Evaluation of Effect of Parameter Values on Evolutionary Algorithms based Hybrid Coverage Optimization Technique

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Abstract - Efficient Routing, Lifetime, Deployment, Energy Consumption and Coverage are the major factors those effects the performance of network. Many research works have been done and many algorithms have been developed to apply on sensor networks to make the networks efficient. We have proposed a hybrid technique based on evolutionary algorithms to optimize the coverage of network. Results have been analyzed to evaluate the effect of parameters on the performance of hybrid technique. We conclude that the average value of parameter balances the execution time as well the objective of algorithm.

***Keywords** - Coverage; Effect of Parameters; Evolutionary Algorithm; Hybrid optimization techniques.*

I. INTRODUCTION

The advanced technology gives us the cheap and effectively service providing systems. In the current time, the small-sized wireless sensor networks those consume less power are available to provide better quality of service. Wireless sensor network is made up of these sensor nodes that can perform functions of sensing, computation and data communication of any condition. This technology can be used in several areas such as military, industrial production, transportation, and health etc. With the development of wireless communications, it is possible to construct cheap, small-sized and low-power sensor nodes. To operate the Wireless sensor networks more efficiently energy efficient deployment, architecture, protocols and algorithms are needed [1]. Coverage, Energy Consumption, Lifetime and efficient Routing are the major issues that causes problem for efficient performance of network.

The basic work of sensor network is to sense, process and collect data from any specific environment. The main part of the whole network is the nodes those are used to send the data to sink node for future purposes. The Wireless Communication technology has very vast level useful applications such as for military purposes, industrial areas, health, home purposes and transportation. The nodes are working on the power of battery that is supplied to it. In various situations it is difficult or not possible to change the batteries after the batteries become dead [2]. To make a sensor network an efficient one, many developed methods, protocols, techniques and algorithms are required [3]. Many experiments have been done on WSNs by using developed techniques, and algorithms to justify the optimal solutions of the problems of sensor networks. The issues regarding the WSN are such as Power/Energy Consumption, Coverage Rate, Routing and Network Lifetime. All of the above mentioned problems affect the quality of service of wireless network.

II. EVOLUTIONARY ALGORITHM: AN OVERVIEW

The placement of sensors in a sensing area is essential & one of the important factors to optimize the coverage. Optimization is a big challenge because the placement of sensors can be grid based, area, target etc. The determination of best placement strategies is a part of optimization. The demands for the WSN problems needs that the optimization algorithms must be robust and efficient.

In our work, we apply the evolutionary algorithm such as particle swarm optimization (PSO) algorithm and genetic algorithm to optimize sensor locations. The evolutionary algorithms have been already used in many areas. We demonstrate that how the swarm optimization performs combines with GA for deployment problem. Both the algorithms use their own operators to obtain new solutions from the existing solutions. The concept of randomness is used by both the algorithms to avoid local minima problem.

The main difference between these algorithms is of operators. Genetic Algorithm uses three operators such as selection, crossover, and mutation. These operators are of many types. The choice of type of operator depends up on the problem for which it is used [4, 5]. The Particle Swarm Optimization (PSO) algorithm is simple. It uses one operator called velocity and also uses previous solutions.

In our work, we apply a hybrid technique based on PSO and GA. We study and analyze the effects of parameters of PSO and number of iterations on the results of optimization. Most of the time, the comparisons between PSO and GA shows that the difference between the results of both the algorithm is very small. That's why we proposed a new hybrid technique to improve the results.

III. RELATED WORK

The authors in [6] uses voronoi diagram with diamond pattern to arrange the sensor nodes. In diamond pattern the nodes has four-way connectivity with its neighbor nodes. The coverage is full and the communication range is divided by the range. The authors prove mathematically the validity of their used diamond pattern. The pattern is not used practical in actual deployment.

In [7] the authors designed three types of deployment strategies to provide maximum coverage with minimum movement. The results showed that these strategies are very effective for limited number of sensors. The question is that these protocols will be optimal for large numbers of sensors. Several algorithms and strategies for best coverage of homogeneous network are explained ***by authors in [8] and in [9]*** the authors suppose that the sensors used are the homogeneous sensors. The same experiments are repeated with different sensing range to prove the performance and optimality of the algorithms presented in ***[8].***

In [10] a rectangular based coverage model is described which is using homogeneous sensors and monitor the barriers. The authors used theorem for WSN to analyze the results. They put the maximum and minimum values of range into the theorem to prove the validity of the algorithm.

An energy efficient network for homogeneous sensors is developed ***by authors in [11].*** Weighted Voronoi diagram is used to fulfill the requirements. This technique is extended for heterogeneous networks.

A brief summary of different energy efficient coverage problems is discussed ***in [12].*** The authors Chen, Kumar, and Lai proposed a barrier coverage protocol to save the energy. In this approach, when there is adequate k-coverage then the node goes into sleep mode. After a random period of time the node wakes up and finds whether there is coverage or not. In this way the extra energy consumption is saved.

The authors in [13] proposed a new protocol in which the sensor nodes can be in any of five states.

- From sleep mode to wake up state.
- Beacon state
- Waiting state.
- Withdraw state.
- Active state.

Wang, Hu, and Tseng in [14] discussed the effect of obstacles on coverage. The authors do their experiments on homogeneous nodes by deterministically deploy the nodes. The field is divided into smaller areas. The nodes are deployed in these small areas.

The authors in [15] consider forces applied by obstacles which affect the coverage. The Knowledge of the obstacles is required to improve the coverage from the random deployment to final deployment.

Poduri and Sukhatme in [16] analyze the k-coverage problem of mobile network. Their proposed algorithm applies force on the sensors and compels them to go away from each other and in this way the maximum coverage and k-coverage is attained. The centralized and distributed algorithms are described ***in [17].*** The authors said that both algorithms give solutions near to the optimal.

The authors in [18] present the developed versions of centralized and distributed algorithms. The results of the algorithms show that the proposed algorithms give results very fast and very near to the optimal. These algorithms also consume less energy.

In [19] the art gallery approach is used for deployment. The authors said that this approach can be used when the shape of the sensing field is known before the deployment. It is used when deterministic placement is employed.

The authors in [20] give a review on the Voronoi diagram used for solving the coverage problems. Different algorithms for heterogeneous nodes as well as for homogeneous nodes are described.

In [21] and [22] a distributed algorithm is given for target coverage. This algorithm is applied on each node at its turn to cover the target point. This algorithm is extending the lifetimes of network. Before each cycle, all the nodes recalculate their sensing time period. This algorithm better suits for clustering. Only the stationary targets are monitored by this algorithm.

IV. PROPOSED WORK

A. *Problem Statement*

The world becomes more complex that's why the decisions must be optimal one. The optimization methods are reliable to obtain the best results. Efficient Routing, Lifetime, Deployment, Energy Consumption and Coverage are the major factors those effects the performance of network. Many research works have been done and many algorithms have been developed to apply on sensor networks to make the networks efficient. Our work is related to the problem of coverage. We have proposed a hybrid technique to optimize the coverage of network. The proposed algorithm is based on evolutionary algorithms. The main role is of PSO (particle swarm optimization) and the genetic operators are used for fast convergence.

B. *Objective of Study*

- The main objective of this work is to study the optimization techniques.
- Second is to implement the proposed hybrid algorithm based evolutionary algorithms for optimizing the efficient coverage of sensor network.
- Analyze the parametric effect on performance of evolutionary algorithms.

C. *Methodology*

At the first step the Particle Swarm Optimization Algorithm is initiated, and then the Genetic Algorithm is used to generate the Global Best and Local Best of particles. The velocity and new particle positions are updated by using PSO. The steps and flow of algorithm is as follows:

1. Randomly deploy the nodes.
2. Calculate Total Area Coverage (TC).
3. Calculate Actual Area Coverage (AC). If TC=AC go to step 7 else go to step 4.
4. Apply the PSO to calculate new particle positions. Use Genetic Algorithm to generate global best and local best.
5. Jump back to step 3 until all nodes have better coverage.
6. When the goal achieved from Step4, and then deploys the nodes with those coordinates as centre.
7. Calculate total area coverage.

V. RESULT ANALYSIS

We have performed more experiments based on values of constant parameters of particle swarm optimization algorithm. There are four main constant parameters in PSO those have effect on the velocity of particles. The velocities of particles have effect on the performance of algorithm.

Table I: Standard Values of Parameters

Parameter Description	Value of Parameters
Swarm Size	n
c1	1
c2	1
r1	between 0 to 1
r2	between 0 to 1
Range	r
Crossover	Single point crossover
Mutation	Uniform Mutation

In the above table, we took the rand values between 0 and 1 for r1 and r2. The values for c1 and c2 are equal to 1. There is reason behind choosing the value of weights equal to 1. The following experiments and result analysis gives answer for this question. We have performed experiments with different values of weights and analyze the results on the basis of number of iterations and coverage.

We have taken 50 sensors for analyzing the parametric effect on the performance of proposed hybrid technique of coverage. For better performance of algorithm, we have considered that the algorithm should give optimal coverage in less number of iterations with optimal number of sensors. The following tables and graphs represent the results for different experiments.

Table II: Different values of weights for 50 sensors

c1	c2	Sensors	Coverage	Iterations
0.1	0.1	50	2500	24
0.2	0.2	50	3008	23
0.3	0.3	50	3021	21
0.4	0.4	50	3060	20
0.5	0.5	50	3123	20
0.6	0.6	50	3267	19
0.7	0.7	50	3956	18
0.8	0.8	50	3995	17
0.9	0.9	50	4056	16
1	**1**	**50**	**5399**	**15**
1.5	1.5	50	3851	10
2	2	50	3311	7

In the above table, we observed that the number of iterations decreases as the value of c1 and c2 are increased. But on the other hand the coverage is not as much optimal as we want it have to be. The eleventh row of table highlighted by red color is a solid point in this experiment. The value of c1 and c2 is equal to 1. With this value, the number of iterations is average; these are not more or not less. With this number of iterations the hybrid algorithm gives optimal coverage which is very close to the actual coverage. This effect can be observed in the following graphs.

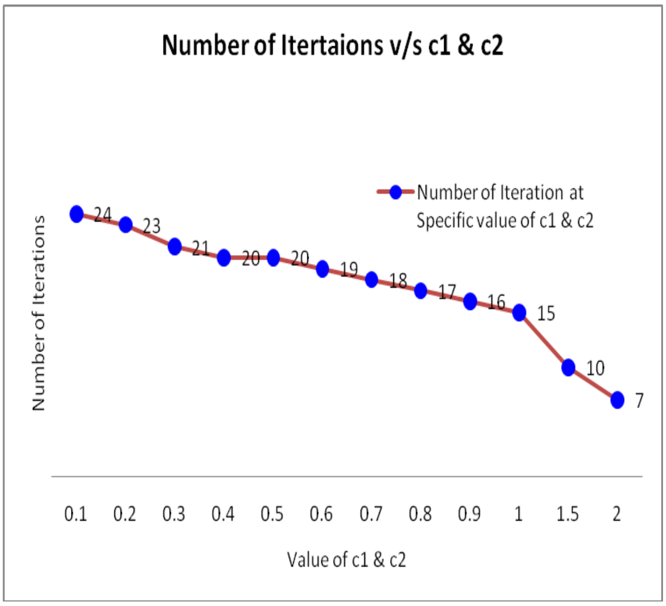

Fig.1: Number of Iterations v/s c1 & c2

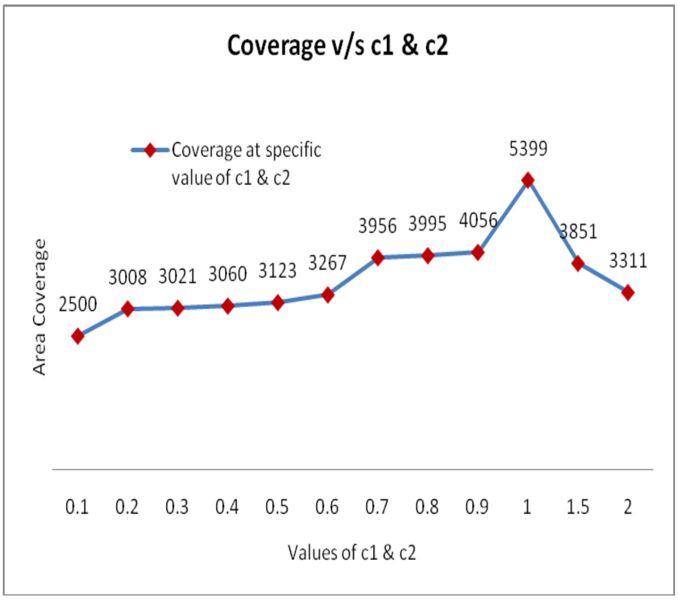

Fig.2: Area Coverage v/s c1 & c2

Table III: c1 & c2 versus Number of Iterations and Nodes

Nodes	C1	C2	Range	Iterations
10	0.1	0.1	6	14
10	0.2	0.2	6	12
10	0.3	0.3	6	10
20	0.4	0.4	6	18
20	0.5	0.5	6	15
30	0.6	0.6	6	18
30	0.7	0.7	6	17
40	0.8	0.8	6	14
40	0.9	0.9	6	9
50	1	1	6	17
50	1.5	1.5	6	13
50	2	2	6	4

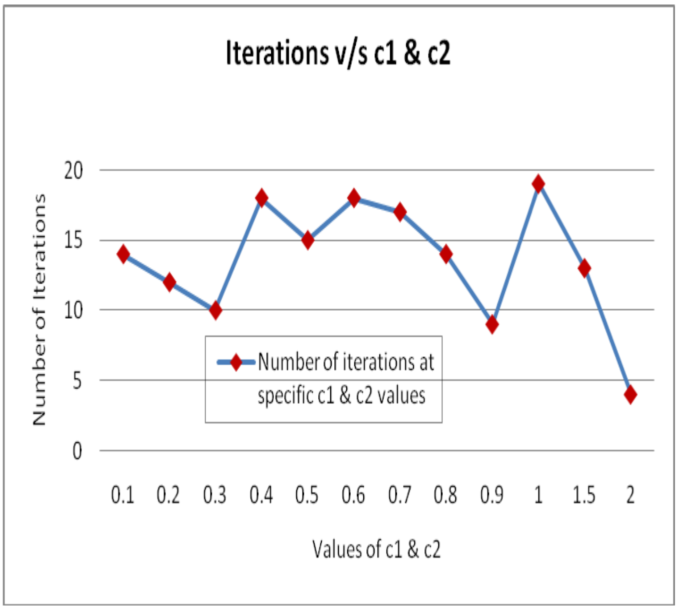

Fig.3: Number of Iterations v/s c1 & c2

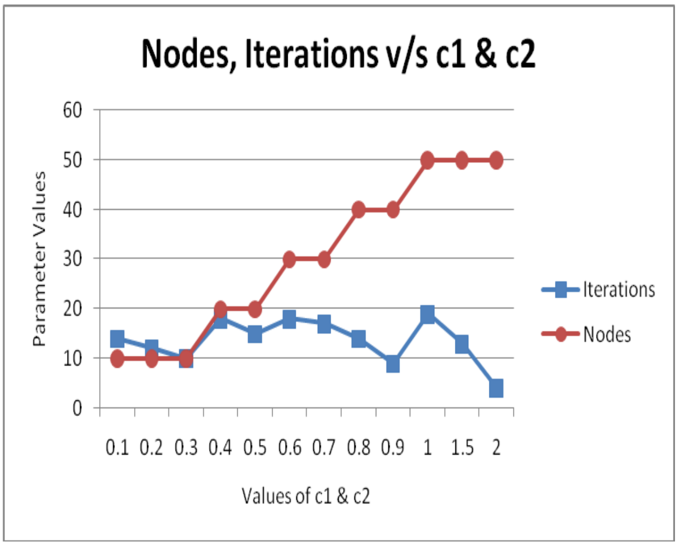

Fig.4: Number of Iterations & Nodes v/s c1 & c2

VI. CONCLUSION & FUTURE SCOPE

The result analysis shows that the proposed algorithm covers area as much the actual coverage of nodes. In this paper, we had worked on coverage. The hybrid algorithm provides an efficient deployment of nodes. The same area dimensions are covered by less number of nodes in very efficient manner. In each case the coverage increases as the hybrid technique is applied. This gives better placement strategy as well as better coverage. The parametric effect is also analyzed. The constant parameters of PSO algorithm have a great effect on the performance of the algorithm. From experimental study, we conclude that the value of constant must be average. The high value of parameters decrease execution time but the objective of algorithm leaves behind. The low value of parameters increases the execution time. The average value of parameter balances the execution time as well the objective of algorithm. In our work, we take the constant value as '1'.

In future, we will do the research work on other optimization algorithms and will compare the results of this hybrid technique with other optimization algorithm.

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