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# Maximizing The Lifetime Of Wireless Sensor Node

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***Abstract*—Sensor nodes have limited lifetime batteries due to high energy consumption. Energy conservation and Coverage are two major problems in wireless sensor networks. The objective of this paper is to minimize the energy consumption while maintaining the full sensing coverage and extend the network lifetime. The main focus of this paper is to obtain increase the network lifetime, minimize the energy consumption, as well as maintain the full coverage. In this paper, we propose a ERGS(Energy Remaining Greedy Scheduling Algorithm),which can reduce overall energy consumption, therefore increasing network lifetime, by minimize the number of active nodes. We implement our proposed scheme in NS-2 as an extension of Energy Remaining Greedy Scheduling Algorithm. Simulation results show that our scheme can reduce the energy consumption, full coverage and increase the network lifetime.**

***Index Terms* — 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. WSNs are typically used to monitor a field of interest to detect movement, temperature changes, precipitation etc.The nodes are typically equipped with power constrained batteries, which are often difficult, expensive and even impossible to be replaced once the nodes are deployed. Therefore energy awareness becomes the key research challenge for sensor networks protocols. The energy consumed by a node depends on its state.

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Each node may be in one of four states: transmit , receive, idle(when the node keeps listening to the medium even when no messages are being transmitted) and finally sleep state(where the radio module is switched off: no communication is possible).Significant energy savings can be achieved by scheduling nodes activities in high-density WSNs. Specifically, some nodes are scheduled to sleep whereas the remaining ones provide continuous monitoring. The main issue here is how to minimize the number of active nodes in order to maximize the network lifetime and at the same time to ensure the required quality of service (QoS) for applications.

Particularly, coverage may be considered as the measure of the QoS of the sensing function for a WSN. For example, in an application of forest monitoring, network can observe a given area and fire starting in a specific location of forest will be detected in a given time frame. Many researchers are currently engaged in developing solutions related to coverage problem, while integrating some considerations for optimizing the utilization of network resources or for supporting specific application requirements(e.g. network connectivity, energy consumption etc.).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 [5], introduces priorities between nodes. Nodes with minimal remaining energies will have greater priority to turn off.Thus,if each node guarantees the full coverage of its sensing area by a subset of working neighbours before entering its sleep state, then the coverage of the target area will be preserved after the deactivation of redundant nodes.So,each node can self-schedule its activity based on localized information. The blind point could be avoided, if only node 4 or node 1 has considered the verification of its eligibility.Thus,it is easy to conclude that any two neighbour nodes should not simultaneously consider themselves. To achieve this, a notion of priority must be introduced between the nodes. Priority allows to avoid the blind point without the need to exchange additional messages. In this work, we implement the proposed scheme as an extension of Energy Remaining Greedy Scheduling algorithm. We compare the coverage, energy consumption with and without the extension and analyze the effectiveness of our algorithm in terms of energy saving, optimizing the functioning of the WSN, while conserving, as long as possible, the full coverage of the target area, by preserving the redundant nodes. Thus, a Energy Remaining Greedy Scheduling algorithm is introduced.Our simulation results show that the prolonged network lifetime in the extended ERGS algorithm.

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

## II. RELATED WORK

Minimizing the energy consumption and Maximizing the network lifetime has been a major design goal for wireless sensor networks. Many researchers are currently engaged in developing solutions related to coverage problem for wireless sensor networks. The coverage problem [16,14] is subject to a wide range of interpretations. The Coverage problem can be classified under different objectives and metrics. The different approaches to the coverage problem are centralized algorithm, distributed algorithm, localized algorithm, coverage preserving and coordinated sleep algorithm, Computational Geometry and Graph Theoretic Techniques ( Voronoi diagram and Delaunay triangulation). Based on the objective, the coverage problem [10] formulation varies to reflect the different assumptions and objectives. The coverage type is shown in fig "(a)".

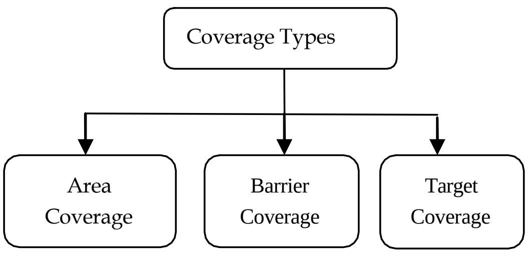


Fig "(a)": Hierarchy Structure of Coverage Types

The Coverage may be divided into three categories depending on what exactly that you are attempting to monitor.

1. Area coverage: Each location of the interest area within the sensing range of at least one node.
2. Target coverage: Observing a fixed number of targets. To maintain target coverage while conserving energy.
3. Barrier coverage: Detection of movement across a barrier of sensors.

The coverage types such as area coverage [4,3] , target coverage [6,7] , barrier coverage [8] . The type of coverage has obvious used in military applications (target coverage).To maintain coverage [13] while conserving energy. This paper considers the area coverage problem. Thus, some related works are detailed in the remaining of this section to better understand the development of the proposed algorithm. Since the sleeping state is the least energy consuming state, keeping nodes in the sleeping state is a good way to save energy. However, the full area coverage must be ensured when some nodes are sleeping.

Some works as centralized algorithm presented in [18] 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 WSNs 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 [17] ,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 coordinated sleep algorithm, coverage preserving presented in [9], a node assumes multiple roles namely ,the roles of a' head', a 'sponsor' and a regular node. Periodically, each node determines a subset of its neighbours covering its sensing area and sends a request message to each presumed sponsor. Each node receiving such message will assume a role of sponsor for the specified sleep time confirms it via an acknowledgement message. The eligible node upon receiving confirmation from the whole sponsors, assumes the role of a head and enters the sleep state for the specified period of time. The cost of the performance is a significant communication overhead increasing power consumption. Otherwise, the execution of this algorithm may be hardly affected by the loss of messages.

The localized algorithm for node scheduling presented in [8,9],to enter OFF state, each node node must verify that it is not closest to the optimal location that covers the crossing points of the sensing areas of two working neighbours. Computing the location of an optimal node, that can cover a particular crossing point, may be hard. On the other hand, the verification of the coverage of the sensing area, any time a new power on message is received, is energy constraining.

The distributed algorithm presented in [24,20], 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.

The computational geometry and graph theoretic techniques [3], investigate the problem of best and worst case coverage. In worst-case coverage, attempts are made to quantify the quality of service by finding areas of lower observability from sensor nodes and detecting breach regions. In best-case coverage, finding areas of high observability from sensors and identifying the best support and guidance regions are of primary concern. By combining computational geometry and graph theoretic techniques, specifically the Voronoi diagram and Delaunay triangulation to compute the path that maximizes the smallest observability (best coverage) and the path that minimizes the observability by all sensors (worst coverage).This techniques not scale well for coverage.

Previously presented works consider the disk based sensing model presented in [11,15] , represent the sensing area of nodes. Disk Based Sensing Model, formulate the problem of k-coverage in networks. This Approach presented for both homogeneous and heterogeneous sensors. They examine the coverage of the perimeter of the sensing range of each sensor. This algorithm can be utilized to discover insufficiently covered regions.

Thus, the ERGS algorithm [22] was introduced, to provide the full coverage over an area of interest while minimizing the number of active nodes. Thus, it maximizes the duration of the coverage and extend the network lifetime, minimize the energy consumption.

The comparison of other references with base paper is done in table "(a)". The merits and demerits of reference papers and the base paper approaches are listed.

Table "(a)": 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 |
| Localized Algorithm | Maximize the energy consumption | Robust | Lifetime reduced |
| Coordinated, Coverage preserving algorithm | Increasing power consumption | Robust | Lifetime reduced |
| Computational Geometry and Graph Theoretic Techniques. | Maximize the energy consumption | Robust | Lifetime reduced |

| | | | |
|---|---|---|---|
| Disk Based Sensing Model | Maximize the energy consumption | Robust | Insufficient coverage, lifetime reduced |
| Energy Remaining Greedy Scheduling Algorithm | Minimize the energy consumption | Robustness against node failures | Full coverage and 33.33% increase the lifetime. |

## III. ENERGY REMAINING GREEDY SCHEDULING ALGORITHM

The proposed a novel Energy Remaining Greedy Scheduling Algorithm(ERGS) [22] considers the problem of nodes scheduling while preserving the full coverage of a target area.

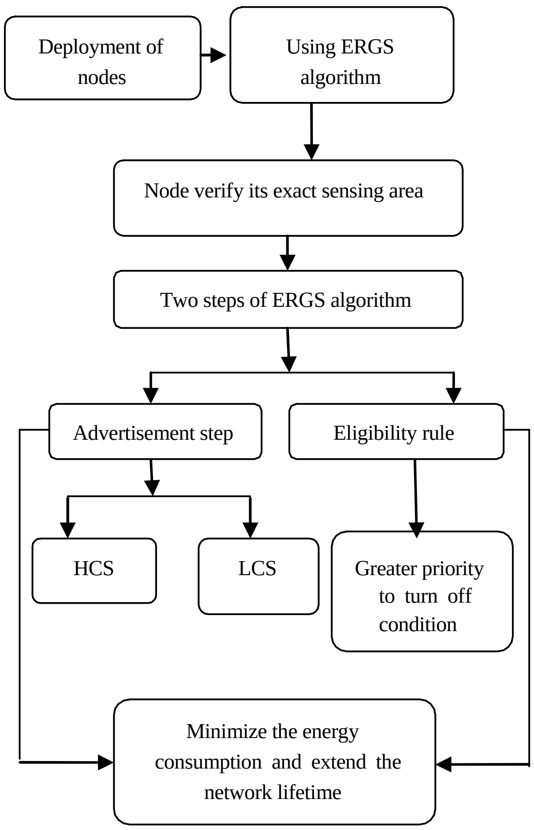


Fig "(a)": Proposed Block Diagram of ERGS

The proposed energy remaining greedy scheduling(ERGS) algorithm is a localized self-scheduling algorithm which considers only one-hop neighbourhood knowledge. The proposed diagram is shown in fig "(a)".

### A. Flow Chart

The flow chart of ergs is represented in fig"(a)".

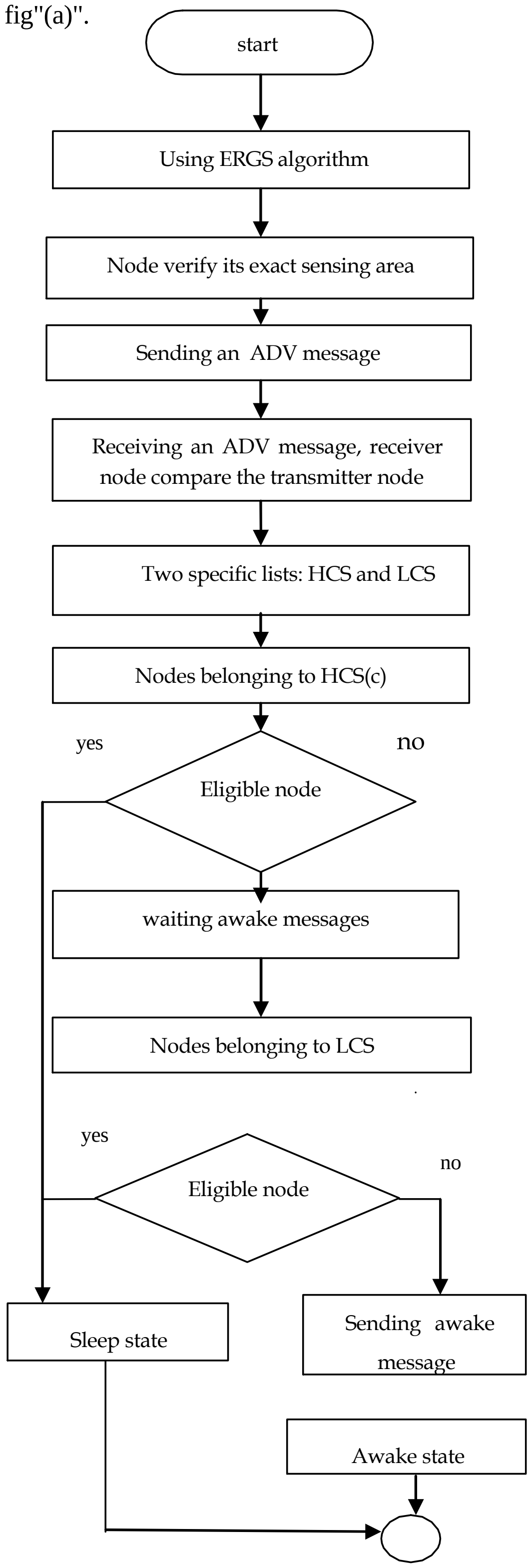


Fig "(a)": Flow chart of ERGS

*B. Ergs Algorithm Steps*

The ERGS algorithm is divided into rounds, where each one begins by a self-scheduling phase. In this phase, the nodes verify the coverage of their sensor area(SA).In self-scheduling phase, nodes investigate the off-duty eligibility rule. Eligible nodes trade off their communication unit and sensing unit to save energy. Ineligible nodes will perform sensing tasks during the remaining of the current round. To minimize the energy consumed in the self-scheduling phase, the sensing phase should be long compared to the self-scheduling phase. During the self-scheduling phase, the sensing tasks remain ensured by all working nodes.

The self-scheduling phase includes two steps. First, each node advertises its position and listens to advertisement messages from other nodes to obtain neighbouring nodes position information. Second, each node calculates its eligibility and decides whether it is eligible to enter its sleep state. The Two Steps Of The ERGS Algorithm.

*B.1 Positioning Information Step*

At the beginning of the step, each node transmits to its neighbour nodes an advertisement

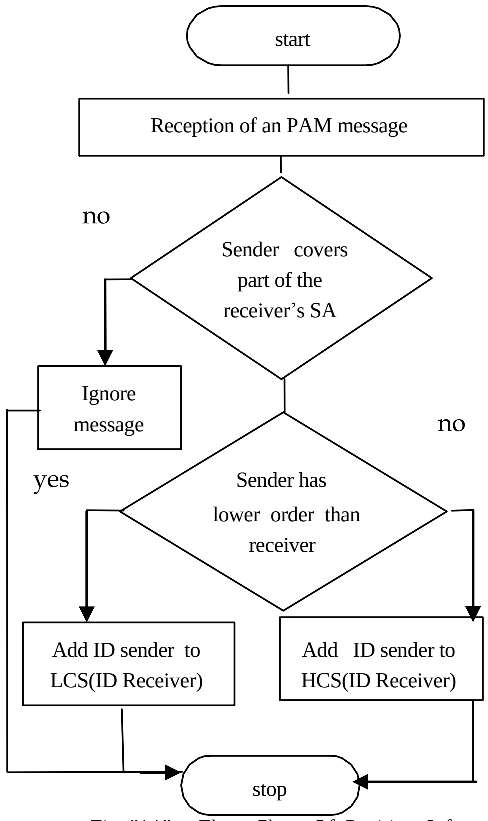


Fig "(a)": Flow Chart Of Position Information

message(ADV),including its ID and its current remaining energy. As only the nodes within a communication range equal to sensing range (Rm) are considered for the verification of the SA coverage, each node can transmit its ADV message with the minimum power allowing to reach this range. This power adaption also enables to minimize the energy consumption.

The transmitter node will be added to one of two specific lists: HCS(Receiver) list and LCS(Receiver) list. The nodes belonging to the HCS (receiver) list have less priority than the receiver node to be deactivated. otherwise, the nodes belonging to the LCS(Receiver) list have more priority to be deactivated. The PAM messages will not be forwarded, because the nodes just need to know their one-hop neighbours. The update of the HCS(Receiver) and the LCS(Receiver) lists, when receiving an PAM message is described in detail by the flowchart represented in Fig "(a)".

*B.2 Eligibilty rule*

After finishing the collection of Positioning neighbour information step , each node evaluates its eligibility for turning off [12] . However , if all nodes make decision simultaneously, blind points may appear. To avoid such problem ,the proposed ERGS algorithm introduces priorities between nodes. Nodes with minimal remaining energies will have greater priority to turn off.

If SA(c) is covered by the union of the SA of the nodes belonging to its HCS list, then it enter directly to the sleep state , where it turn off its radio and sensing units. When deciding to be inactive ,the node 'c' is certain that none of the nodes belonging to its HSC(c) list will consider it to verify its eligibility. Thus, the problem of blind points, caused by simultaneously decisions, is avoided.

If it is not covered ,the node can directly decide to be active. Such decision does not minimize the number of active nodes. Indeed, SA(c) may be covered by the nodes belonging to HSC(c)list and some nodes of LCS(c) list that have already decided to be awake. In this situation, the node 'c' will be redundant .In order to maximally decrease the number of redundant nodes, each node 'c' must re-compute its eligibility once all nodes belonging to its LCS(c) have made their decisions. In this case, its decision will not induce any redundancy among the inactive nodes. The problem is that 'c' should be informed of the decision of all its neighbours belonging to LCS(c)list. Obtaining such information will induce a consequent messages exchange. On the other hand ,the node 'c' needs only to know which nodes will remain active. Thus, it is possible to assume that only ineligible nodes will inform their neighbours about their decision to reduce the number of exchanged message. Consequently, each node must delay its decision after the reception of all the eventual awake message from its neighbour nodes belonging to the LCS list.

As some nodes belonging to LCS list can decide to be inactive and so they will not send awake messages the waiting delay must be timed out. As all decision are based on energy, the duration of the waiting delay will also be proportional to the remaining energy of the node. Thus, the node having less remaining energy than its neighbours will receive their eventual awake messages and then it can consider them for its evaluation.

*B.2.1. Blind Point Occurrence*

If all nodes simultaneously make decisions ,blind points [9] may appear .Node 1 finds that its sensing area can be covered by nodes 2-4.According to the eligibility rule, 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.

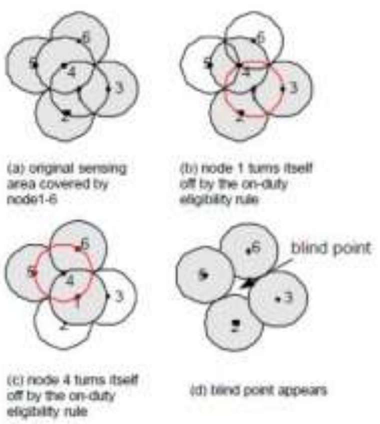


Fig 3.2.2.1 Occurrence Of Blind Point

*B.2.2. Blind Point Avoidance*

The blind point could be avoided if only node 4 or node1 has considered the other one to the verification of its eligibility. 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. Such priority must introduce a unique order between neighbours which may be locally computed. Thereby, in example of fig.3,based on this priority only node 1 or node 4 will consider the other nodes in its eligibility computation.

C. Reduces The Complexity

The complexity of the algorithm is evaluated in terms of the number of exchanged messages and operations .According to the considered assumptions ,a node ‘c’ can only receive message from NCS(c) nodes. According to ERGS algorithm description ,each node maximally sends two messages every round( an ADV message and an awake message if it decides to be active for the current round). This is pretty low if the sensing phase is rather long against the duration of a local transmission. As control messages are not broadcast, it is not necessary to evaluate the total number of messages exchanged over all the WSN. It is interesting to evaluate the execution cost of the ERGS algorithm around one node. The operational complexity of the ERGS algorithm depends on the complexity of the algorithm used for the evaluation of the SA coverage .The complexity of the determination of the HCS and LCS neighbours is negligible compared to the complexity of the coverage evaluation algorithm. ERGS algorithm may be perfectly used for the eligibility verification. This algorithm reduces the complexity.

## IV. IMPLEMENTATION DETAILS AND SIMULATION RESULTS

Implementation [19] is the state in the project where theoretical design turned in to working system. The most crucial stage is achieving a new successful system and giving confidence in new system that will work efficiently and effectively. The system is implemented only after thorough checking is done and if it is found working in according to the specifications. It involves careful planning, investigation of the current system and constraints on implementation, design of methods to achieve. Network simulator 2 is used as the simulation tool in this project. NS was chosen as the simulator partly because of the range of features it provides and partly because it has an open source code that can be modified and extended.

*A. Module Description*

Different modules of this project include the following: Node deployment, Positioning Information step enables to minimize the energy consumption, eligibility rule extend the lifetime of network and provides the full coverage.

*A.1. Node Deployment*

Sensors are randomly [4] deployed in large areas. Random deployment of sensor nodes regards the ability to maintain coverage while minimizing the amount of energy expended.

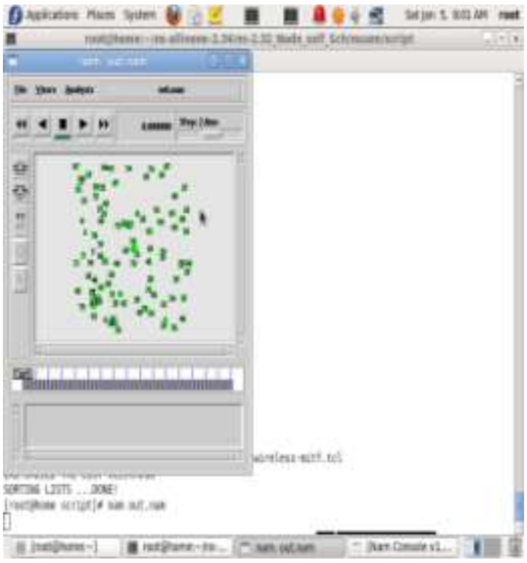

Fig "(a)": Random Deployment Of Nodes

*A.2. Positioning Information Step*

1. At the beginning of the step, each node transmit to its neighbour nodes an advertisement message, including its ID and its current remaining energy.

2. As only the nodes within a communication range equal to sensing range are considered for the verification of the SA coverge, each node can transmit its this range.

3. This power adaption also enables to minimize the energy consumption.

4. When receiving an ADV(Advertisement) message, the receiver node will compare itself to the transmitter node.

5. Based on the comparison result, the transmitter node will be added to one of two specific lists: HCS(Receiver) list and LCS(Receiver) list.

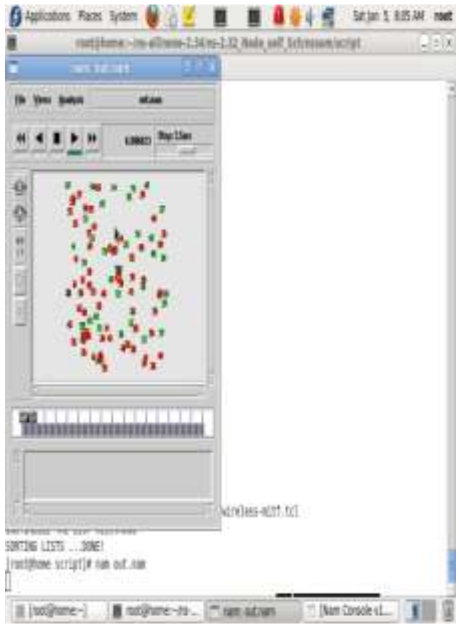

Fig "(a)" : Compare HCS and LCS List

6. The nodes belonging to the HCS (receiver) list have less priority than the receiver node to be deactivated. otherwise, the nodes belonging to the LCS(Receiver) list have more priority to be deactivated.

7. The ADV messages will not be forwarded, because the nodes just need to know their one-hop neighbours.

8. The update of the HCS(Receiver) and the LCS(Receiver) lists, when receiving an ADV message is described. This step minimizes the energy consumption.

*A.3. Eligibility Rule*

1. After finishing the collection of Positioning neighbour information step , each node evaluates its eligibility for turning off.

2. If all nodes make decision simultaneously, blind points may appear. To avoid such problem ,Ergs algorithm introduces priorities between nodes.

3. Nodes with minimal remaining energies will have greater priority to turn off. Thus a node will compute its eligibility only considering nodes belonging to its HCS list.

4. This step extend the network lifetime and provide full coverage.

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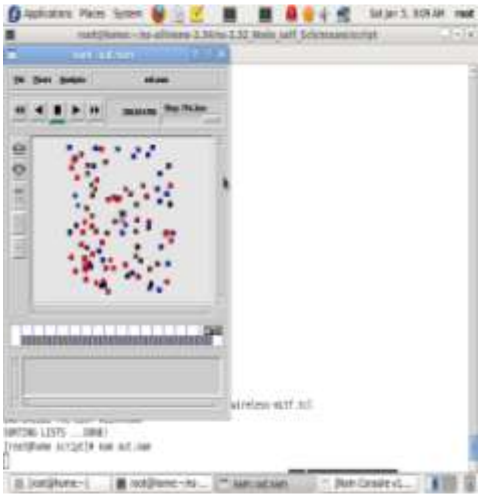

Fig "(a)" : Verification of Eligibility Rule.

*B. Clustering Technique*

In Future enhancement, to reduce energy consumption in every node in the network. We are using clustering technique [15] . In this technique, nodes check neighbours energy. For every cluster one node with high energy is elected as cluster head. Receiving node is less than the own energy, it is converted into member. All the nodes in each cluster are supposed to convey the data to their respective cluster head. This technique reduce the energy consumption in every node and extend the network lifetime.

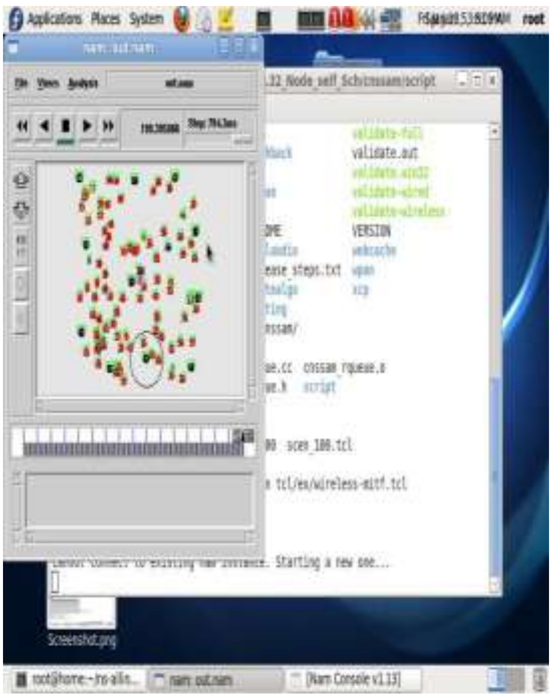

Fig "(a)" : Using Clustering technique, to minimize the number of active nodes while maintain the full coverage and reduce the energy consumption in every node.

## V. CONCLUSION

In this paper, we proposed a Energy Remaining Greedy scheduling Algorithm, which can reduce energy consumption, therefore increase system lifetime, by minimize the number of active nodes. We presented a basic model for Positioning Information steps, node verify its exact sensing area and compare the HCS and LCS list. This step minimize the energy consumption. To further maintain the full sensing coverage 33.33% in a real time environment, we introduce a eligibility rule. This rule based on priority of nodes. Nodes with minimal remaining energy have greater priority to turn off condition. This step extend the network lifetime. In future enhancement, we using clustering technique. This technique, reduce energy consumption in every node and energy saving, extend the network lifetime.

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