of genes according the required field. According to the finiteness, function result of each individual, the classification of whole population done by sorting from best to worst. The best parent are selected and pass it to next generation. In the mutation stage, turn over a two segments from randomly selected genes. The mutation rate is conserve low to maintain good futures of individuals [11].

4. *Related Works*

In [12], they propose authenticate solution that save energy using drones as mobile gateways where it is fly periodically and gather data. They propose communication form as point to point among drones and nodes using communicating protocol (LoRaWAN).

In [13], they suppose an approach to improve Wireless sensor networks autonomously, which is able to find solution in distributed way for coverage and lifetime maximizing. The supposed approach relays on three components: (a) Multi-Agent translating system, where the agent forming is done, separated area and time by using two-dimensional second-degree cellar machine. (b) the describing of interaction among agent by using spatial prison problem. Moreover (c) there exist local evolutionary mechanism to compete between agents.

In [14], the goal was is achieve the optimal solution for network deployment to cover area 100% using optimal number of nodes and using optimal cluster head coverage. The optimal node number help to minimize total cost of deployment to use minimum number of wireless sensors. As a result the cost considered as critical factor when the cluster head work to achieve maximum coverage which is important attribute.

In [15], the researchers in this paper introduced general overview on WSNs structure and they focus on the area in the field of interest that consume high energy waste and useful. They analysis the some used techniques to support lifetime my minimize energy consumed by network.

In [16], the paper focus on coverage and connectivity problems and their challenges. The wireless sensor networks from particular view, when its required goals with different priority, specify the value of q for each goal, which is the number sensors that are, cover it as well as the number of routs for each node to transmit sensing data to the base station. When q>1, the network can guaranty to fault tolerance. This constraint called Q-coverage and Q-connectivity. In this paper, they suggest solution to the problem consist of two stages, greedy with linear programming for first stage(GLA) and accumulating with graph in the second stage (Max Flow Approach). In addition, the analyze the algorithms using multi data sets and comparative study with traditional approaches.

In [17] in Wireless Sensor Networks (WSNs) that are stand for goal, the coverage and connectivity considered as the most important two issues to guaranty data forwarding from each goal the far base station. In this research, they suggest approach stand for Genetic algorithms (GA) to solve the problem. Taking in consideration the wireless sensor nodes is susceptible to failure, this suggested approach coverage k for whole goals and connectivity m for each sensor node. The suggested approach that stand for genetic algorithms with active chromosome representation and active fitness function, the approach is simulated on wide range using different scenarios. Comparative study is conducted with some algorithms related to this subject to prove the approach activity.

In [18], the research suggest unique compilation strategy to enhance performance of Wireless Sensor Networks due making their sets more stable. One of most important problem that face Wireless Sensor Networks is traffic data, which is consume network resources. The Agent Based Modeling is provide good evaluation to these networks.

In [19], they considered making three-dimensional network in after disaster scenario, where the large urban area is splatted from external environment by communication without infrastructure to damaged network. The main goal of this study is to recommunicate isolated regions with external environment using unnamed aerial vehicles (UAVs) by build special aerial three-dimensional networks. Before network building, they goals to pick up global map information for Region of Interest (Roi) by discover whole obstacles in unknown region. They suggest active technique for three dimensional cooperative land discover using unnamed aerial vehicles using distributed path planning algorithms, which is discover the paths empty from collision. After that they build optimal three-dimensional aerial network with full coverage by deploy minimum number of unnamed aerial vehicles in the regions to achieve maximum coverage.

In [20], the authors are suggested Genetic Algorithm based Static Wireless Sensor Networks. Where adaptive Genetic Algorithm is suggested to minimize energy consuming in wireless sensor networks through energy balance filter. The suggested strategy include inelegance accumulating protocol target for maximize network and minimize consumed energy.

5. Suggested Approach

Genetic Algorithms are considered as powerful tool to solve many problems in Wireless Sensor Networks, they can be used when we need to maximize results in more than one trend optimally. It uses crossover, mutation and tournament selection among generated chromosomes as well as sorting solution after each generation.

5.1 Approach Structure

1. In each generation, each chromosome will represent a solution.
2. Each solution will contain n position for n drone sensors as well as coverage and average lifetime.
3. transmission range = remaining energy/4.5 …… eq. (1)
4. Wireless Sensor Network parameters will be Number of nodes, Area of Interest, Sensing Diameter and Transmission range.
5. Genetic Algorithm parameters will be: Population size, Crossover rate, stopping criteria and chromosome size will be specified automatically by number of nodes. Fig. 2: Shows value to each drone node parameters.

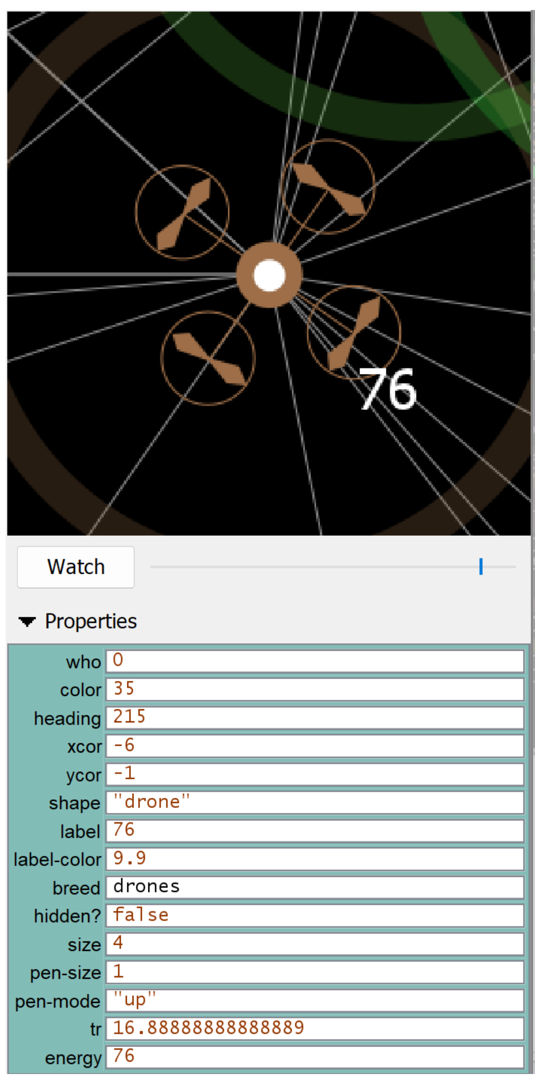

Fig. 2: Shows value to each drone node parameters.

5.2 Approach Steps

1. Initially, the population is generated; each solution in each generation represents a network solution.

2. Computing coverage fitness and lifetime fitness.

3. Sorting according lifetime and coverage.

4. Crossover.

5. Mutation.

6. Repeat steps 1 to 4 until the stopping criteria is achieved.

Fig. 3: Show Suggested Approach Structure.

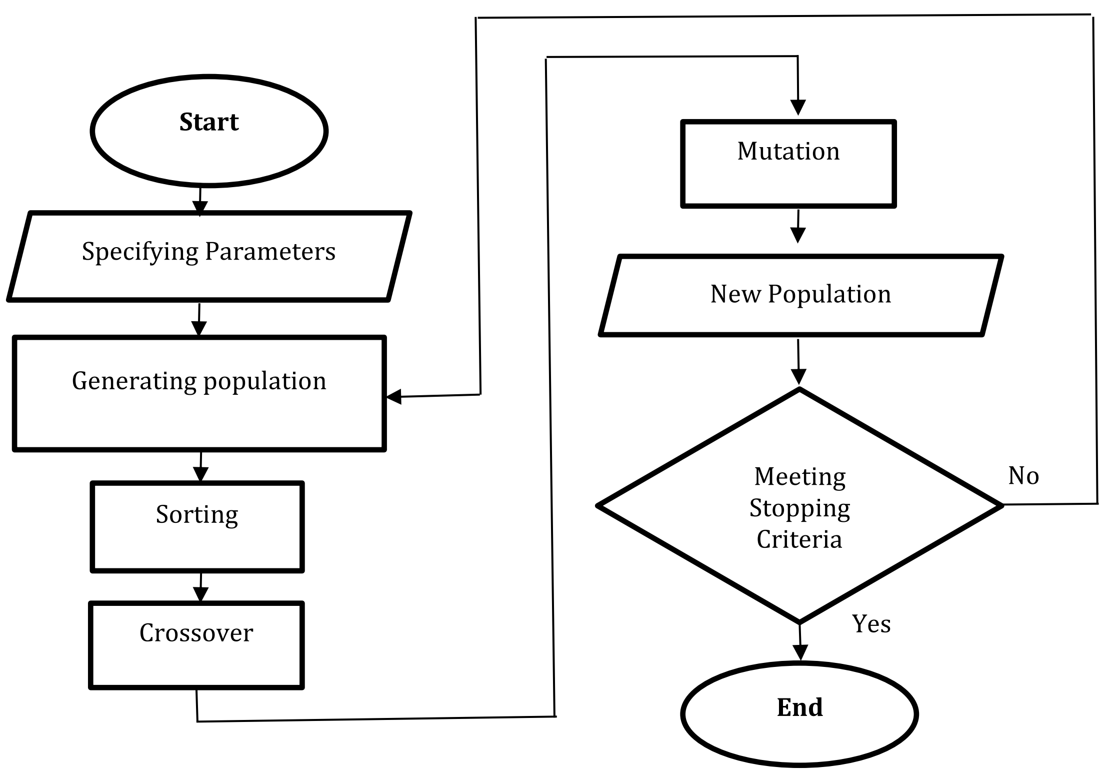

Fig. 3: Show Suggested Approach Structure.

6. Experimental Results

We are varying number of drones using Agent Based Modeling (ABM), number of nodes and area of interest with stabilizing of other parameters to investigate the approach features with compare with basic approach to clarify the activity behind our approach.

6.1 Varying number of Drones

We vary the number of nodes in the simulation to investigate the approach due different situations, Table **1: Shows Used Parameters**

Table 2: Shows The Simulation **Results** for 10, 20, 30 and 40 drones. Fig. 4: Shows Covered area for different number of nodes Fig. 5: Shows Average Lifetime for different number of nodes.

Table 1: Shows Used Parameters

	Parameter	Value
WSN Parameters	AoI	2000m2
	Sensing Diameter	50m
	Transmission Range	Computed by equation 1
	Number of Drones	10, 20,30 and 40
GA Parameters	Population Size	20
	Crossover rate	0.5
	Stopping Criteria	Steady standard deviation

Table 2: Shows The Simulation Results

Used Technique	Suggested Approach		Basic Approach	
Number of Drones	Covered Area	Average Lifetime	Covered Area	Average Lifetime
10	430m^2	8.341h	416m^2	8.001h
20	790m^2	8.451h	746m^2	8.092h
30	1370m^2	8.775h	1299m^2	8.121h
40	1790m^2	8.931h	1712m^2	8.153h

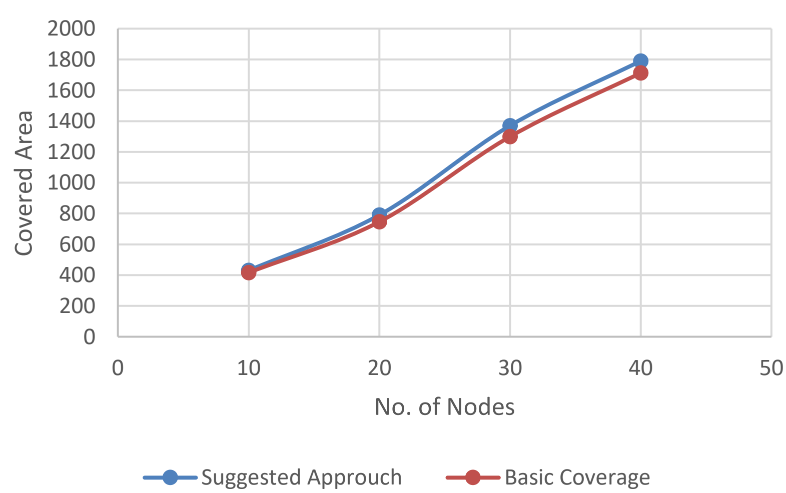

Fig. 4: Shows Covered area for different number of nodes

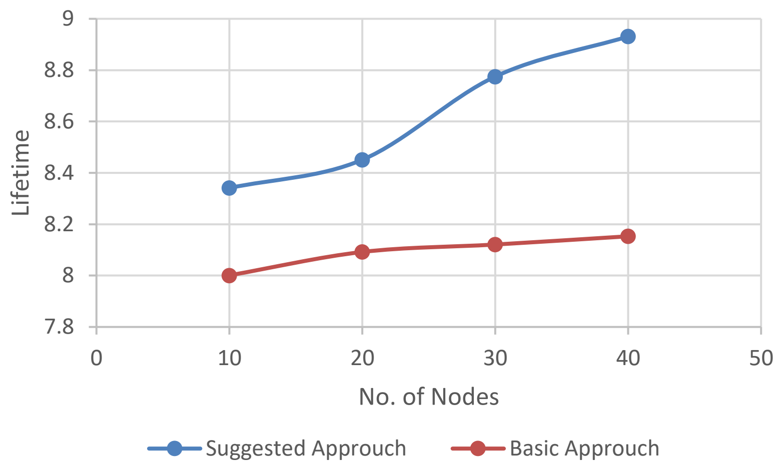

Fig. 5: Shows Average Lifetime for different number of nodes

The following figures show 10, 20, 30 and 40 node respectively, sensing diameter 10m and area of interest 200m^2 as example clarify how the nodes are positioned and connected to each other's depending on its energy and GA.

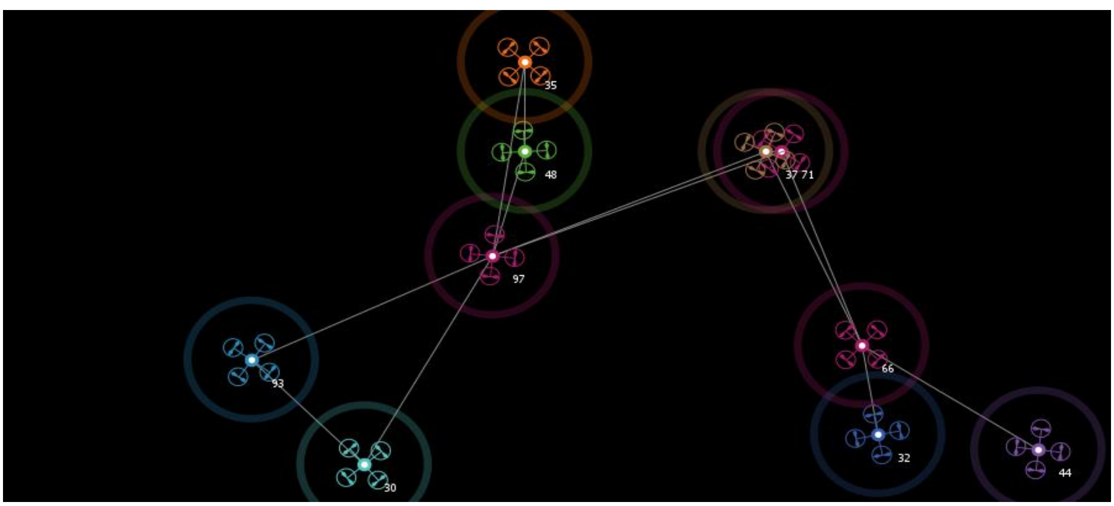

Fig.6: Shows 10-Drone Nodes Deployment In200m2.

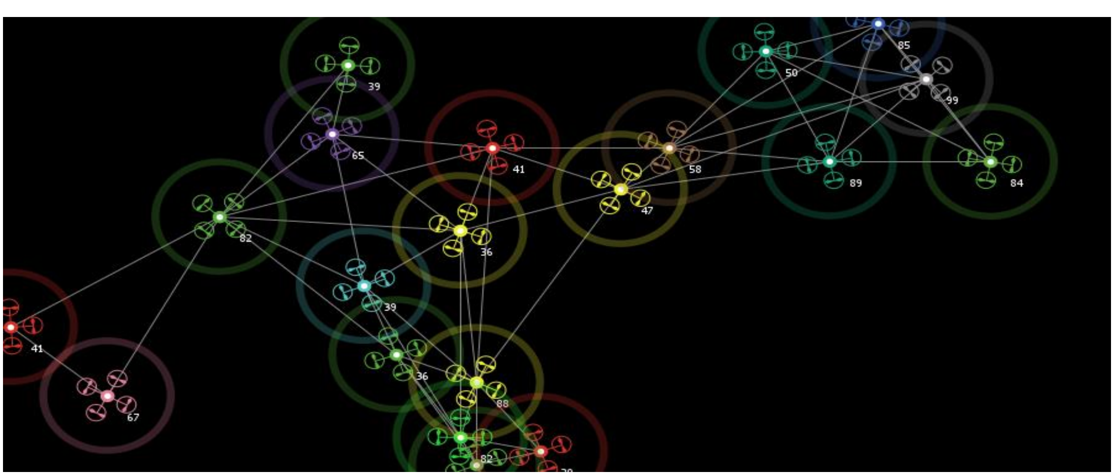

Fig. 7: Shows 20-Drone Nodes Deployment In200m2.

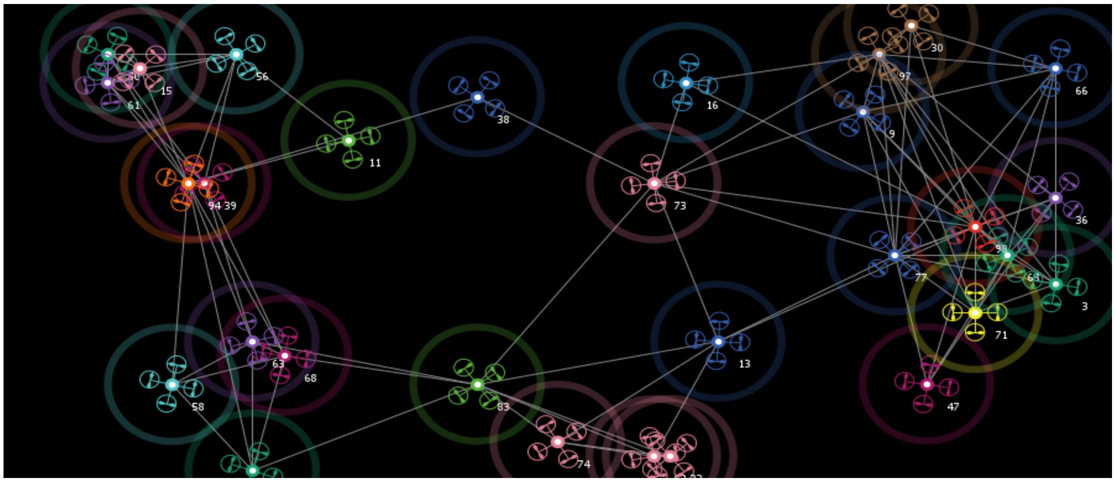

Fig. 8: Shows 30-Drone Nodes Deployment In200m2.

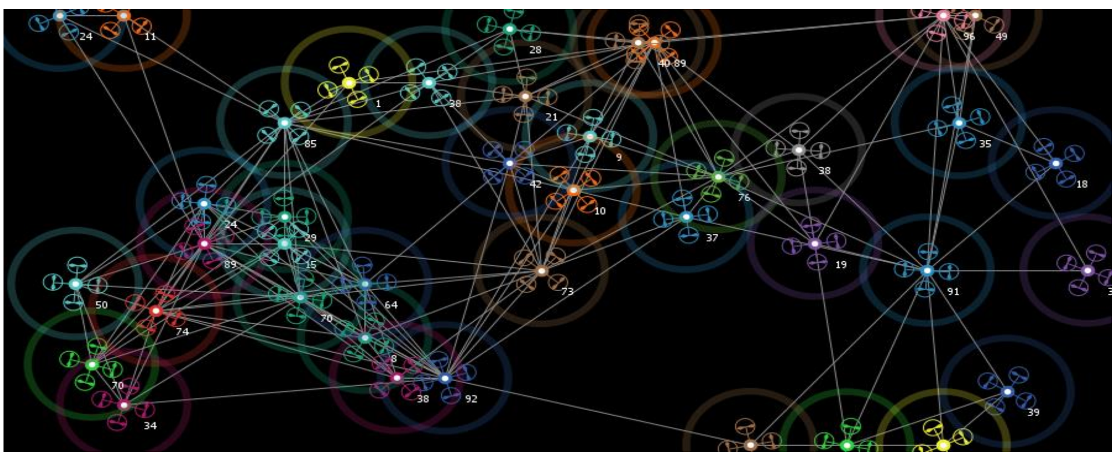

Fig. 9: Shows 40-Drone Nodes Deployment In200m2.

6.2 Varying Area of interest

We vary the Area of Interest in the simulation to investigate the approach due different situations, Table 3: Shows Used Parameters.

Table 4: Shows The Simulation Results for 5000, 10000, 15000 and 20000m^2. Fig. 10: Shows Covered Area For Different Aoi. Fig.11: Shows Lifetime for different Aoi.

Table 3: Shows Used Parameters.

	Parameter	Value
WSN Parameters	AoI	5000m^2, 10000m^2, 15000m^2, 20000m^2
	Sensing Diameter	50m
	Transmission Range	Computed by equation 1
	Number of Drones	30
GA Parameters	Population Size	20
	Crossover rate	0.5
	Stopping Criteria	Steady standard deviation

Table 4: Shows The Simulation Results

Used Technique	Suggested Approach		Basic Approach	
Area of interest	Covered Area	Average Lifetime	Covered Area	Average Lifetime
5000m^2	1467m^2	21.341h	1432 m^2	20.331h
10000m^2	1478 m^2	15.019h	1460 m^2	14.528h
15000m^2	1489 m^2	12.761h	1475 m^2	12.478h
20000m^2	1498 m^2	8.795h	1481 m^2	8.015h

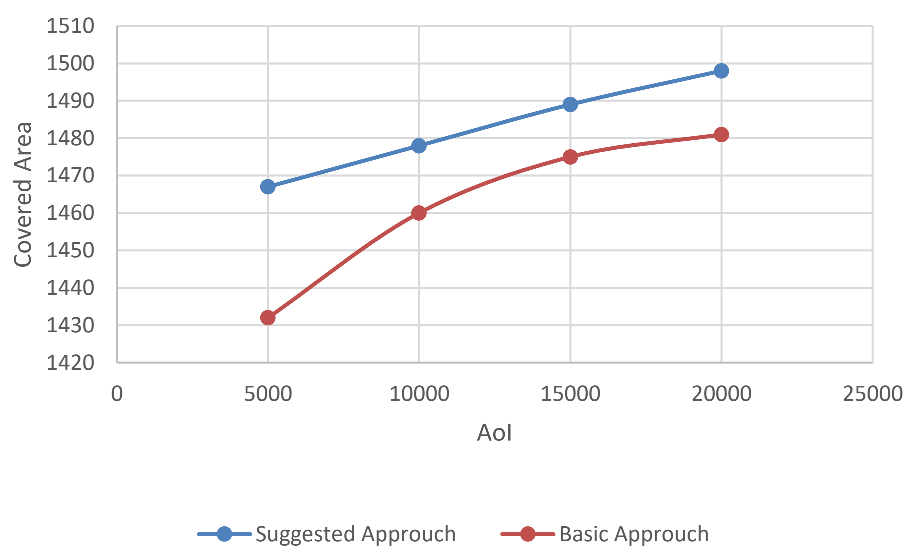

Fig. 10: Shows Covered Area For Different Aoi.

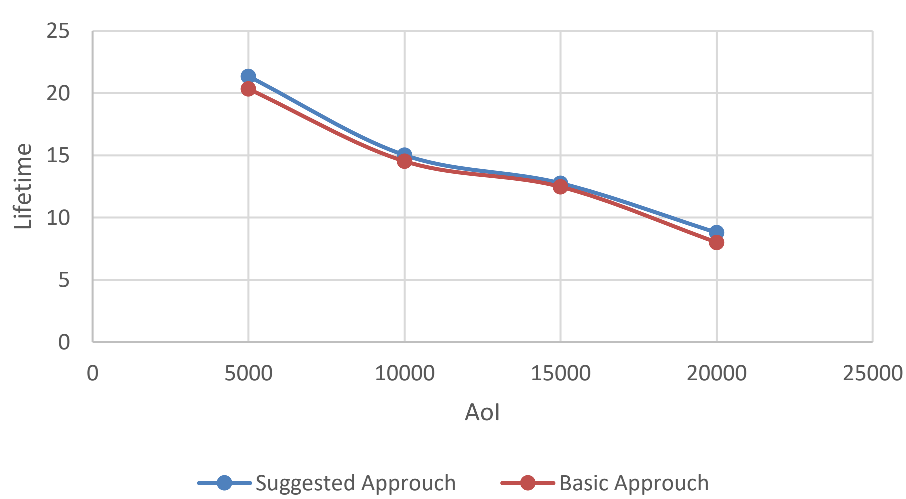

Fig.11: Shows Lifetime for different Aoi.

7. Discussion

From the above results, we fine the impact of using the Genetic Algorithm with equation one (eq. …1) on simulation results. Where when we place the drone in optimal location with activating suitable transmission range according the remains energy using (eq…1) and the learning of genetic algorithm contribute to place the node in the optimal location this will maximize network lifetime due minimizing of transmission rang (tr). The approach provide the value of the suitable transmission according to the position and using the equation.

When we vary the number of nodes from 10 to 40 as clarified in the
Table 2: Shows The Simulation **Results**, we fine that the suggested approach has been increased the area of interest and lifetime. The same happened with Table 4 that shown the simulation results.

8. Conclusion

There important point in WSNs, huge part of energy is consumed by connectivity, through sending or receiving data, it is important to provide low energy consuming sensors to minimize total energy consuming. The goal of this paper is minimize energy consumed by activating optimal transition range according node position in addition to place the high energy node in optimal position if there is needing for it. From the experimental results, we found, that this approach, we can achieve optimal lifetime and coverage at same time while they converse for suggested parameters, we also tested for other parameters, and we found by this we can achieve optimal positions that give maximum coverage and lifetime.

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