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Deployment of nodes for Maximum Coverage in Heterogeneous Wireless Sensor Network Using Genetic Algorithm

Gursharan Kaur Brar[1]
Computer Science and Engineering
SGGSWU
Fatehgarh Sahib – India

Amandeep Kaur Virk[2]
Assistant Professor, Computer Science and Engineering
SGGSWU
Fatehgarh Sahib – India

Abstract: Wireless Sensor networks (WSNs) are large-scale ad-hoc multi-hop network deployed in a region of interest for surveillance purpose. A number of techniques and algorithms are used for coverage problem but coverage is still an active issue in WSNs. Coverage problem casts that how the sensor nodes are deployed in the given sensing area. In this paper we use genetic algorithm to tackle the coverage problem and heterogeneous i.e. nodes having different range are used to cover the area. Genetic algorithm (GA) is an efficient algorithm for this problem. It places the sensing nodes on their best positions removes intersection and covers maximum area.

Keywords: Coverage, Wireless Sensor Networks, genetic algorithm, Heterogeneous nodes, position.

I. INTRODUCTION

From recent few years Wireless Sensor Networks (WSNs) become the most active research topic due to its interesting and bright future. WSNs have so many applications such as medical, commercial, scientific and military domains. A wireless sensor network consists of large number of sensing nodes. Sensing node is made up of four basic components: a sensing unit, a processing unit, a communication unit and a power unit (Battery) [1].

Fig.1.1 Typical WSN Architecture

Depending on the required application, the sensor nodes are capable for sensing, computation and communication tasks. In each node sensing task is usually configured, so the sensing attribute is considered a key factor in designing WSNs [4]. Coverage is fundamental issue in WSNs. It is heavily dependent on individual sensor's coverage model and also the location of deployed sensor. Wireless sensors can either be randomly placed or deterministic placed in the sensing field [6]. Coverage problem relates with the Quality of Service of the network ensuring that the particular sensor network is monitored or observed by at least one sensor node. It is divided into three categories: Area coverage, Target coverage and Coverage dealing with the determination of the maximum support/breach path.

The Rest of this paper is organized as follows. Section 2 will discuss about related work. Section 3 will discusses the proposed algorithm "Genetic algorithm". Section 4 presents the experiments and results, and section 5 concludes the paper.

II. Related Work

Salehizadeh S. M. A et al. in 2010 proposed a novel deployment algorithm for mobile sensor network which is based on individual particle optimization (IPO). Author states that mobile nodes relocate themselves to find the best deployment under various situations to cover largest area. The new locations were determined by IPO. IPO considerably reduces the run-time comparison with the previous PSO based approaches while increasing the effective coverage area [2]. **Poursheykhali Saleheh et al. in 2011** addresses the issue of coverage in a hybrid wireless sensor network with regard to energy constraints. Proposed deployment algorithm obtained maximum coverage subject to energy constraints. Algorithm was presented in three phases and covers an area with considerably less active sensors in comparison with each other algorithms. In future author intended to study about how to preserve the structure of the network once we have designed from disruptions which may occur in the network due to energy depletion of sensors [3]. **Banimelhem Omar et al. in 2013** studied that in hybrid wireless sensor networks composed of both static and mobile sensor nodes. After initial deployment, mobile sensor node was added to overcome coverage holes problem. To find the best positions of the additional mobile nodes author proposed Genetic algorithm (GA). The proposed algorithm determines the minimum number and best locations of the mobile nodes that needed after the initial deployment. Holes problem might be reduced. Author said that GA can maximize the coverage of the sensing field by finding minimum number of additional mobile nodes [4]. **Mahboubi Hamid et al. in 2013** proposed efficient scheme to increase sensing coverage in a network composed of both Static and mobile sensors. The proposed deployment techniques properly assign a virtual weight to every point in the sensing field based on the information received from the other sensors regarding their sensing radii and the location of static ones. The mobile sensors then move iteratively to proper locations out of the covered area of static sensors. Farthest weighted vertex (FWV) strategy was more efficient in terms of fast time response [5].

III. Proposed Algorithm

The main goal of this paper is developed such an algorithm that can remove intersection form the Heterogeneous sensing nodes and covers the maximum area. In the sensing area sensing nodes are firstly deployed using the initial possible co-ordinates locations provided and then new final locations are generated using the final co-ordinates to remove intersection and area covered is maximized.

Genetic Algorithm:

Genetic algorithms (GAs) were invented by John Holland in the 1960s and were developed by Holland and his students and colleagues at the University of Michigan in the 1960s and the 1970s. Holland's original Genetic algorithm is known as the simple genetic algorithm (SGA). Initially a number of individual solutions are randomly generated to form an initial population and its size depends on the nature of the problem. Algorithm starts with a set of solutions represented by chromosomes is called initial population. Solution from one population are taken and used to generate a new population. This is motivated by hope that new generated population is better than old one. The solution are selected to generate new population are selected on the basis of their fitness function. The more suitable they are the more chances they have to reproduce. This procedure is repeated until some condition is satisfied [8].

Basic Genetic Algorithm:

1. [Start] Generate random population of *n* chromosomes
2. [Fitness] Evaluate the fitness *f(x)* of each chromosome *x* in the population
3. [New population] Create a new population by repeating following steps until the new population is complete
    1. [Selection] Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)

2. [Crossover] With a crossover probability cross over the parents to form a new offspring (children). If no crossover was performed, offspring is an exact copy of parents.
3. [Mutation] With a mutation probability mutate new offspring at each locus (position in chromosome).
4. [Accepting] Place new chromosomes in a new population

4. [Replace] For a further run of algorithm use new generated population.
5. [Test] If the condition is satisfied then stop, and return the best solution in present population
6. [Loop] Go to step 2 [7].

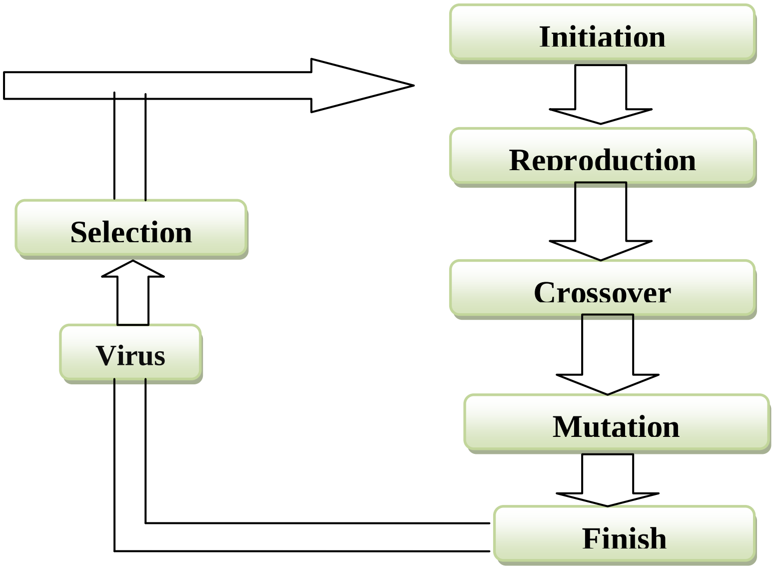
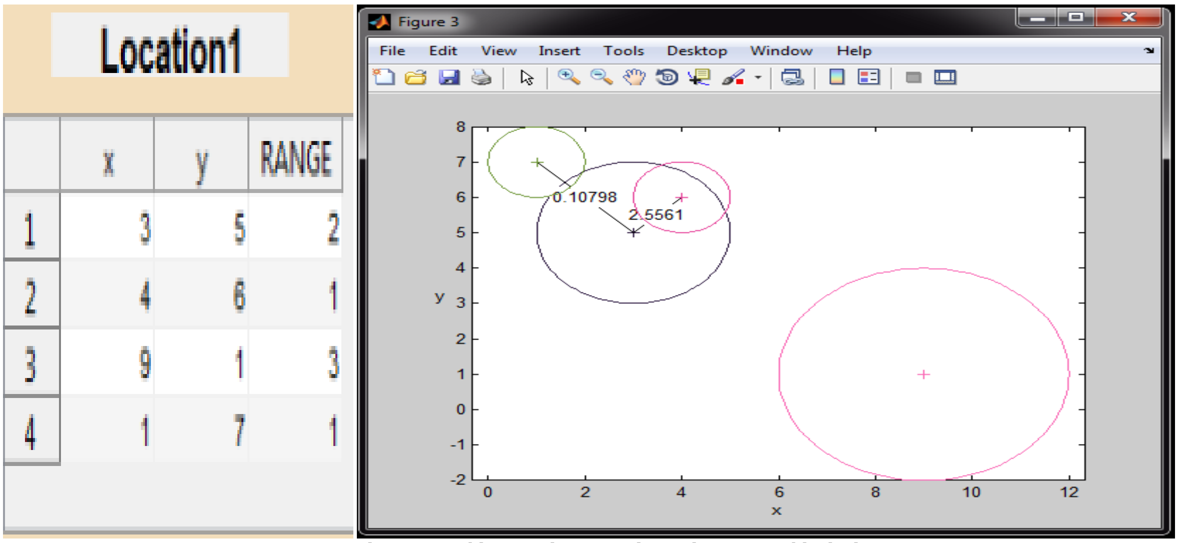


Fig 1.2 Flow Chart of Genetic Algorithm

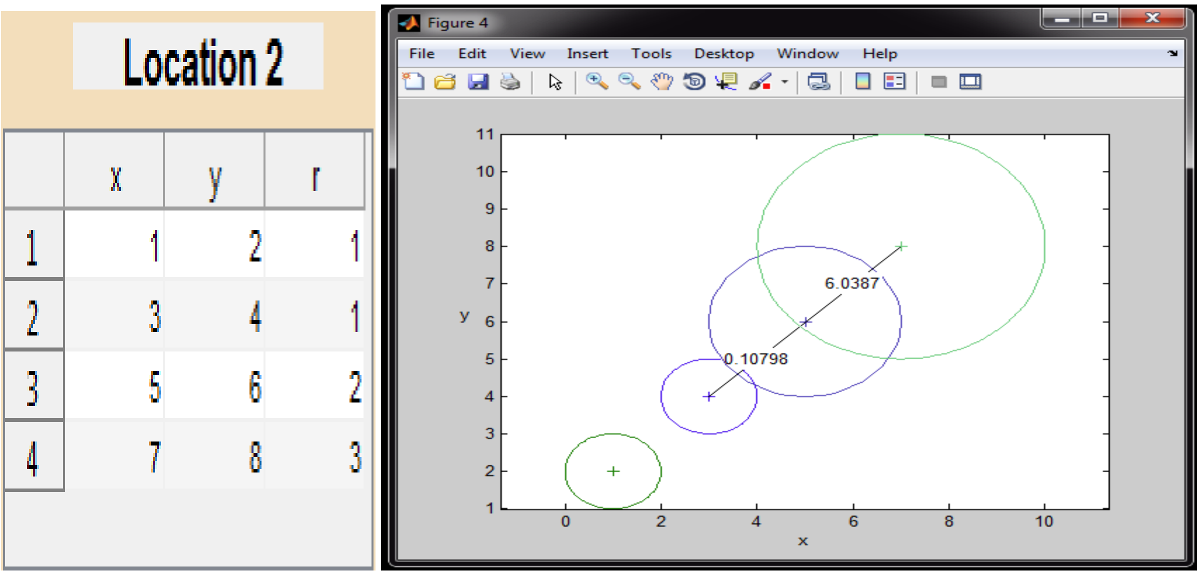
IV. EXPERIMENT AND RESULTS

For experiment purpose we have four heterogeneous sensors and used MATLAB (version 7.11) at the back end. In our experiment we use Heterogeneous sensor nodes i.e. sensors having different range or cover different area. Firstly we place sensors on their initial possible positions. The below given figures Fig. 1.3-1.6 show the four possible locations of four sensors in the given area. In fig. 1.3 table (location1) first giving the x and y co-ordinate and range of all the sensors. Due to heterogeneous sensors the range of sensors is different and deployment figure shows the location of sensors in the area and so on.


Location1

	x	y	RANGE
1	3	5	2
2	4	6	1
3	9	1	3
4	1	7	1

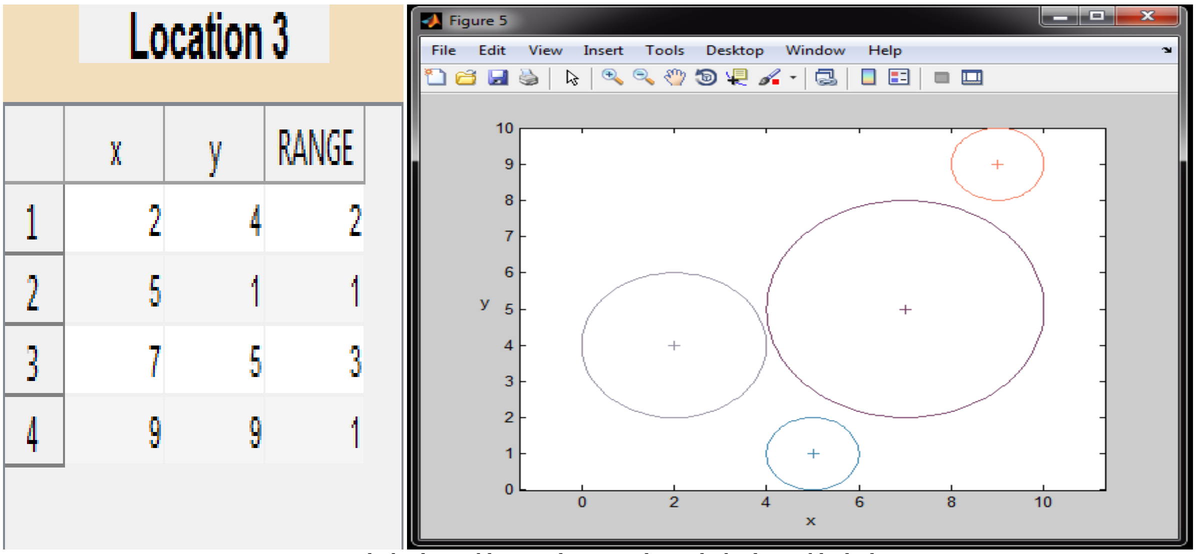
Fig. 1.3 Initial First Possible co-ordinates and Initial First possible deployment



Location 2

	x	y	r
1	1	2	1
2	3	4	1
3	5	6	2
4	7	8	3

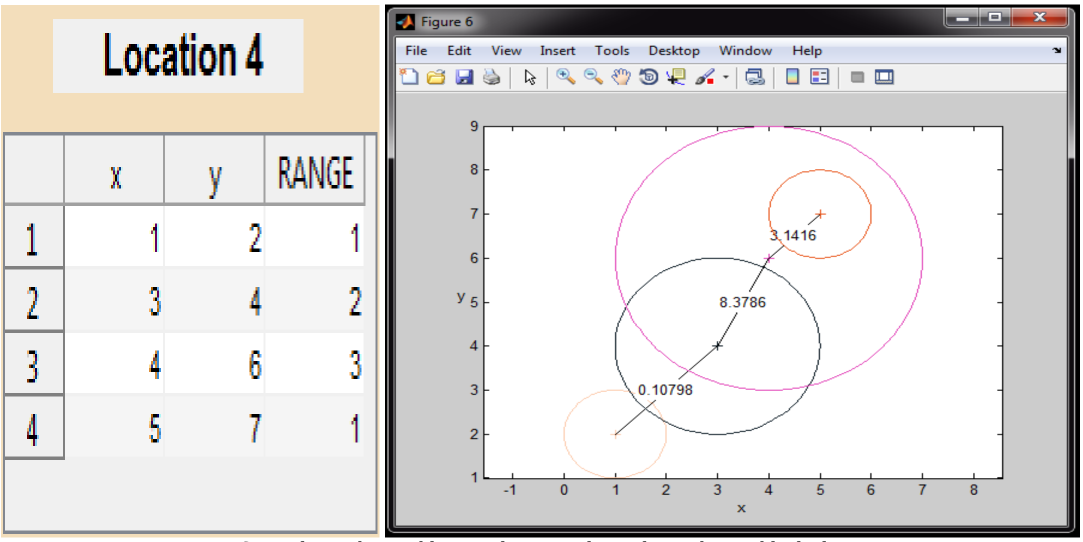
Fig. 1.4 Initial Second Possible co-ordinates and Initial Second possible deployment



Location 3

	x	y	RANGE
1	2	4	2
2	5	1	1
3	7	5	3
4	9	9	1

Fig. 1.5 Initial Third Possible co-ordinates and Initial Third possible deployment



Location 4

	x	y	RANGE
1	1	2	1
2	3	4	2
3	4	6	3
4	5	7	1

Fig. 1.6 Initial Fourth Possible co-ordinates and Initial Fourth possible deployment

As, we see that given four possible locations of heterogeneous sensors. The below given Fig.1.7 show the area of sensor i.e. the total given area, intersection area i.e. intersection between sensors and area without intersection i.e. area covered by sensors in the given total area.

Total Area of all possible Sensor Locations

	Area of Sensor	InterSecArea	area without intersec
1	47.1239	2.6640	44.4598
2	47.1239	6.1467	40.9772
3	47.1239	0	47.1239
4	47.1239	11.6282	35.4957

Fig. 1.7 Area covered after initial possible Deployment

As we see there exists lot of intersection in the above given figures. To remove intersection that exists between the sensor nodes we use Genetic Algorithm (GA). GA provides us two optimal solutions given below. In fig. 1.8-1.10 show final co-ordinates x and y positions and deployment figure gives the positions of sensors in the given area. Fig. 1.9-1.11 the table shows the total area covered and 0 or no intersection between sensors.

Location1

	x	y	RANGE
1	2	4	2
2	5	1	1
3	7	5	3
4	9	9	1

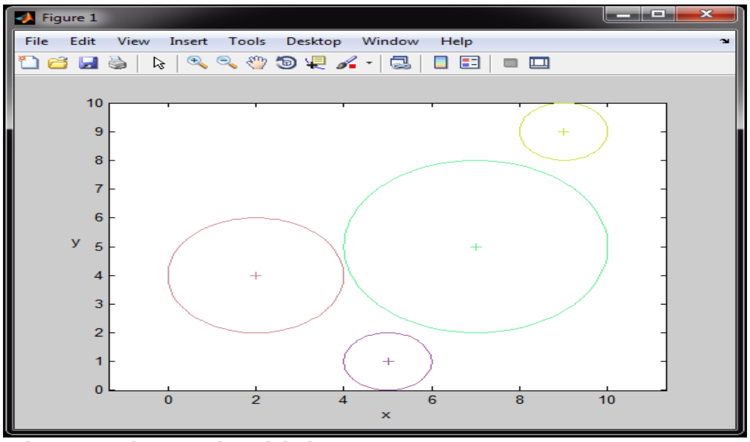


Fig. 1.8 Final First co-ordinates and Final deployment

	1	2	3	4
1	12.5664	0	0	0
2	0	3.1416	0	0
3	0	0	28.2743	0
4	0	0	0	3.1416

	AreaSensor	InterSecArea1	Areawithoutinterse
1	47.1239	0	47.123

Fig 1.9 Area covered after initial and final deployment

Location2

	x	y	RANGE
1	5	1	2
2	2	5	1
3	7	9	3
4	9	4	1

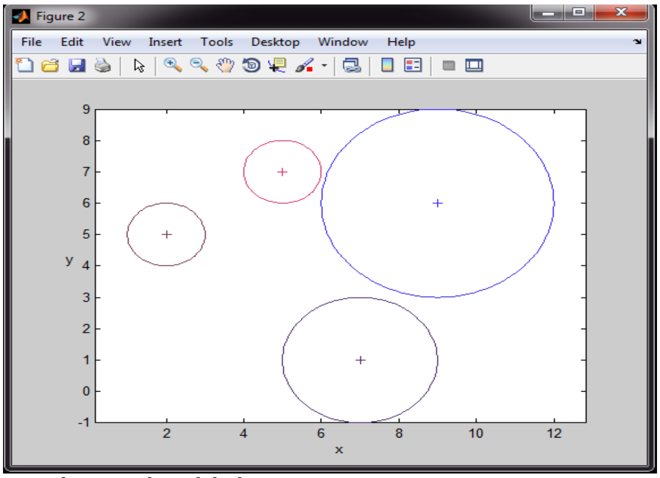


Fig. 1.10 Final First co-ordinates and Final deployment

	1	2	3	4
1	12.5664	0	0	0
2	0	3.1416	0	0
3	0	0	28.2743	0
4	0	0	0	3.1416

	AreaSensors	InterSecArea2	Areawithoutinterse
1	47.1239	0	47.123

Fig 1.11 Area covered after final deployment

The results show that Genetic algorithm place the sensors on their best positions and remove the intersection. So the covered area is maximized.

V. Conclusion

This paper concludes about the coverage problems in wireless sensor networks. To overcome these problems we propose genetic algorithm. Heterogeneous nodes i.e. nodes having different coverage range are used in the. After using Genetic algorithm experiments and results shows that there exists no intersection between the nodes and area covered by the sensing nodes is maximized. In future we may use Ant colony optimization (ACO) algorithm.

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