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Clustering Approach For Maximizing The Lifetime Of Wireless Sensor Networks

Sangeetha S*, Ramalakshmi K**
*(Department of Computer Science and Engineering, Karunya University, Coimbatore-641114, India)
**(Department of Computer Science and Engineering, Assistant Professor, Karunya University, Coimbatore)

ABSTRACT

Wireless sensor networks(WSNs) consists of a large number of wireless sensor nodes that have sensing, data processing and communication functionalities. WNSs are typically used to monitor a field of interest to detect movement, temperature changes, precipitation etc. Energy Consumption and Coverage are two major problems in wireless sensor networks. We implement our proposed scheme in NS-2 as an extension of Clustering technique. Clustering technique is one of the approaches to solve this problem. Clustering technique will be proposed for increase of network lifetime greater than 44%, tremendous energy saving and reduce the energy consumption in every node in the network. The proposed algorithm was compared with existing algorithm (Energy Remaining Greedy Scheduling Algorithm) in terms of network life-time by simulation. Simulation results show that tremendous energy saving, reduce the energy consumption, full coverage and prolong the network lifetime greater than 44% can be achieved by clustering technique.

Keywords - **Cluster Head (CH), Coverage, Energy saving, Increase the Lifetime, Reduce the energy consumption, Wireless Sensor Networks .**

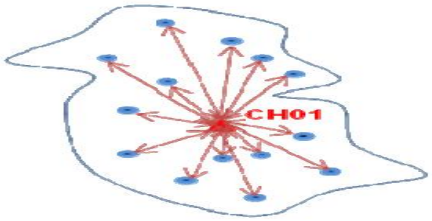
I. INTRODUCTION

Wireless sensor networks [1] consists of a large number of wireless sensor nodes that have sensing, data processing and communication functionalities. Wireless sensor networks has a great deal of research attention due to wide-ranged potential applications that will be enabled by wireless sensor networks, such as battlefield surveillance, machine failure diagnosis ,biological detection, home security, smart spaces, inventory tracking, etc. WSNs are typically used to monitor a field of interest to detect movement, temperature changes, precipitation etc. Energy awareness [12,14] becomes the key research challenge for sensor networks protocols. In wireless sensor networks, energy source provided for sensors is usually battery power, which has not yet reached the stage for sensors to operate for a long time without recharging. Moreover, sensors are often intended to be deployed in remote or hostile environment, such as a battlefield or desert; it is undesirable or impossible to recharge or replace the battery power of all the sensors. However, Prolong system lifetime is expected by many monitoring applications. The Network lifetime, which is measured by the time until all nodes have been drained out of their battery power or the network no longer provides an acceptable event detection ratio, directly affects network usefulness.

The energy consumed by a node depends on its state. Each node consists of two modes: 1.Active Mode (when the node keeps listening to the medium even when messages are being transmitted). 2. Sleep Mode (where the radio module is switched off: no communication is possible).

Coverage may be considered as the measure of the QoS of the sensing function for a WSN [11]. Many researchers are currently engaged in developing solutions related to coverage problems. To offer guaranteed coverage, it is essential that the coverage be solved with sufficient available resources and possibly by incorporating optimization.

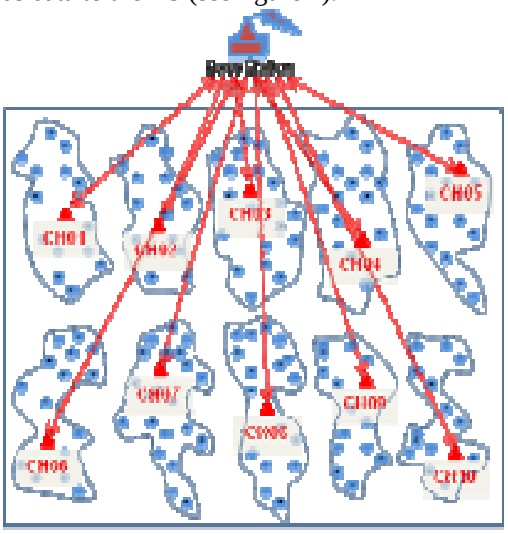
In the proposed approach, to reduce the energy consumption in every node in the network, we are using clustering technique. In this technique, the clustering operation includes two phases: Clustering Formation Phase and Clustering Eligibility Phase. In this technique the nodes are added into group of nodes which are called cluster.



"Fig 1":Data communication between nodes and its cluster head

For every cluster, check neighbours energy. Among the neighbours choose high energy node, announce high energy node is elected as cluster head (CH). Receiving node verifies cluster head energy with its own energy. If it is less than, convert as member. All

the nodes in each cluster are supposed to convey the information to their respective cluster heads (CH) (see figure 1). Cluster head node is responsible for collecting the information ,then it processes data and sends data to the BS (see figure 2).



"Fig 2": Data communication between Cluster heads and Base station the network.

Therefore, the cluster head minimize the number of active nodes, by this reduced the energy consumption in every node in the wireless sensor networks. Specifically, some nodes are active whereas the others enter sleep state so as to save the energy. Clustering technique presents an original algorithm for each node can self scheduled to decide which ones have to switch to the sleep state. Cluster head nodes may be redundant for some rounds of operation. The residual energy at every node in the decision of turning off redundant nodes. Hence, the node with low residual energy has greater priority over its neighbours to enter sleep state. Significant energy savings can be achieved by sleep scheduling nodes activities in high-density WSNs. Clustering technique is one of the approaches to minimize the number of active nodes in order to maximize the network lifetime, reduce the energy consumption, provide full coverage and saving the tremendous energy. The main benefits of proposed scheme are that the energy consumption is reduced and better network lifetime can be carried out.

The rest of this paper is organized as follows: section 2 reviews the related work in the literature. In section 3, we introduce the details of the proposed scheme. Section 4 discusses implementation details and presents the simulation results. Section 5 concludes the paper. At the end of the paper is a list of references.

II. RELATED WORK

Minimizing the energy consumption [6] and Maximizing the network lifetime [4] has been a major design goal for wireless sensor networks.

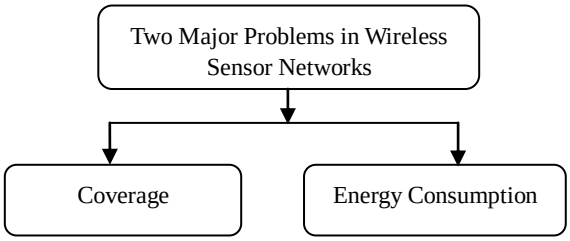


Fig 3: Hierarchy Structure of Major Problems In Wireless Sensor Networks

Many researchers are currently engaged in developing solutions related to coverage problem for wireless sensor networks. The coverage problem is subject to a wide range of interpretations. The Coverage problem [8,3] can be classified under different objectives and metrics. The different approaches to the coverage problem are centralized algorithm, distributed algorithm and configuration algorithm. Based on the objective, the coverage problem [9] formulation varies to reflect the different assumptions and objectives. The major problems in wireless sensor networks (see Figure 3).

Some works as centralized algorithm presented in [5] propose to divide the nodes into disjoint sets, such that every set can individually and successively perform the area monitoring task. These sets are successively activated and all nodes, not belonging to the active set, will be in the sleep state. Generally, such algorithms are centralized based on a full knowledge of the network topology, which increases the cost of the algorithm. Indeed, when a node fails, the coverage is no more guaranteed despite the fact that the other nodes belonging to the same set remain working. Centralized algorithms are not suitable for real wireless sensor networks as they induce a consequent overhead. Moreover, this entity must transmit many messages to inform each node about its schedule, which will also consume more energy.

The configuration algorithm [10], must be robust despite the loss of messages. Indeed, when lost messages are not critical situations may appear. For example, the loss of deactivation messages may lead to the occurrence of blind points. Hence as the neighbouring nodes have not received the deactivation message they may decide to be inactive, believing that the former node is remaining active, which introduces the occurrence of blind point. Using the same nodes to cover the area of interest exhaust their batteries. Consequently, they will fail more quickly than others, which lead to network partitioning or failure of some application functionality.

The distributed algorithm presented in [16,7], involve

multiple nodes working together to solve a computing problem. Using Distributed Algorithm can be designed by paying attention to the inherent dependency that exists between different cover sets since they share sensors in common. This algorithm capturing the dependencies between different cover sets, examine localized heuristics based on this dependency model and present various improvements on the basic model. Distributed Optimum Coverage Algorithm (DOCA) which is designed to maximize the network lifetime by having the sensors periodically calculate their power to adjust their waiting time. When the waiting time expires they transition to an active state. These heuristics represent a 20-30% increase in the network lifetime , uses greedy criteria to make scheduling decisions.

Previously presented works consider the ERGS algorithm [17], according to verification of its eligibility rule to minimize the energy consumption and extend the 33.33% greater than network lifetime.

Thus, the Clustering Technique was introduced, for every cluster, check neighbours energy. Among the neighbours choose high energy node, announce high energy node is elected as cluster head (CH). Receiving node verifies cluster head energy with its own energy. If it is less than convert as member. All the nodes in each cluster are supposed to convey the data to their respective cluster heads (CH). By this reduced the energy consumption in every node in the network. Clustering technique is one of the approaches to save tremendous energy by minimizing the number of active nodes, full coverage and prolong the network lifetime. The comparison of other references with base paper is done in table 1. The merits and demerits of reference papers and the base paper approaches are listed.

"Table 1": Comparison Of Other References With Base Paper

Techniques used	Energy consumption	Robust	Network lifetime
Centralized algorithm	Maximize the energy consumption	Robust	Lifetime reduced
Configuration Algorithm	Energy depletion among nodes	Robust	Lifetime reduced
Distributed Algorithm	Minimize the energy consumption	Robustness	20-30% increase the lifetime
Energy Remaining Greedy Scheduling Algorithm	Minimize the energy consumption	Robustness against node failures	Full coverage and 33.33% greater than the network lifetime
Clustering Technique	Minimize the energy consumption	Robustness against node failures	Full coverage and 44% greater than the network lifetime

III. CLUSTERING TECHNIQUE

In Clustering Technique, the large number of sensor nodes will be divided into several clusters. For each cluster, a high energy node is selected as a cluster head. The Clustering Technique based on highest residual energy is proposed to improve the network lifetime, reduce the energy consumption in every node in the network, provide the full coverage and tremendous energy saving. In this technique, the clustering operation includes two phases: Clustering Formation Phase and Clustering Eligibility Phase. The details of these two phases are introduced as follows.

3.1 Clustering Formation Phase

At the begining of the clustering formation phase, nodes are randomly deployed in large areas. Each node contains ID and its residual energy. Each node obtains the neighbouring nodes information. As only the nodes within a communication range equal to sensing range are considered for the verification of the sensing area coverage. In this technique the nodes are added into group of nodes which are called cluster. For every cluster check neighbours energy. Among the neighbours choose high energy node, announce high energy node is elected as cluster head (CH). Receiving node verifies cluster head energy with its own energy. If it is less than, convert as member. All the nodes in each cluster are supposed to convey the message to their respective cluster heads. Each node can transmit its clustering message with minimum power allowing to reach this range. By this technique, minimize the number of active nodes in order to minimize the energy consumption [12] and prolong the network lifetime greater than 44% [15]. Let C be the center location for all sensor nodes. If there are n sensor nodes in the wireless sensor networks, C can be calculated by

$$C = \frac{\sum_{i=1}^{n} Xi}{n} \qquad (1)$$

where Xi is the coordinate of sensor node i.
Let R be the average distance between C and all sensor nodes, which can be calculated by

$$R = \sum_{i=1}^{n} \frac{|Xi - C|}{n} \qquad (2)$$

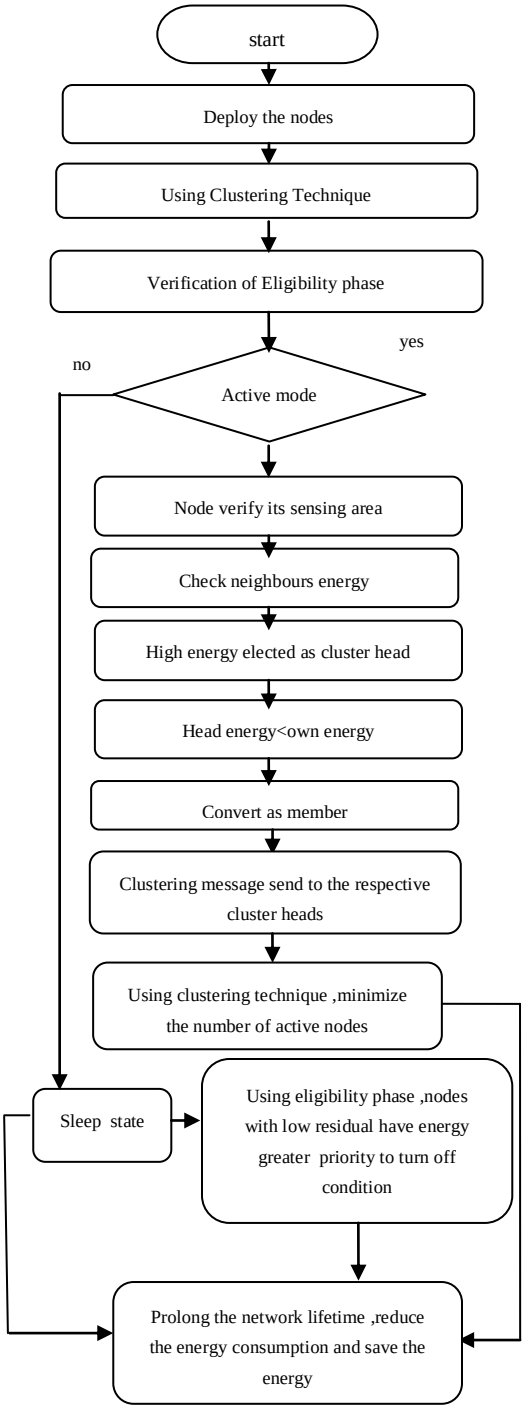
According to C and R, the locations of initial mean of point *mi*(*mix* ,*miy*) for the cluster i is calculated by

$$\begin{cases} m_{i_x} = R \times \cos\left(\frac{360}{k} \times (i-1) \times \frac{\pi}{180}\right) + C_x \\ m_{i_y} = R \times \sin\left(\frac{360}{k} \times (i-1) \times \frac{\pi}{180}\right) + C_y \end{cases} \quad (3)$$

where k is the number of clusters and i = 1, 2,..., k.

3.1.1 Clustering Status Advertisement Message

In this phase, receiving an CSAM (clustering status advertisement message),the receiver node will compare itself to the transmitter node.



"Fig 4": Flow Chart Of Clustering Technique

Based on the comparison result, the transmitter node will be added to one of two specific lists: HCS and LCS. The nodes belonging to the HCS (Receiver) list have less priority than the receiver node to be deactivated. Otherwise, the nodes belonging to LCS (Receiver) list have more priority to be deactivated. If SA(c) (sensing area) is covered, the nodes belonging to its HCS list, then it enters directly to the sleep state, where it turns off its radio and sensing units. Some nodes of LCS (c) list that have already decided to be awake. The CSAM messages will not be forwarded, because nodes just need to know their neighbours. The flow chart of clustering Process (see Figure 4) .

3.3 Clustering Eligibility Phase

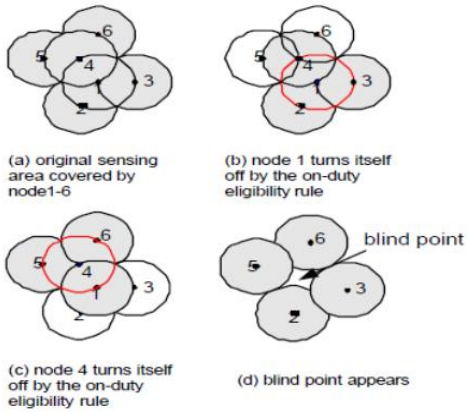
After finishing the clustering formation phase, each node decides its eligibility to turn itself off. The clustering technique introduces the priorities between nodes. Nodes with low residual energy will have greater priority to turn off. The residual energy can be calculated by using equation 3

Overall residual Energy= Total Residual Energy

Total number of Nodes

$$\textit{Residual Energy} = \sum_{i=i}^{n} \frac{Xi\ (Total - Energy)}{n\ (Total\ Number\ of\ Nodes)} \quad (4)$$

If all nodes simultaneously make decisions ,blind points [17,13] may appear (see Figure 5) . Node 1 finds that its sensing area can be covered by nodes 2-4. According to the sleep scheduling, node 1 turns itself off. While at the same time, node 4 also finds that its sensing area can be covered by nodes 1,5,6. Believing node 1 is still working, node 4 turn itself off too. Thus, a blind point occurs after turning off both nodes 1 and 4.



"Fig 5": Blind Points Appear

The blind point could be avoided if only node 4 or node1 has considered the other one to the verification of priority. Thus, it is easy conclude that any two neighbour nodes simultaneously consider themselves. To achieve this objective, a notion of priority must be introduced between nodes. This priority avoids the use of additional messages and allows to remain robust despite the loss of messages while ensuring the avoidance of blind points.

"Table 2": Clustering Operational Phases

Processing phases	**Tasks Performing phases**
1.Clustering formation Phase	All parts of the sensor are fully powered. Sensor performs sensing the environment, processing, receiving message from cluster head. This phase extend the network lifetime greater than 44% and reduce the energy consumption.
2.Clustering Eligibility Phase	It is energy saving phase

IV. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

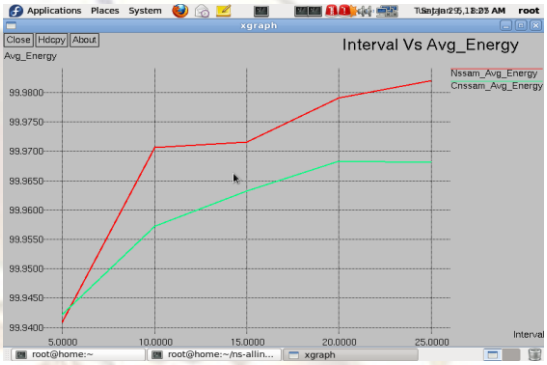
In this section, we evaluate the performance of our proposed Clustering Technique using a simulation model. We describe our simulation model and illustrate the simulation results, and compare our scheme with Energy Remaining Greedy Scheduling Algorithm. We design a simulation environment by using NS2. The assumptions for our simulation study are as follows. Figure 1 shows the total network average energy when the number of sensor nodes is 100 and the sensing area is 100 m × 100 m. It is evident that the residual energy of our proposed CT scheme is higher than that of ERGS. This is because our proposed CT scheme provides the better lifetime and reduce the energy consumption. The data transmission distance from each sensor node to its cluster head node is minimized. Thus, the energy consumption is saved. The overall Energy consumption can be calculated by

Total energy consumption = $\frac{\text{Total-Energy}}{\text{Total number of Nodes}}$

The energy consumption model determines the sensor lifetime. The energy calculation for a single cycle is done by using the following equation 5 in fig 6.

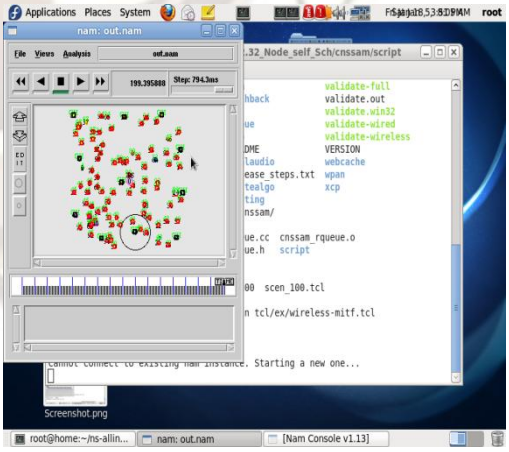
$$Ecycle = ED + ES + ET + ER \qquad (5)$$

Where *ED, ES, ET* and *ER* represent the energy required for data processing, sensing, transmitting and receiving per cycle time, respectively. The quantity of energy spent for each operation depends on the network.



"Fig 6" : Minimize the energy consumption

When we compared our scheme with the ERGS, as shown in the fig 7,fig 8. our scheme shows, high energy node elected as cluster head. All the nodes in each cluster are supposed to convey the message to their respective cluster heads .By this minimize the number of active nodes, to reduce the energy consumption and increase the lifetime.



"Fig 7": All the nodes in each cluster are supposed to convey the message to their respective cluster heads

In the proposed approach, less energy consumption could be achieved by transmitting packets directly to

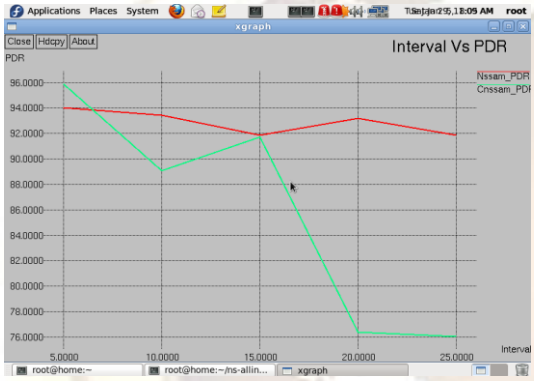
cluster head toward the BS through the shortest paths and considering the remaining energy of the nodes to balance energy among the nodes in fig 8 and fig 9.

Packet Delivery Ratio (PDR) is the ratio of the number of data packets delivered to the BS to the number of packets generated by the source nodes as below:

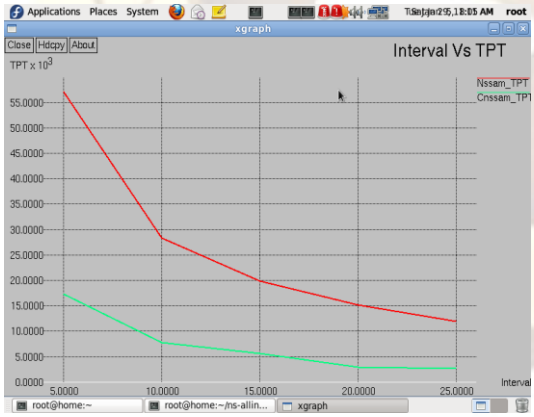
$$\text{PDR} = \frac{\text{Total Number of packets Received at BS}}{\text{Total Packets Sent}}$$

$$\textit{Total Packet Sent} = \sum_{i-1}^{n} \textit{Number of Nodes X Number of Packets Sent by each node.}$$

$$\textit{Total Number of Packets Received at BS} = \sum_{i=1}^{n} \textit{Number of Source Nodes X Number of Packets X Received at BS by each node}$$



"Fig 8": Extension Of Network Lifetime



"Fig 9": Compare between Ergs and Clustering technique, increase the lifetime.

V. CONCLUSION

In this paper, we proposed a Clustering Technique, which can reduce energy consumption, energy saving and therefore increase system lifetime, by minimize the number of active nodes. We presented a basic phases for clustering formation phase and clustering eligibility phase. Clustering formation Phase, minimize the energy consumption and extend the network lifetime greater than 44%. Clustering eligibility phase, based on priority of nodes. Nodes with lowest residual energy have greater priority to turn off condition. This phase saving the energy. Clustering technique is one of the approaches to provide full coverage, increase the lifetime, saving the energy and reduce the energy consumption.

REFERENCES

[1] Arms Chris, Townsend. S., (2004) Wireless Sensor Networks: Principles and Applications.

[2] Ali Raza Zaidi,S. ,Hafeez, M., D.C. McLernon d.c.Ghongo, M (2004) A Probabilistic model of k-coverage in Minimum Cost Wireless Sensor Networks.

[3] Ammari. M., Giudiel, J., (2009) On the connected k-coverage problem in heterogeneous sensor nets: the curse of randoms and heterogeneity.

[4] Anh Nguyen, Anna Forster, Daniele Puccinelli, Silvia Giordano S(2011) Sensor Node Lifetime.

[5] Cardei. M.. Thai. M.T., Yingshu, L., Weili. W., (2005) Energy-efficient target coverage in wireless sensor networks.

[6] Chang., J .H., Tassiulas. L., (2000) Energy conserving routing in wireless ad-hoc networks .

[7] Chen. A., (2007) Designing Localized algorithms for barrier coverage ,Proc.ACM MobiCom.

[8] Fan,G.J. ,Jin, S.Y(2010) Coverage problem in wireless sensor network: a survey.

[9] Gao,S. ,Wang,X ., Li,Y .(2005) p-Percent Coverage Schedule in Wireless Sensor Networks'.*ICCCN'08:17th Int. Conf.on computer communication and Networks.*

[10] Huang, D.F., Tseng, Y.C. (2003) The coverage problem in wireless sensor network.

[11] Li1,Y. ,Ail, C., Cai2,Z., Beyah ,R.(2009) Sensor scheduling for p-percent coverage in wireless sensor networks, *Cluster Comput.pp.27-40.*

[12] Mulligan.R (2001) Coverage in wireless sensor networks: a survey, *Network Protocols Algorithms,pp.27-53.*

[13] Slijepcevie. S., Potkonjak, M., (2001) Power efficient organization of wireless sensor networks ICC 2001 : *IEEE Int.Conf.on Communications, pp.472-476*

[14] Tian. d., Georganas. N. D., (2002) A coverage-preserving node scheduling scheme for large wireless sensor networks.

[15] Ye, F., Zhong., Lu. G., Zhang. S., (2002) Peas:a robust energy conserving protocol for long lived sensor networks.

[16] Zhang, H., Hou., (2005) Maintaining sensing coverage and Connectivity in large sensor networks, Ad Hoc Sensor Wireless Networks 1(2) pp.89-124.

[17] Zhang. H.. Wang. H., Feng. H., (2009) A Distributed optimum algorithm for target coverage in Wireless sensor networks.

[18] Zauri.S,B.Zouari, E.Niel, E.Dumitrescu., (2012) :Node self-scheduling Approach for maximizing wireless sensor network lifetime based on remaining energy.