International Journal of Advanced Technology in Engineering and Science
Vol. No.3, Special Issue No. 01, September 2015
www.ijates.com
ijates
ISSN 2348 - 7550

COVERAGE VS NODE & DEPLOYMENT CHARACTERISTICS FOR WIRELESS SENSOR NETWORKS

Vishal Gupta[1], M.N.Doja[2]

[1]Research Scholar, [2]Professor, Department of Computer Engineering, JMI, Delhi, (India)

ABSTRACT

Coverage is a very important parameter because it measures how effectively a target field is monitored by the sensor network. This paper provides a comparative statistics for the impact of various node characteristics on the area coverage. In this paper, we have also focused on sensor networks with two types of nodes that differ in their capabilities, and discussed the effects of heterogeneity of sensing on the network coverage. This work can serve as a guideline for designing large-scale sensor networks cost-effectively. The work can also be extended to more complicated heterogeneous wireless sensor networks with more than two types of sensors.

Keywords: Coverage, Heterogeneity, Wireless Sensor Network (WSN)

I. INTRODUCTION

Sensing coverage is one of the fundamental QoS problems in sensor networks is sensing coverage. Coverage in sensor networks is a measure to how closely target area is observed by the sensor nodes. The coverage problem in sensor networks was first investigated as one of the network QoS metrics by Meguerdichian et al. [1]. Due to the resource constraint nature of the sensor node/WSN, there are many limitations in this area. [2] Provides some details about the sensor nodes with respective processing capabilities.

Intuitively, it seems that the introduction of some sensor nodes with greater capabilities can help enhance the overall network coverage. However questions of whether how many and what types of heterogeneous resources to deploy remain largely unexplored [3]. This raises the issue of quantifying the effects of deploying heterogeneous sensor nodes on the quality of service (QoS) of the whole network.

The rest of the paper is organized as follows. Section II gives the definition of coverage and its types. Section III, provides the brief survey of some the research done in this area. In section IV, we have presented our work with the simulation support in MatLab. Finally, fifth section gives a summary and the conclusion of the paper.

II. COVERAGE

According to [4], in the given sensor network, coverage denoted by C is defined as the mapping from a set of sensors S, to the set of area A, in the given field of interest F or Coverage C is defined as a mapping $C:S \rightarrow A$ such that $\forall s_i \in S$, $\exists a_i \in A$ and overlapping between each a_i is removed, where:

1. S is set of sensor nodes denoted by s_i which can be identified by their coordinates (x_i,y_i).

2. A is the set of area denoted by a_i which is identified by summing $\pi*(Rs_i)^2$, where Rs_i is the sensing radius of sensor s_i.

3.F is the given area which has to be monitored (Field of Interest).

4. C is termed as coverage which maps S to A.

5. Cardinality of S and A are same.

To be specific, it reflects how well the sensed field is monitored or tracked by the sensors.

Depending upon the objectives and applications, three types of coverage are defined in the literature [5][6][7][8]: ***Area Coverage*****:** To ensure that every point of the whole area to be monitored by at least one sensor node. ***Point/Target Coverage*****:** To cover up the set of predetermined target/s in the given region of interest (ROI).

Barrier Coverage**:** To guarantee that every object moving across the given barrier to be detected by the deployed sensors.

The problem of area coverage deals with two important factors: the node type and the deployment strategy. Node can be of different types: static, dynamic, homogeneous and heterogeneous. The deployment strategy can be: Deterministic, Random, Sparse or Dense. The selection of proper node and deployment strategy depends on the application in which sensor nodes are going to be used.

III. LITERATURE REVIEW

Authors in [9] have discussed different types of coverage issues. Full coverage issue is examined by considering different points such along with the strategy used to detect full coverage and positioning based/independent algorithms.

In paper [10], the authors have established the optimal polynomial time algorithm in worst-case and average-case for network coverage calculation using graph theoretic and computational geometry. C. M. Cardei et al. [7] have suggested one method to improve the sensor network lifetime while providing target point coverage using the concept of set covers.

A. Chen et al. in [8] have proposed a Localized Barrier Coverage Protocol (LBCP). P. Balister et al. in [11] suggested a method to find reliable density estimates for providing barrier coverage in belt shaped region and connectivity in network.

In [12] Maxim A. Batalin et al., have used a mobile robot to traverse and deploy sensor nodes in the given target area. Saurabh Ganeriwal et al. [13] proposed an algorithm to repair coverage gap due to reduction in energy of sensor node.

Ziqiu Yun et al. [14] have studied different arrangements for sensor deployment to provide full coverage and k-connectivity (K<6). Work of S. A. R. Zaidi et al. [15] gives solution to the problem of providing full coverage in target field with minimum number of sensors for any geometrical area in case of deterministic deployment.

[16] Discusses the impact of Heterogeneity on Coverage and Broadcast Reachability in Wireless Sensor Networks. M Singaram et al. [17] proposed ERGS algorithm for randomly deployed sensor nodes. Optimal Geographical Density Control (OGDC) algorithm by H. Zhang et al. [18] considers dense deployment for sensors in the monitoring area. In [19] the authors have proposed a circle intersection localized coverage algorithm to maintain connectivity based on the loose connectivity critical condition.

This work is an extension of our earlier work [20] that dealt with the trade-off between number of sensor nodes deployed and coverage in WSN.

IV. PROPOSED WORK

In this work, we have simulated the change in the coverage obtained by varying the node and deployment characteristics. In all cases, we have assumed the static node, random deployment strategy. The complete work can be divided into following cases. A very large number of iterations have been taken to derive at the result and conclusion in every case.

4.1 Homogeneous Deployment Case

4.1.1 Effect on the coverage from sparse to dense deployment keeping sensing range constant.

Area = 100 * 100 unit   Sensing Range = 5 unit (constant)

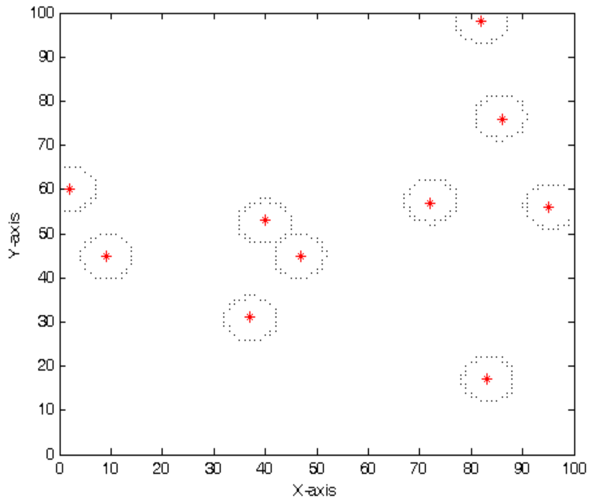

Fig.1 Homogeneous Deployment

(No of nodes = 10)

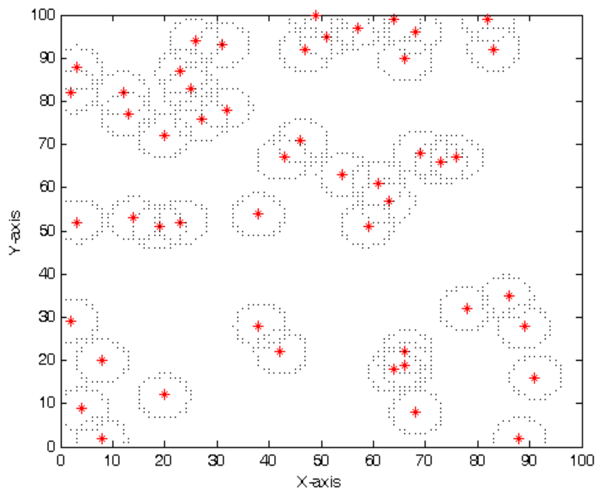

Fig.2 Homogeneous Deployment

(No of nodes = 50)

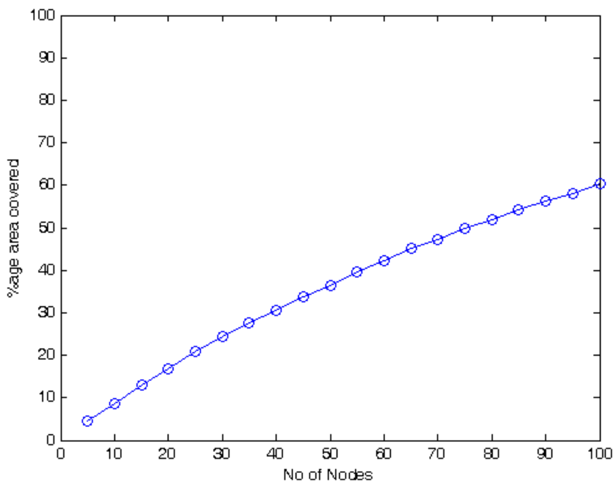

Fig. 3 Homogeneous Deployment (%Coverage Vs Number of Nodes)

Result: As shown by the graph in Fig.3, increasing the number of nodes deployed in ROI doesn't result in the proportionate increase in the coverage area.

4.1.2 Effect on the coverage with respect to the change in the sensing range of the nodes keeping number of nodes constant.

Area = 100 * 100 unit Number of Nodes = 20 (Constant)

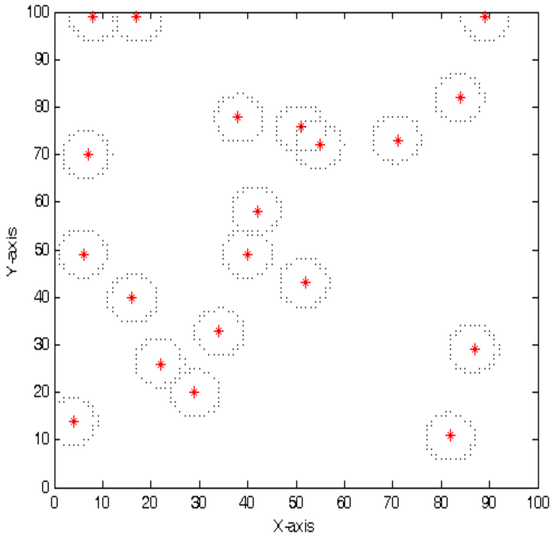

Fig.4 Homogeneous Deployment

(Sensing range = 5 Unit)

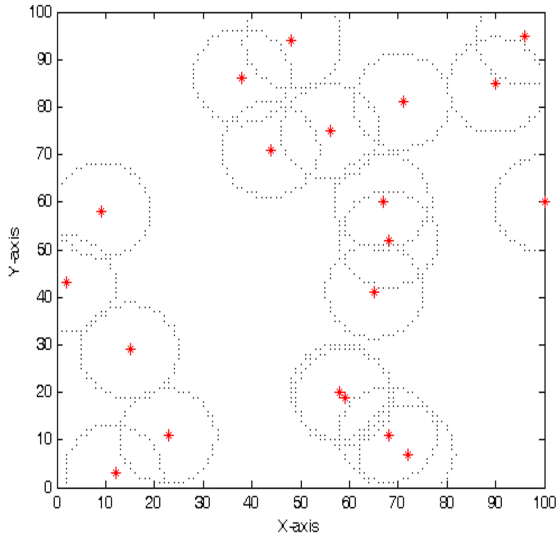

Fig.5 Homogeneous Deployment

(Sensing range = 10 Unit)

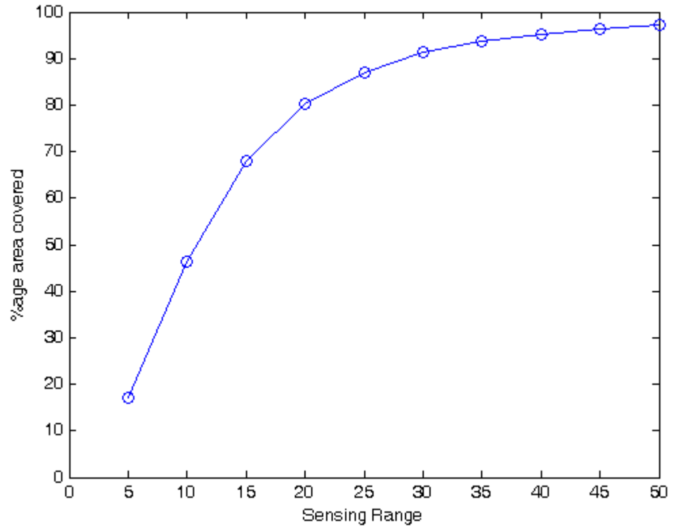

Fig. 6 Homogeneous Deployment (%Coverage Vs Sensing Range of the Nodes)

Result: As shown by the graph in Fig.6, increasing the sensing range of the deployed nodes directly affects the coverage gain initially in the ROI. But beyond a point, this increase has virtually no effect on the coverage as shown in the figure.

4.2 Heterogeneous Deployment Case

4.2.1 Effect on the coverage keeping number of nodes constant.

Area = 100 * 100 unit, No of Nodes = 10 (Constant),

SR_1 = 5 Unit, SR_2 = 10 Unit

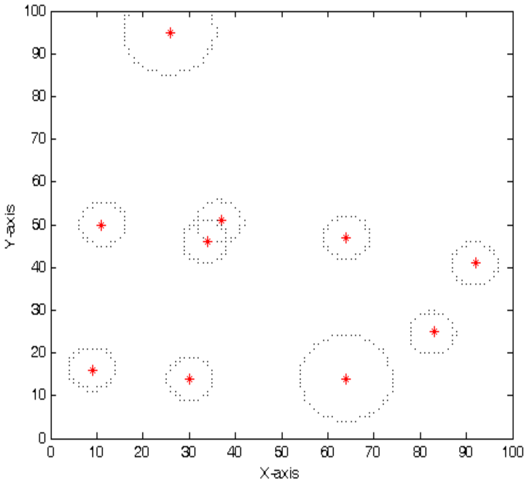

Fig. 7 Heterogeneous Deployment

(N_1 = 8, N_2 = 2)

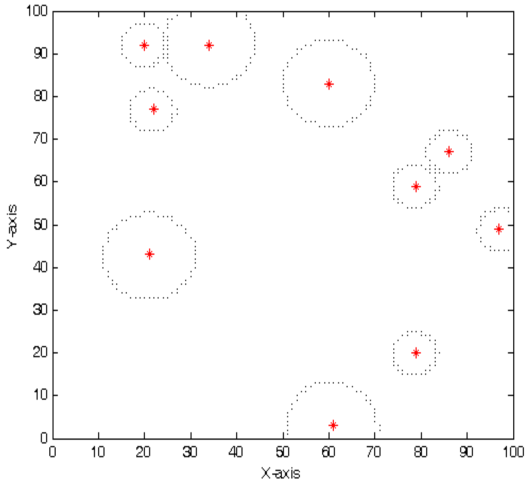

Fig. 8 Heterogeneous Deployment

(N_1 = 6, N_2 = 4)

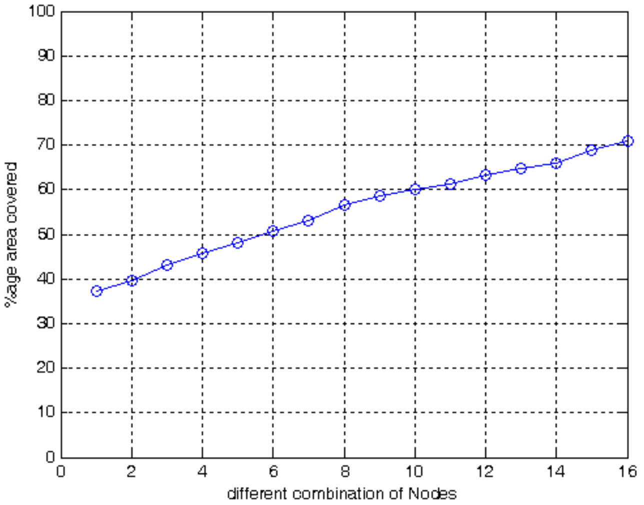

Fig. 9 Heterogeneous Deployment

(%Coverage Vs Different combinations of nodes keeping total number of nodes constant)

(SR_1 = 10, SR_2 =20, No of nodes = 15)

Result: As shown by the graph in Fig.9, increasing the number of nodes with higher sensing range in the mix increases the coverage area.

4.2.2 Effect on the coverage keeping the cost of the network constant.

Max_Network_cost = 100 unit; SR_Ratio = 2; $SR_1 = 10$; C_Ratio = 2; $C_1 = 10$;

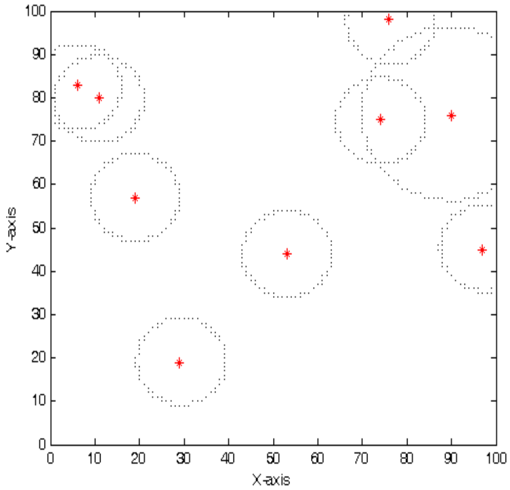

Fig. 10 Heterogeneous Deployment

($N_1 = 8$, $N_2 = 1$)

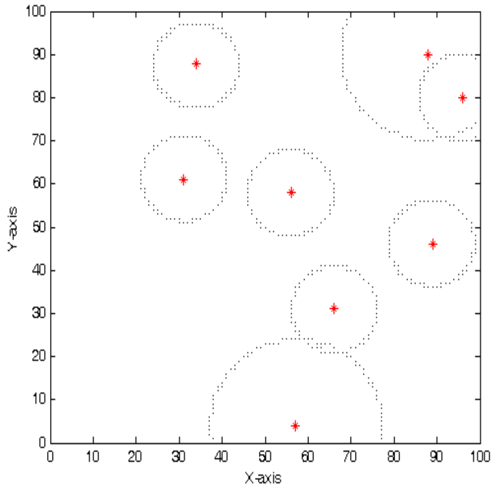

Fig. 11 Heterogeneous Deployment

($N_1 = 6$, $N_2 = 2$)

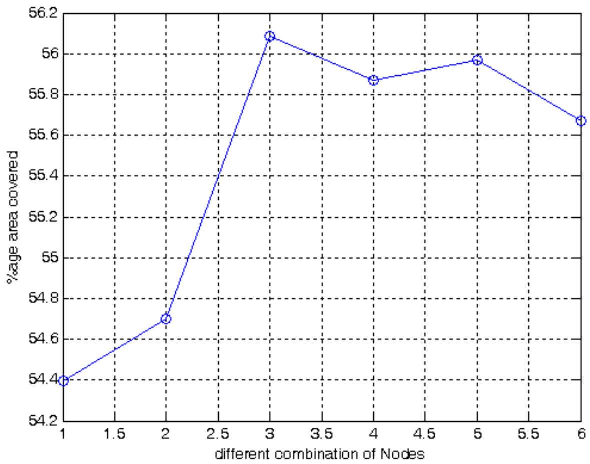

Fig. 12 Heterogeneous Deployment

(%Coverage Vs Different combinations of nodes keeping cost constant)

(Max_Network_cost = 200; SR_Ratio = 2; $SR_1 = 20$; C_Ratio = 2; $C_1 = 20$;)

Result: As shown by the graph in Fig.12, increasing the number of nodes with higher sensing range in the mix keeping cost to the network constant increases the coverage area. But the graph shows a strange behaviour that going beyond a range; the result may have adverse effect.

V. CONCLUSIONS

Coverage is a basic issue in wireless sensor networks. In this paper, the coverage issue was discussed. Area coverage issue was discussed in detail by classification of research work based on node and deployment type.

We conclude that for homogenous networks, enhancing the node characteristics doesn't necessary increase the coverage in the same proportion. This is due to the increase in the overlapping of the area covered by different nodes. Similarly, for heterogeneous networks, increasing the high quality nodes in comparison to the low quality nodes does not necessarily qualify for the improved coverage area. Again the reason is the overlapping that seems to have more negative effects when the high quality nodes get increasing in number as compared to low quality nodes.

We further conclude that the heterogeneity may give improved results when the deployment is deterministic as the high quality & hence the costly nodes may be placed at appropriate points in the ROI for maximum coverage.

In this work, we have not considered the environment that may have obstacles through which radio signals cannot propagate.

REFERENCES

[1]. S. Meguerdichian, F. Koushanfar, M. Potkoljak and M. B. Srivastava, "Coverage problems in wireless ad-hoc sensor networks", Twentieth Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM 2001), vol. 3, April, 22-26 2001, pp. 1380 - 1387.

[2]. "List of wireless sensor nodes" main page en.wikipedia.org, [Online] Available at: ht tp://en.wikipedia.org/wiki/List of wireless sensor nodes

[3]. M. Yarvis, N. Kushalnagar, H. Singh, A. Rangarajan, Y Liu, and S. Singh, "Exploiting heterogeneity in sensor networks," Proc. of IEEE INFOCOM, 2005.

[4]. C. Zhu, C. Zheng, L. Shu and G. Han, "A survey on coverage and connectivity issues in wireless sensor networks", Journal of Network and Computer Applications, Volume 35, Issue 2, March 2012, Pages 619-632.

[5]. R. Mulligan, H. M. Ammari, "Coverage in Wireless Sensor Networks", Network Protocols and Algorithms, ISSN 1943-3581, 2010, Vol. 2, No. 2.

[6]. L. Mo, L. Zhenjiang and A.V. Vasilakos, "A Survey on Topology Control in Wireless Sensor Networks: Taxonomy, Comparative Study, and Open Issues", Proc. of the IEEE, vol.101, no.12, pp.2538-2557, Dec.2013

[7]. M. Cardei, M. T. Thai, Li Yingshu and W. Weili, "Energy-efficient target coverage in wireless sensor networks", 24th Annual Joint Conference of the IEEE Computer and Communications Societies INFOCOM 2005. Proceedings IEEE, vol.3, pp.1976-1984, 13-17 March 2005.

[8]. A. Chen, S. Kumar, and T. H. Lai, "Designing localized algorithms for barrier coverage", Proc. of the 13th annual ACM international conference on Mobile computing and networking (MobiCom '07), ACM, New York, NY, USA, 2007, 63 -74

[9]. A. Singh and T. P. Sharma, "A survey on area coverage in wireless sensor networks", International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014 Pages: 829 - 836, DOI: 10.1109/ICCICCT.2014.6993073.

[10]. S. Megerian, F Koushanfar, M. Potkonjak, and M. B. Srivastava, "Worst and best-case coverage in sensor networks", IEEE Transactions on Mobile Computing, vol. 4, no. 1, pp. 84-92, January/February 2005.

[11]. P. Balister, B. Bollobas, A. Sarkar, and S. Kumar, "Reliable density estimates for coverage and connectivity in thin strips of finite length", Proc. of the 13th annual ACM international conference on Mobile computing and networking (MobiCom '07), ACM, New York, NY, USA, 2007, 75-86

[12]. M. A. Batalin and G. S. Sukhatme, "Coverage, exploration, and deployment by a mobile robot and communication network", Proc. of the 2nd international conference on Information processing in sensor networks, Springer-Verlag, Berlin, Heidelberg, 2003, 376-391.

[13]. S. Ganeriwal, A. Kansal and M.B. Srivastava, "Self aware actuation for fault repair in sensor networks", Proc. of IEEE International Conference on Robotics and Automation (ICRA '04), vol.5, pp.5244-5249, April 26 2004-May 1 2004

[14]. Y. Ziqiu, B. Xiaole, X. Dong, T .H Lai and J. Weijia, "Optimal Deployment Patterns for Full Coverage and k -Connectivity ($k \leq 6$) Wireless Sensor Networks", IEEE/ACM Transactions on Networking ,vol.18, no.3, pp.934-947, June 2010

[15]. S. A. R. Zaidi, M. Hafeez, S.A. Khayam, D.C. McLernon, M. Ghogho and K. Kim, "On minimum cost coverage in wireless sensor networks", 43rd Annual Conference on Information Sciences and Systems (ACISS 2009) pp.213-218, 18-20 March 2009

[16]. Y. Wang, X. Wang, D. P. Agrawal and A. A. Minai, "Impact of Heterogeneity on Coverage and Broadcast Reachability in Wireless Sensor Networks", Proc. of 15th International Conference on Computer Communications and Networks, (ICCCN 2006) 2006. Pages: 63 - 67, DOI: 10.1109/ICCCN.2006.286246

[17]. M. Singaram, S. Finney, D. Shadrach, N. S. Kumar and V. Chandraprasad, "Energy Efficient Self-Scheduling Algorithm for Wireless Sensor Networks", International Journal of Scientific and Technology Research Volume 3, Issue 1, January 2014.

[18]. H. Zhang and J. C. Hou, "Maintaining Sensing Coverage and Connectivity in Large Sensor Networks", in Ad Hoc and Sensor Wireless Networks, Vol. 1, 3 March 2005, pp. 89-124

[19]. H. Xin, Y. Ke and G. Xiaolin, "The Area Coverage Algorithm to Maintain Connectivity for WSN", Ninth IEEE International Conference on Computer and Information Technology, 2009. CIT '09, Year: 2009, Volume: 2, Pages: 81 - 86, DOI: 10.1109/CIT.2009.82

[20]. G. Bhatia, V. Gupta and M. N. Doja, "Trade off between number of sensor nodes deployed and coverage in WSN", International Journal of Engineering Technology, Management and Applied Sciences, Vol. 2 Issue 2, July 2014.