International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

Multi-Objective Soft Computing Techniques for Dynamic Deployment in WSN

Shiwani Gupta [1], Dr. Shuchita Upadhyaya [2]

[1]*M.Tech Scholar, Dept. of Computer Science & Applications, Kurukshetra University, Haryana, India*
[2]*Professor, Dept. of Computer Science & Applications, Kurukshetra University, Haryana, India*

Abstract - WSN stands for Wireless Sensor Network. In WSN deployment, the nodes are deployed in such a way that they cover the maximum area. The sensor nodes have limited amount of energy. The lifetime of nodes cannot be increased. The main problem in WSN deployment is to cover the maximum area and minimize the energy consumption by deploying lesser number of sensor nodes. This problem is known as Coverage Energy balancing Sensor Problem (CEBSP). Most of the work carried out in this field focuses on how to cover the maximum area or to decrease the energy consumption separately. The multi objective means having more than one objective. Here, the objectives are coverage and energy, and we are required to cover maximum area and decreasing the energy consumed by nodes in transmitting the information. In this paper, we have focused on increasing coverage area and reducing the energy consumption by deploying lesser number of nodes in the network.

Key Words: **WSN, energy, coverage, deployment, Coverage Energy balancing Sensor Problem**

1. INTRODUCTION

1.1 Background

WSN is a system which contains a large number of sensor nodes which is distributed geographically in the region which is to be monitored. Many applications are – military applications such as battlefield surveillance, industrial such as industrial process monitoring, health and specific area such as habitat monitoring, earthquake observation, environmental conditions such as forest fire control etc. According to these applications, many WSN's are developed such as wireless sensor networks for multimedia, underground, underwater etc. Sensor nodes are built up of "nodes" from several hundred to thousands. Nodes are of two types:

- Homogenous,
- Heterogeneous

In **homogenous sensor nodes**, all the nodes are identical and they have same energy level but in **heterogeneous sensor nodes**, there are two or more than two types of nodes. The energy level of all nodes is different. The lifetime of node is limited. The battery cannot be recharged. Each node consists of three subsystems and these are:

- Sensor subsystem
- Processing subsystem
- Communication subsystem

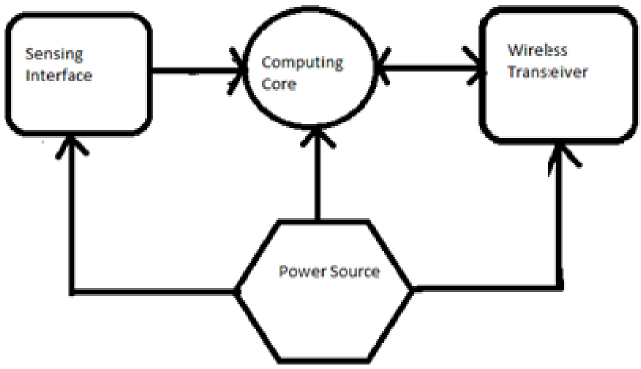

Fig-1: Subsystem of Sensor Nodes

There are certain issues that affect the design and performance of a WSN which are described below:

- Hardware and Operating System for WSN
- Deployment
- Localization
- Synchronization
- Quality of Service

In this paper, we focus on WSN deployment i.e. how the sensor nodes should be deployed so as to cover maximum area thereby consuming less energy.

For finding appropriate clustering of the network to find shortest path of transmission and to reduce the energy consumption, the genetic algorithm is used as it provides the optimal solutions. The operations of genetic algorithms are selection, crossover, mutation. Before selecting the mating pairs the scaling of fitness function is done.
Fitness value after scaling = (fitness value before scaling) – (smallest fitness value).

1.2 Authors' Contribution

In this paper, balancing of coverage and energy by deploying less number of sensor nodes is proposed. The Intersection between nodes can be defined as the common covered area by two sensor nodes [1], and, it needs to be minimized. Also, the lifetime of nodes is limited. The Coverage C of a sensor node S_i in area A is defined as C (S_i ,A) and the energy E of a sensor node S_i can be defined as E(S_i ,A).

The objectives of this papers are:

- Increasing the maximum area covered by nodes.
- Increasing the lifetime of sensor nodes.
- Balancing the energy and coverage by deploying less number of sensor nodes.

The rest of this paper is organized as follows: in Sect.2 the literature review related to the WSN Deployment, coverage and energy in WSN is briefed. In Sect.3 the proposed framework is discussed. In Sect.4 the experimental setup and the experimental results has been discussed and finally the conclusion is outlined in Sect.5.

2. RELATED WORK

Ozan Zorlu et al. [1] proposed the consequence of advances in wireless communication, digital systems and microelectronic mechanical system technologies, Node deployment affects other problem domains directly or indirectly. Therefore, in this study, node deployment problem is dealt with. Also, coverage area of WSN system with an organized deployment approach is tried to be increased. This problem is known as maximum coverage sensor deployment problem (MCSDP) and NP-hard. To do so, a genetic algorithm proposed for increasing the coverage of given WSN topology with homogeneous sensors in a 2-D Euclidean area. But this has a limitation, that energy and coverage cannot be balanced at the same time means the area covered by sensor nodes should be maximized while the energy consumed by sensor nodes should be minimized. Shiyuan Jin et al. [2] proposed Many methods related to *genetic* algorithm have been evaluated in the literature for energy efficient WSN in which Coverage is the fundamental challenge. Deployment can be done in two ways:

- Deterministic Deployment
- Random Deployment

Mohammad M. Shurman et al.[7] proposed how Hierarchical clustering is used with the genetic algorithm. Their results shows that hierarchical clustering reduces the long distance between sensor nodes and the sink node. The consumption of energy is also reduced with reduction of distance. Amol P. Bhondekar et al. [8] presented The parameters of these algorithms are Field Coverage (FC), Overlap per cluster change in error (OPCIE), Sensor out of range(SORE), Sensors per cluster in charge(SPCI), and network energy. The result showed that the evolution of parameters conclude that high number of sensor nodes can be used with low power consumption and this approach is used for better network configuration and sensor placement. Seyed Mahdi Jameii et al. [5] proposed algorithms for energy-efficient sensing coverage. These are further divided into two categories.

- Location-dependent
- Location-free

Genetic Algorithm is used to find the appropriate clustering of the network to find In Location dependent algorithms. The results of this approach determine that the node which is nearest to sink will become a cluster head and if the sink is at the center of network more clusters are used. S.M. Hosseinirad et al.[6]concluded that in several situations, random deployment has better performance compared to grid deployment and second result is that population size is a trade-off between wireless sensor network parameters and Genetic Algorithm parameters. Y Zou et al. [9] presented a sensor network generally consists of several tiny sensor nodes and a few powerful control nodes also called base stations or called as sink. Sensor nodes are usually densely set up in a large area and communicate with each other in short distances through wireless communication. C. S. Raghavendra et al. [11] presents that one fundamental challenge in sensor networks is its dynamics. Over the time some nodes will fail functioning properly for different reasons such as running out of energy, crash due to software bug, overheat in the sun, carried away by wind etc. Shashi Phoha et al. [12] presents that a key attribute of sensor networks is to be able to self-form. That is, when randomly deployed in a region, the nodes should be able to organize into an efficient network capable of collecting data in a useful and efficient manner. Adam Dunkels et al. [13] proposed that the architecture is expressive enough to accommodate typical sensor network protocols. Measurements show that the increase in execution time over a non-adaptive architecture is small. Xi

CHEN et al. [14] propose a broadcasting communication protocol with high energy efficiency and low latency for large scale sensor networks based on the Small World network theory. Simulation and experiment results show that our schemes and protocol have good performance. Zoran Bojkovic et al. [15] proposed that how to deal with challenges for WSNs deployment, they start with mobility-based communication in WSNs. In recent years extensive research has opened challenging issues for wireless sensor networks (WSNs) deployment.

3.PROPOSED WORK

The proposed approach for balancing coverage and energy by deploying less number of sensor nodes has been given the name "Coverage and Energy balancing Sensor Problem" (CEBSP) because it balances the energy and coverage of WSN network simultaneously.

The proposed CEBSP consists of:

- MOGA
- LEACH

3.1 Dynamic Deployment using MOGA: Multi-Objective Genetic Algorithm

Multi-objective involves more than one object which is to be optimized simultaneously. The task of finding one or more optimal solution is known as multi-objective optimization. In genetic algorithm, only one factor is considered and when fitness is calculated only one value is achieved. But if more than one factor is included then multi objective genetic algorithm is used because when fitness is calculated then as a result a set of values is achieved. With multi objective instead of single solution they get a whole set of solutions. This set is called a Pareto front. Every solution in set is not worse than the others. In this, the population is generated randomly. This population then produces a population of offspring. Both populations are combined into one population. Then this population is transferred to non-dominate sorting procedure. Non dominated sorting is a procedure in which a rank or level is assigned to each organisms. The population members are ranked according to their fitness values (f_{rank}) and are selected for genetic operation, on a pair-wise comparison to produce an offspring in the generation. If any pair is having the same rank, then the crowded distance assignment operator provides basis and helps to maintain diversity in the population. To change the attributes of offspring, crossover and mutation operations were performed.

i. Pseudo Code of MOGA

```
Begin
t=0
Initialize population P(g).
Evaluate population by calculating its fitness P(g).
While not terminate
Do
g:= g+1
Select P(g+1) from P(g)
Crossover P(g+1) from P(g)
Mutate P(g+1) from P(g)
Evaluate P(g+1)
end while
end
```

ii. Flow Chart of MOGA

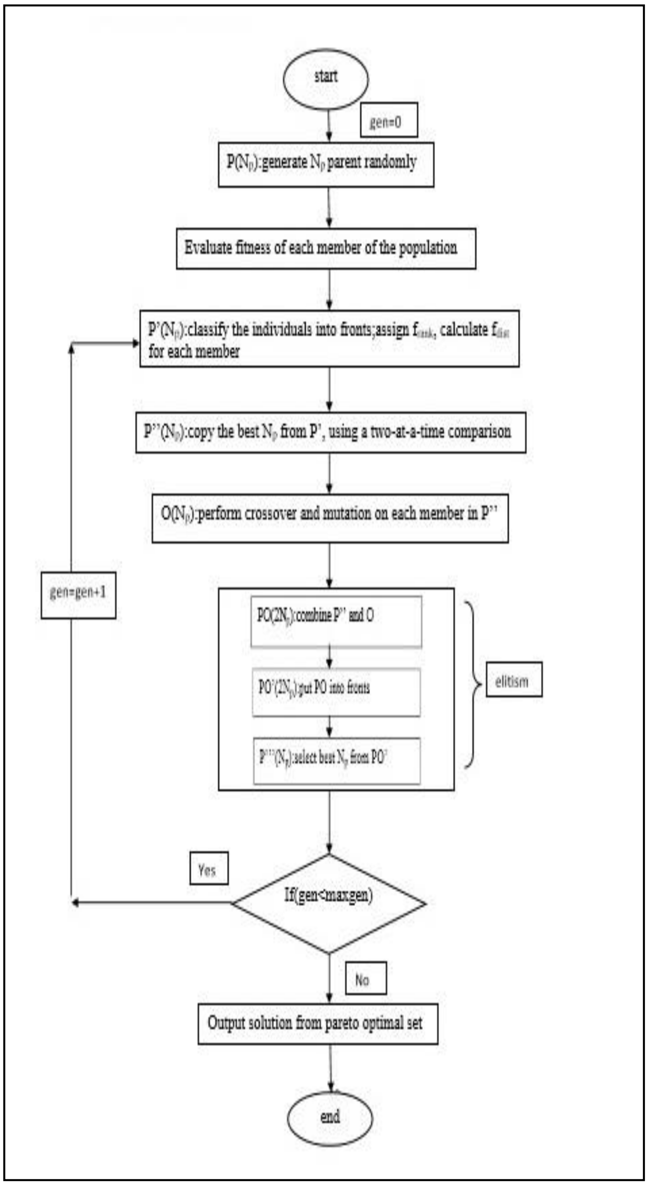

Fig.-2: Flow Chart of MOGA

Here, first the population is initialized within the specified variable ranges. After evolution of this population, based on non-dominated sorting approach, the generated alternatives are classified into different fronts. The population members are ranked according to their fitness values (f_{rank}) and are selected for genetic operation, on a pair-wise comparison to produce an offspring in the generation. If any pair is having the same rank, then the crowded distance assignment operator provides basis and helps to maintain diversity in the population. To change the attributes of offspring, crossover and mutation operations were performed. Here, first the population is initialized within the specified variable ranges. After evolution of this population, based on non-dominated sorting approach, the generated alternatives are classified into different fronts. The population members are ranked according to their fitness values (f_{rank}) and are selected for genetic operation, on a pair-wise comparison to produce an offspring in the generation. If any pair is having the same rank, then the crowded distance assignment operator provides basis and helps to maintain diversity in the population. To change the attributes of offspring, crossover and mutation operations were performed. To preserve the best solutions obtained through generations and to speed up the convergence, the algorithm uses elitism, in which combination of parents and offspring population are grouped into different individuals selected for next generations.

iii. Pareto Front

With multi objective, instead of single solution a whole set of solutions is derived. This set is called a Pareto front. A set of actions with multi-dimensional output is evaluated by the Pareto front. A very weak desirability partial ordering applies only when one process is better for all outputs. Basically Pareto front is a framework which reduces the set of candidates for further analysis, operations are performed on all inputs, the set of better results is created and further processing is performed on it. It shows the output in multi-dimensions. It selects only those values which lie in the specified range and rejects the rest. So for output, all the factors should be satisfied. If any factor does not satisfy, then it will not be accepted. Pareto Front is the factor which generates during Multi Objective Genetic Algorithm. This factor shows the output in multiple dimensions. It accepts only those data which lies in the specified range and rejects the rest data. In fig-3 the red dots shows that these are accepted because they satisfies the condition like they cover the maximum area by consuming lesser amount of energy. The dots which are blue are rejected because they are satisfying only one factor i.e. coverage. They are covering maximum area but consuming a large amount of energy, so these are rejected. As the name suggests Multi Objective Genetic Algorithm there is more than one objective. If there is a single object which do not satisfies then that data will not be accepted. From Fig-3, we can see that there are two objectives. One is coverage and another is energy. The red dots show that both the conditions are satisfied, whereas blue dots show that only one factor is satisfied. Hence these are rejected. For example: If we have two sets of organisms. The first organism will dominate the other if all factors of first organism are satisfied and if any one factor among all the factors does not satisfy the condition. Further processing is performed on the accepted values.

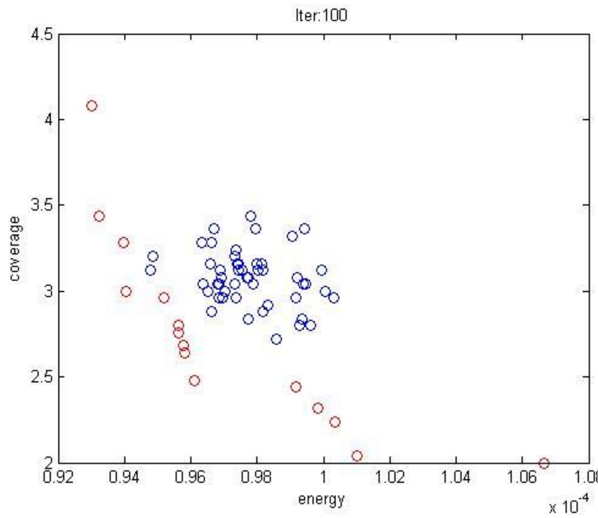

Fig-3: Function of Pareto Front

3.2 LEACH

As we want to increase the lifetime of sensor nodes, to do so, Leach is used. LEACH stands for Low Energy

Adaptive Clustering Hierarchy. Leach is TDMA based approach in which the same frequency channels are used by dividing the signal into different time slots. The main aim of LEACH is to decrease the energy consumption required to create and maintain the clusters which improve the lifetime of WSN. LEACH is a hierarchical protocol in which cluster heads are created. The Cluster heads collect the data, compress it and transmit it to the base station.

i. Pseudo Code of LEACH

a) Set up phases:

- Threshold, Cluster heads are selected
- All CH'S transmit ADV message to all non-CH nodes.
- All non-CH nodes select their cluster heads on the basis of RSSI of ADV message.
- After selecting clusters non-CH nodes send join request to Cluster heads. Now TDMA schedule is created by CH and send it to all non-CH nodes.

b) Steady State Phase:

- Sensor nodes start sensing and transmitting data to the cluster heads as per their TDMA schedule.
- After receiving data CH aggregates the data and transmit it to the base station in a single hop, in this way the energy gets reduced.
- After some time network goes back to setup phase and starts another round.

At cluster nodes, different CDMA code is used to reduce the interference from other nodes.

4. Experimental Setup

The implementation environment was a Windows 8 system on Dell PC with a memory of 500GB and Intel Core i3-2100 CPU (3.1 GHz) and 4GB RAM. All the programs are implemented with MATLAB.

4.1 Experimental Results:

Many assumptions are made to implement the proposed work. In this paper, experiments are conducted in 100x100 2-D Euclidean space domain A-observed area. The number of sensor nodes (N) for each test instances is calculated to match the approximate tightness ratios a=0.60, 0.70, 0.80, 0.90, respectively. The Used formula to define the number N sensor nodes for each instance is depicted in Equation:

$$N = \frac{X*A(area)}{3.14*r_i^2}$$

Here, N- number of nodes to be deployed

A-area

r_i- sensing range of nodes for test instances

X- The number of sensor nodes for each test instances are calculated to match tightness ratio. The tightness ratio is different for each test instance.

Table-1: Test Data

	Crossover Rate	Id	R	N	X
Area (A)	0.5	i-0.6	14	10	0.61
	0.5	i-0.7	6	62	0.70
	0.5	i-0.8	8	40	0.80
	0.5	i-0.9	12	20	0.90

4.2 Graphs

In the experimentation results comparisons between MCSDP(maximum coverage sensor deployment problem) [1] and CEBSP (coverage energy balancing sensor problem) are shown through graphs. These are:

- Randomly deployed nodes in the network,
- Balancing of Energy and Coverage, and
- The comparison of dead nodes which involves first dead node, half dead node and last dead node. The table is provided to differentiate the performance of MCSDP[1] and CEBSP.

The experimentation results of Balancing of energy and coverage by deploying less no. of sensor nodes are shown below:

a) Node Deployment

A large number of nodes are deployed in the network. They are deployed in such a way so that they cover the maximum area. Nodes are deployed randomly. They are scattered from environment. No calculation is performed to deploy these sensor nodes.

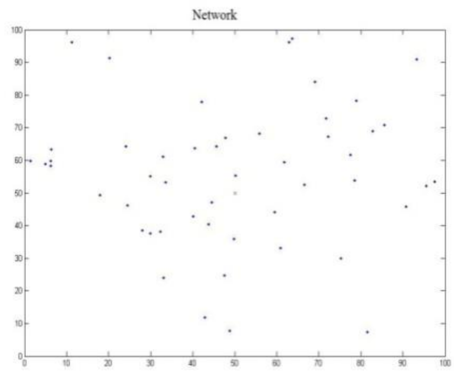

Fig-4: Nodes deployed in the network

b) Function of Pareto Front

The Pareto front shows the output in multi dimensions. Pareto front accepts only those values which lie in its range means if both the factor satisfies the condition. Pareto front accepts only those values in which both the factors perform their own task accurately.

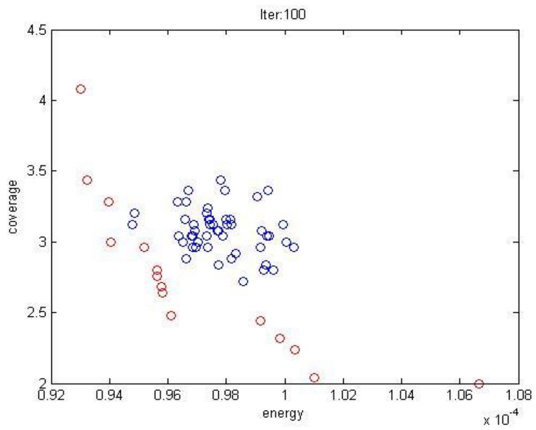

Fig-5: Balancing of Energy and Coverage

From the Fig.-5 it can be seen that there are two factors, energy and coverage. The red colored nodes are covering maximum area and consuming less amount of energy, hence they are satisfying the condition. So, these will be accepted. The blue colored nodes are covering maximum area but consuming a larger amount of energy. Blue nodes are not satisfying the condition. So, these nodes are rejected.

The values of the round number at which the first node, half node and last node dead for the MCSDP(maximum coverage sensor deployment Problem)[1] and CEBSP(coverage energy balancing sensor problem) method is shown in the table.

Table-2: Comparison of dead nodes on the basis of MCSDP [1] and CEBSP method

Comparison	MCSDP	CEBSP
First node dead	141	150
Half node dead	182	193
Last node dead	306	480

The round number at which the first node dies is known as **First Node dead.**
The rounds taken to die the half nodes of the system show the **Half Node dead.**
The round number at which the last node of the system got dead shows the **Last Node dead.**

c) FND Comparison

FND stands for First Node dead. The round number at which first node dies is known as First Node dead.

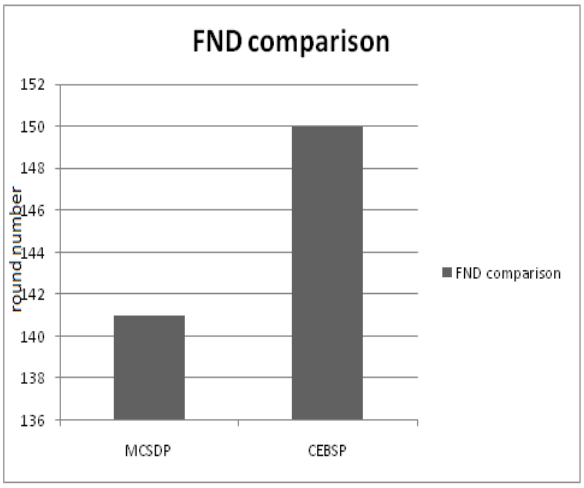

Fig-6: First node comparison

The corresponding graph is shown below which depicts that in the MCSDP[1], at the round number 141 the first node dies whereas, in the CEBSP this round number got increased to 150. Hence, the CEBSP performs better.

d) HND Comparison

HND stands for Half Node dead. Every node has limited energy. If half of nodes from the total deployed nodes go dead, it means half of the nodes of system are dead and the round number at which this occurs is termed as half node dead.

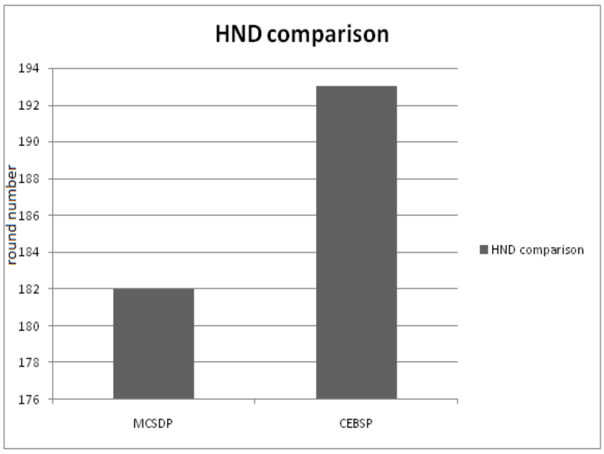

Fig-7: Half node Comparison

In graph the comparison of MCSDP[1] and CEBSP is performed. The CEBSP performs better also in case of half node dead which shows at round number 182 half nodes got dead in MCSDP[1] whereas in CEBSP this number increased to 193.

e) Network Energy Consumption

Remaining energy is the energy which is left after consumption. Our main motive is to maximize the remaining energy. The energy is required to transmit the information to the destination (base station).

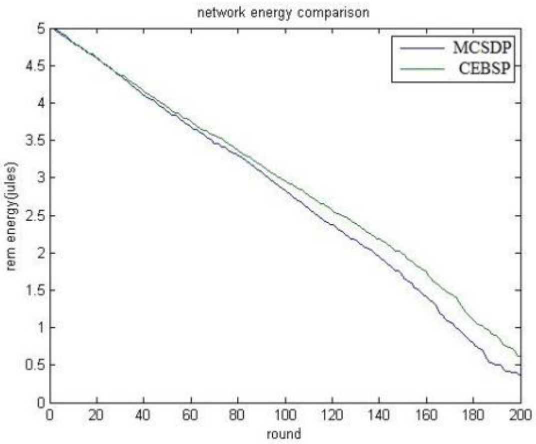

Fig-8: Network Energy Comparison

The Energy consumption by nodes should be minimized or the remaining energy should be maximized. For the same number of round, the comparison of MCSDP [1] and CEBSP is performed and CEBSP consumes less amount of energy than MCSDP[1].

f) Last Node Dead Comparison

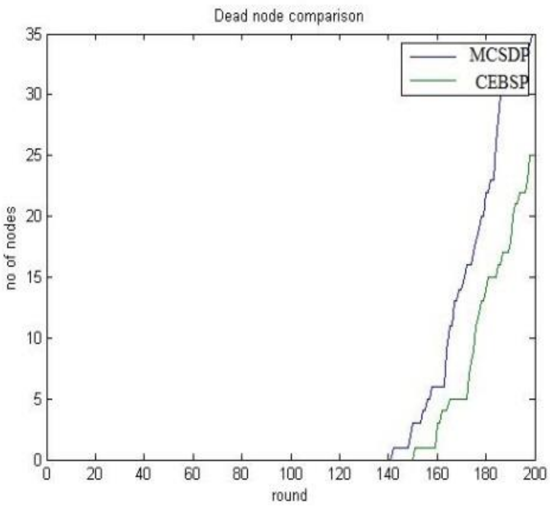

Fig-9: Last Node Dead comparison

The round at which the last node of the system got dead is known as Last Node Dead. The Last node dead comparison of MCSDP [1] and CEBSP is shown in the graph which also shows that the CEBSP performs better than the MCSDP because the last dead node according to CEBSP occurs later than MCSDP [1].

4.3 Summary of Results

In this section, metrices like first node dead, half node dead, last node dead, energy consumption comparison are defined. It is identified that proposed CEBSP performs better than that of MCSDP [1].

5. CONCLUSIONS

In this paper, our main motive is to perform balancing of the energy and coverage means the nodes should be deployed in such a way in which nodes cover the large area and consume less energy and we have achieved that goal (maximizing coverage and minimizing the energy consumption) by applying multi objective genetic algorithm.

REFERENCES

[1]Ozan Zorlu, Ozgur Koray Sahingoz, "Increasing the coverage of Homogeneous WSN by Genetic Algorithm based deployment," ISBN:978-1-4673-9609-7 2016 IEEE.

[2]Shiyuan Jin, Ming Zhou, Annie S. Wu, "Sensor Network Optimization Using GA,"School of EECS, University of Central Florida Orlando, FL 32816.

[3]NaeimRahmani, FarhadNematy, Amir MasoudRahmani, Mehdi Hosseinzadeh, "Node Placement for Maximum Coverage Based on Voronoi Diagram Using Genetic Algorithm in WSN," Australian Journal of Basic and Applied Sciences, 5(12): 3221-3232, 2011 ISSN 1991-8178

[4]Yang SUN†, and Jingwen TIAN, "WSN Path Optimization Based on Fusion of Improved Ant Colony Algorithm and Genetic Algorithm," Journal of ComputationalInformationSystems6:5(2010)1591-1599

[5]Seyed Mahdi Jameii and Seyed MohsenJameii,"Multi-objective Algorithm for Coverage in sensor networks," IJCSEIT, Vol.3, No.4, August 2013.

[6]S.M. Hosseinirad, and S.K. Basu," Wireless sensor network design through genetic algorithm," Journal of AI and Data Mining Vol. 2, No .1, 2014, 85-96.

[7]Mohammad M. Shurman, Mamoun F. Al-Mistarihi, Amr N. Mohammad, Khalid A. Darabkh, and Ahmad A. Ababnah, "Hierarchical Clustering Using Genetic Algorithm in Wireless Sensor Networks," MIPRO 2013, May 20-24, 2013, Opatija, Croatia.

[8]Amol P. Bhondekar, RenuVig, C Ghanshyam, MadanLalSingla, and PawanKapur,"GA-BasedNode Placement Methodology for WSN," IMECS 2009 Vol. 1.

[9]Y Yoon and Y H. Kim, "An Efficient Genetic Algorithm For Maximum Coverage Deployment in Wireless Sensor

Networks ",IEEE Trans. Cybern., vol. 43, no. 5, pp.1473-1483, April 2013.

[10]Y Zou and K. Chakrabarty, "Sensor Deployment and Target Localization Based on Virtual Forces", in Proc. Twenty-Second Annual Joint Conf. of theIEEE Computer and Communications, IEEE Societies, San Francisco, CA, April 2003, pp.1293-1303 vol.2.

[11]C. S. Raghavendra (Editor), Krishna M. Sivalingam (Editor), Taeib F. Znati (Editor). "*Wireless Sensor Network",* Springer. 2006.

[12]Shashi Phoha (Editor), Thomas F. La Porta (Editor), Christopher Griffin (Editor). *"Sensor Network Operations",*Wiley–IEEE Press. 2006

[13]Adam Dunkels ,Fredrik ¨Osterlind and Zhitao He, "An Adaptive Communication Architecture for Wireless Sensor Networks", November 6–9, 2007, Sydney, Australia.

[14]Xi CHEN,Qianchuan ZHAO and Xiaohong GUAN, "ENERGY-EFFICIENT SENSING COVERAGE AND COMMUNICATION FOR WIRELESS SENSOR NETWORKS", National Natural Science Foundation (No. 60574087, 60574064) and the "111 International Collaboration Project" of China, feb 2007.

[15]Zoran Bojkovic and Bojan Bakmaz, "A Survey on Wireless Sensor Networks Deployment", ISSN: 1109-2742 Issue 12, Volume 7, December 2008.